Tennessee Naturalist Program

Nocturnal Naturalist
Tennessee at Night

Enhanced Study Guide
Tennessee Naturalist Program

www.tnnaturalist.org

Inspiring the desire to learn and share Tennessee’s nature

These study guides are designed to reflect and reinforce the Tennessee Naturalist Program’s course curriculum outline, developed and approved by the TNP Board of Directors, for use by TNP instructors to plan and organize classroom discussion and fieldwork components and by students as a meaningful resource to review and enhance class instruction.

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Nocturnal Naturalist
Tennessee at Night

Objectives
To gain a better understanding of the world at night through an examination of some of the animals and insects who are active when the sun goes down. Explore particular organism adaptations needed to successfully function at night as well as habitat needs and ecosystem roles. Provide an introduction to the night sky (moon, constellations, and planets) and telescopes. Learn to see, hear, and navigate in the dark.

Time
Minimum 4 hours – 2 in class, 2 in field

Suggested Materials ( * recommended but not required, ** TNP flash drive)
•  Stars and Planets, Fourth Edition (Peterson Field Guides), Jay M. Pasachoff *
•  Nocturnal Naturalist Enhanced Study Guide, TNP **

Expected Outcomes
Students will gain a basic understanding of
1.  nocturnal niche -- animals who function at night
2.  organisms’ special adaptations for night
3.  Tennessee’s bat species
4.  Tennessee’s owl species
5.  nature’s night sounds
6.  the sky at night
7.  adjusting to life in the dark
Nocturnal Naturalist Curriculum Outline

I. Nocturnal Animals and Their Adaptations
   A. Nature’s shifts
      1. diurnal
      2. crepuscular
      3. nocturnal
   B. Adaptations for night life
      1. eyes -- size and vision sharpness
      2. ears -- size and hearing acuity
      3. silent movement -- padded feet, special feathers
      4. whiskers or heat-seeking pits
      5. white flowers and floral fragrance

II. Bats of Tennessee, Order Chiroptera (hand wing) -- 15 species
   A. Defining characteristics
      1. mammal -- hair, live birth, nurse young
      2. flying mammal -- wing design
      3. echolocation and facial design
   B. Summer and winter habitats
   C. Ecological roles
   D. Conservation concern
      1. species decline
      2. White-nose Syndrome
      3. human interactions
         a. rabies

III. Owls of Tennessee, Order Strigiformes -- 8 species
   A. Defining characteristics
      1. eyes -- large, binocular, far-sighted
      2. ears -- asymmetrical placement, feather adjustment
      3. neck design for turning head
      4. feather adaptations for silent flight
      5. vocalizations
   B. Descriptions, habitats, prey, nesting
   C. Human interactions
IV. Sounds and Sights of the Night
   A. Frogs and toads
   B. Insects
      1. Crickets
      2. Katydids
      3. Cicadas
   C. Bioluminescence

V. Astronomy
   A. Constellations and asterisms
      1. orbital and seasonal change
      2. planets
   B. Moon
      1. phases
      2. lunar eclipse
   C. Other phenomenon
      1. comets
      2. aurora
      3. deep sky objects
         a. clusters, galaxies, supernovas, nebulas
         b. Milky Way
   D. Telescopes
   E. Light pollution
   F. Star lore

VI. Adjusting to the Night
   A. “Seeing” in the dark
   B. Red flashlight filters
   C. Tracking sounds

VII. Resources
   A. Publications
   B. Organizations
   C. Internet

VIII. Review Questions
I. Nocturnal Animals and Their Adaptations

To go in the dark with a light is to know the light.
To know the dark, go dark. Go without sight,
and find that the dark, too, blooms and sings,
and is traveled by dark feet and dark wings.

Wendell Berry
“To Know the Dark,” Farming: A Handbook

Nature Works in Shifts
There are three types of organisms.
• Diurnal – daytime organisms
• Crepuscular – twilight species (dusk and dawn)
• Nocturnal – nighttime plants and animals

While kestrels and hawks hunt by day, owls hunt by night. Martins, chimney swifts, and swallows catch flying insects by day; bats and nightjars (whip-poor-wills) catch the night-flying insects. However, nocturnal animals must be equipped for this life after dark.

Some of our night-living creatures include bats, flying squirrels, opossums, raccoons, skunks, owls, mice, coyotes, rabbits, crickets, fireflies, spiders, and moths.

Adaptations for Night Life
Most nocturnal creatures are color blind. They can’t see the color red. Therefore, when on a night hike, naturalists use red-tinted flashlights when not using their night vision. This also protects night vision. Nocturnal animals have few cones and many rods in their retina. Rod cells are used to see light and shadow and shapes. Cone cells are used to see color. This is why the ability to distinguish color decreases at low light levels.

The tapetum lucidum is a glistening opaque layer behind the retina. The tapetum reflects stray light back through the retina, giving it a double chance to pass over the rods. Animals that hunt by both the day and night have a tapetum. It is the tapetum lucidum that creates eye shine. The strange eye reflection you see when a deer is caught in the headlights is light reflected from the tapetum lucidum. Here are some examples of different color eye shines.

Tiny scintillating specks of white – Wolf spiders
Close-set red eyes – Black-crowned Night Heron
Glowing red coals – Woodcock
Large orange-red eyes – Yellow-crowned Night Heron
Small orange-red eyes on tree trunks – Noctuid moths particularly Catocala species
Closely set, large, bright, orange eyes – Bear
Bright yellow eyes – Raccoon
Yellowish white eyes – Bobcat
Opalescent green eyes – Bullfrog
Fiery white – Coyotes, dogs
Pit vipers such as our copperheads and rattlesnakes are nocturnal. They hunt in ambush style at a log or along a trail waiting for a warm blooded creature such as a mouse run by. They use their heat detecting pit to sense the warmth of the animal. The vertical pupil of pit vipers is also an adaptation. However, it is an adaptation to protect the snake’s retina during the day since snakes cannot close their eyes.

Plants that attract night-flying moths as pollinators use white or pale-colored flowers to reflect any ambient light and often augment this with a scent lure of powerful fragrance. Many nocturnal animals also have acute hearing, with larger ears or other special features to maximize their ability to detect sounds and determine direction.
II. Bats of Tennessee

Bats are nocturnal, flying mammals. There are 1,100 species of bats worldwide. We have 15 species of bat that live in Tennessee. Like many of Tennessee’s nocturnal creatures, bats are feared and misunderstood. Here is a list of misconceptions associated with bats and the facts that should dispel them.

**Myth:** Bats are flying rodents.
**Fact:** Bats are actually more closely related to primates than rodents.

**Myth:** Bats get caught in people’s hair because they’re “blind as a bat.”
**Fact:** Bats have excellent vision. Combined with echolocation, they generally don’t run into things and won’t get in your hair.

**Myth:** All bats carry rabies.
**Fact:** Less than one half of one percent of bats carry rabies.

**Myth:** All bats drink blood.
**Fact:** Only vampire bats eat blood, and they don’t live here.

**Bat Classification**
Phylum: Chordata - Animals with a backbone  
Subphylum: Vertebrata - Animals with vertebrate backbone  
Class: Mammalia – Animals with hair that give live birth and nurse young.  
Order: Chiroptera – Bats fly with their hands. Their order means Chiro (Hand) Ptera (Wing)

**Bat Adaptations**
Bats are the only true flying mammals. Other mammals glide, like flying squirrels. Bats emit high frequency sound pulses that help them “see” to move and hunt in the dark. This is called echolocation. Many bats have unusually large ears or odd looking structures in their ears to aid in echolocation.

**Bat Predator-Prey Relationships**
All of Tennessee’s bats are insectivores (insect eaters). Bats in other parts of the world are fruit eaters or nectar feeders (this includes some western U.S. species). Some bats are highly specialized and feed on frogs, fish, or blood such as the Vampire Bat. Vampires do not occur in North America. They live in Mexico and Central and South America. Bats are preyed upon by owls, snakes, raccoons, and cats.
The Importance of Bats

Bats play an important role in controlling insects. All of Tennessee’s bats are insectivores. Bats can eat 50 to 100 percent of their body weight every night. A colony of 1,000 bats can consume 22 pounds of insects nightly. Insect eating bats don’t just eat mosquitoes. They also eat moths and beetles. This helps control crop pests. Many crop pests are beetles and caterpillar larvae of night flying moths.

Bats are also important as pollinators. These are the nectar feeding bats. Some tropical flowers bloom only at night and have special shapes and scents that attract bats. Fruit eating bats are very important for seed dispersal. This is critical for reforestation in the tropics.

Bat Habitats: Where Bats Live

Roosting Locations -- Bats roost in hollow trees and under bark. They also hang from branches or in clumps of leaves. They can be found in buildings as well as caves.

Hibernation Homes -- Bats build stores of fat to survive the winter. Many bats hibernate in caves, but some, especially in Tennessee, hibernate in trees. These bats are especially adapted to tolerate lower temperatures. Their tail is covered in fur, and the bats can use this to help keep them warmer. Red Bats, Silver-haired Bats and Hoary Bats are all tree bats and spend the winter in trees. Red Bats, amazingly, can spend the winter under leaf litter on the ground. Many bats also spend the winter in buildings.

Some species of bats such as the Red and Big Brown bats will awake on warm winter days to feed. The temperature is usually at least 50 degrees to see these bats flying.

Conservation: Bats in Danger

Tennessee has two species of endangered bats, the Gray Bat and the Indiana Bat. Reasons for their decline include habitat loss, cave commercialization, cave flooding, and trash in sink holes. Disturbance during hibernation is a serious threat to bats. Bats live off of stored fat in the winter. If the bats are disturbed, they run out of fat stores before spring and die. Disturbance at maternity colonies is also an issue. When someone disturbs a maternity cave, young bats can fall to the cave floor and die.

How People Can Help Bats

• Help dispel bat myths.
• Don’t disturb hibernating or maternity colonies when spelunking (caving).
• Put up a bat house.
• Maintain wooded buffers around streams and wetlands.
• Limit pesticide use.
• Volunteer at a cave gating. Cave gates protect bats from human disturbance.
Tennessee Bats

The state has 15 species of bats. Gray Bat, Indiana Bat, Northern Long-eared Bat, Little Brown Bat, Southeastern Bat, Eastern Small-footed Bat, Tri-colored Bat, Big Brown Bat, Evening Bat, Rafinesque’s Big-eared Bat, Eastern Red Bat, Seminole Bat, Hoary Bat, Silver-haired Bat, and Brazilian Free-tailed Bat.

Gray Bat – *Myotis grisescens*

- 11-13 inch wingspan
- Only has one pup per year
- Lives in caves in the summer and winter
- Travel great distance between caves
- Endangered species

Indiana Bat – *Myotis sodalis*

- 9-11 inch wingspan
- Summer in hollow trees, under loose bark
- Hibernate in caves
- Only has one pup per year
- Endangered species

Northern Long-eared Bat – *Myotis septentrionalis*

- 9-11 inch wingspan
- Summer in barns, old houses, behind shutters, under loose bark
- Hibernate in caves
- Only has one pup per year

Little Brown Bat – *Myotis lucifugus*

- 9-11 inch wingspan
- Females form maternity colonies in barns, old houses, and attics
- Hibernate in caves
- Only has one pup per year

Southeastern Bat – *Myotis austroriparius*

- Species of Concern in TN
- 9-11 inch wingspan
- Females form maternity colonies in caves, mines, hollow trees
- Hibernate in caves, mines, buildings
- Active year round further south
- Usually has twins
Eastern Small-footed Bat -- *Myotis leibii*
Species of Concern in TN
8-10 inch wingspan
Females form maternity colonies in caves, buildings
Hibernate in caves and mines
Only has one pup per year

Tri-colored Bat -- *Perimyotis subflavus*
8-10 inch wingspan
Lives in trees and caves in the summer
Hibernates in caves
Usually has twins

Big Brown Bat -- *Eptesicus fuscus*
13-16 inch wingspan
Lives in hollow trees, behind loose bark, barns, old houses, and attics
Hibernate in caves, mines, and buildings
Usually has twins

Evening Bat -- *Nycticeius humeralis*
10-11 inch wingspan
Lives in hollow trees and old buildings in the summer
Nobody knows where or if they hibernate
Usually has twins

Rafinesque’s Big-eared Bat -- *Corynorhinus rafinesquii*
Species of Concern in TN
10-12 inch wingspan
Lives in hollow trees, old buildings, caves, and mines in the summer
Hibernate in caves and mines
Only has one pup per year

Eastern Red Bat -- *Lasiurus borealis*
11-13 inch wingspan
Hangs in trees and looks like a brown leaf
Hibernates under leaves on the ground
Has one to four pups
Seminole Bat -- *Lasiurus seminolus*
- 12 inch wingspan
- Hangs in trees, under loose bark, mostly in Spanish moss
- Hibernates?
- Has two to four pups

Hoary Bat -- *Lasiurus cinereus*
- 15-16 inch wingspan
- Hang in clumps of leaves in trees
- Northern populations migrate south, sometimes in groups
- Usually has twins

Silver-haired Bat -- *Lasionycteris noctivagans*
- 10-12 inch wingspan
- Found in TN in the winter and during Fall/Spring migration
- Summer roosts in Northern States and Canada under loose bark, in tree hollows, or abandoned bird nests
- Hibernates in buildings, caves, mines, rock crevices, and hollow trees
- Has one or two pups

Brazilian Free-tailed Bat -- *Tadarida brasiliensis*
- 11-14 inch wingspan
- Summer roosts in building behind shutters and in attics
- Not known to hibernate and is probably rare or accidental in TN
- Only has one pup per year

Bats and Rabies
The Tennessee Naturalist Program encourages participants to appreciate, respect, and conserve nature. However, in some instances caution should be exercised. That is the case with bats. Bats, like all mammals, can carry rabies, but please keep the following facts about rabies in mind to keep things in perspective.

• NEVER PICK UP OR HANDLE A BAT OR ANY OTHER WILD ANIMAL. A BAT ON THE GROUND IS A SICK BAT!
• You will feel it when a bat bites you, but some people (like small children) may not be able to communicate that a bite has occurred.
• A bite may not look serious and may not be visible, but it is just as serious as a dog or raccoon bite and medical attention should be sought.

Rabies Reality Check -- About one person a year dies from rabies in the United States. The chance of getting rabies is less than one in 200 million, and less than 0.5 percent of bats carry
rabies. A person is more likely to be killed by a dog, a bee sting, lightning, or a power mower than by rabies.

**Bats and White-nose Syndrome**

White-nose Syndrome (WNS) is another disease that is affecting bats. WNS is not contagious among people, but it is having a devastating affect on cave bats. This is what biologists know so far.

- The disease was first discovered in New York in 2006 in Howe cave.
- Over 90 percent mortality occurs at many affected sites.
- All six northeastern cave bat species have been affected.
- In total, over one million bats have died.
- It is spreading rapidly and behaves like a pathogen.
- There is no evidence of bacterial, viral, or parasitic cause.
- A specific fungal infection is common to affected sites – *Geomyces destructans.*
- Susceptibility may differ by bat species or with microclimate.

**What you can do to help Tennessee's cave dwelling bats**

- Report bats with White-nose Syndrome symptoms
- Report dead bats outside of caves to TWRA, especially in winter
- Practice clean caving
- Stay out of closed caves
- Spread the word

**Additional Resources on Bats**

- TN Bat Working Group (www.tnbwg.org)
- Bat Conservation International (www.batcon.org)
III. Owls of Tennessee

Owls in the Family Strigidae

Eastern Screech Owl (Megascops asio)
- Identification: Small (8.5”), tufted owl (though tufts not always erect), with red and gray color phases, weight 6 oz
- Habitat: Varied; open woods, edges, suburban areas, riparian areas
- Voice: Descending “whinny” or monotone trill. Whistle-like communication call is given around young owls.
- Common Prey: Small mammals including bats, birds up to the size of a Woodcock, snakes, lizards, frogs, salamanders, insects, snails, spiders, scorpions, and earthworms.
- Finding: Readily responds to imitations of its call. Riparian habitat with Sycamores and railroad right of ways are often used by screech-owls.
- Nesting: Courtship begins in late winter, nests in spring. Young owls may be found in May and June. Young owls “branch” in groups along limbs. Begging call is short scratchy call. Adults make a whistle-like communication call around young owls.

Barred Owl (Strix varia)
- Identification: Large (21”) gray to gray-brown owl with rounded head and no ear tufts. Eyes are very dark brown. Barring on chest contrasts with streaking on belly. Weight 1.6 lbs
- Habitat: Mature woods; elevation ranges in TN from the shores of the Mississippi in the west to Clingman’s Dome in the east.
- Voice: Strident “Who cooks for you – Who cooks for you-all” with many other shrieks, whoops, and cackles.
- Common Prey: Wide variety of small mammals, amphibians, lizards, snakes, fish and insects.
- Nesting: Nests in early spring; young give raspy, upward slurred “begging” call.

Great Horned Owl (Bubo virginianus)
- Identification: Large (22”) tufted owl, rusty brown. Face shape is rectangular. Ear tufts give it a cat-like silhouette. Weight 3.1 lbs
- Habitat: Varied; many seen in open farmland habitats, but can be found almost anywhere in Tennessee.
- Voice: A low soft series of “hoos,” typically Hoo  hoo-hoo-hoo  Hoo  Hooo. Much calling in autumn, as this is their courtship period.
- Prey: Great Horned Owls have tremendous variety in their diet. They may eat anything from insects to mammals as large as skunks and woodchucks or birds as large as Canada Geese.
- Nesting: Our earliest nester, can be on the nest in late January. Great Horned Owls nest in old nests of Red-tail Hawks and other raptors, cavities in trees, and the top of dead stubs. Young owls make short scratchy “begging” cry which continues well into the fall. Young owls jump and exercise their wings in the nest. Adults make a short “squawk” around young.
Owls in the Family Tytonidae

Common Barn Owl (*Tyto alba*)
- Identification: Medium sized (15”), heart-shaped facial disk. These beautiful owls are white beneath and cinnamon above. They have long legs and dark eyes.
- Voice: A hissing shriek mixed with various clicks.
- Distribution: Barn Owls are more common in West Tennessee.

Uncommon or Rare Owls in Tennessee

Short-eared Owl -- *Asio flammeus*
- Winter resident of wet grassy fields, 15”

Snowy Owl -- *Bubo scandiacus*
- Rare visitor – most visiting birds are first year birds. Snowy Owls are our largest owl, 23”
- Harry Potter fans will recognize this species as Hedwig, Harry’s owl.

Long-eared Owl -- *Asio otus*
- Uncommon winter visitor – found roosting in pine grove, 15”

Northern Saw-whet Owl -- *Aegolius acadicus*
- Uncommon winter visitor and migrant. Found roosting in conifers. The Northern Saw-whet is Tennessee's smallest owl at 8 inches.

Owl Adaptations
- Owls can hunt in one-tenth the illumination a human requires to see anything at all. Barn Owls have demonstrated the ability to catch prey in complete darkness. Owls have eyeballs that are shaped like tubes which flare out to the retina. This allows room for a pupil and lens which are proportionately much larger than in a similar-sized globular eye. Because of the tubular shape, an owl cannot move its eyes in its sockets. In order to see objects not directly in front of it, an owl has to turn its head. Owls have seven more vertebrae in their necks than humans and can turn their heads 270 degrees. An adaptation of the neck's blood vessels ensures that this does not impair circulation.
- Owls like the Northern Hawk Owl can hear small rodents moving and feeding beneath the snow and can capture prey by “plunge hunting” through the snow. Owls have one ear opening higher than the other. This vertical asymmetry allows owls to accurately triangulate the position of their prey. The silent flight of owls gives them stealth to catch prey but also allows them to hear their prey as they glide in for a capture. The leading edges of owl flight feathers are fluted allowing air to pass through and therefore not create noise.
**Owls and Night Hikes**

Leaders of night hikes often imitate the calls of owls. Because owls are territorial, they fly closer to check out the intruder. This encounter is somewhat of a stress on the owl and should not be done too often and should not be done during the nesting season.

Young owls – Owl parents often feed young owls long after they have left the nest. Sometimes these young owls are on the ground. People who mean well sometimes pick these owls up and take them to wildlife rehabilitators. If these young become imprinted on humans, they will never be released back to the wild. If you see an owl on the ground and it is not in immediate danger, leave it alone. The parents are still caring for it.
IV. Sounds and Sights of the Night

The Frogs and Toads of Tennessee
Tennessee has 21 species of frogs and toads. They are mostly nocturnal, but can sometimes be heard calling during the day. To learn more about our anuran species, please look at the TNP Amphibians and Reptiles of Tennessee Enhanced Study Guide. To learn the calls of the frogs and toads, listen to the TAMP (Tennessee Amphibian Monitoring Program) CD provided. To hear and see all 21 species of Tennessee frogs and toads, visit the Leaps website -- http://www.leaps.ms/.

Insect Sounds
On night hikes and twilight hikes, naturalists will hear a variety of insects, including crickets, katydids, and cicadas.

Periodical Cicadas
13-Year (three species) and 17-Year (three species)

Katydids
True Katydids (Genus Pterophylla)
False Katydids (Genera Amblycorypha, Microcentrum and Scudderia)
Meadow Katydids (Genera Conocephalus and Orchelimum)
Coneheads (Genus Neoconocephalus)

Northern True Katydid (Pterophylla camellifolia)
Calls from high in the canopy mid to late summer, a raspy, “ka-ty-did” or just “did-did.”
Length: 1.3 – 2 inches

Oblong-winged Katydid (Amblycorypha oblongifolia)
Calls from shrubby vegetation mid to late summer, a raspy note that sounds a little like a match being struck. Length: 1.3 – 2 inches

Robust Conehead (Neoconocephalus robustus)
Typically makes its long, raspy calls from a head-down position along a grass stalk in mid to late summer. Length: 2 – 3 inches

Nebraska Conehead (Neoconocephalus nebrascensis)
Raspy notes approximately 1.5 – 2 seconds long, with a short space between notes. Can be heard mid to late summer. Color phase may be light brown or green. Length: 1.75 – 2.25 inches.
Resources for insects and insect songs

*The Songs of Insects*, by Lang Elliott and Will Hershberger (Houghton Mifflin)

Beautifully written with many spectacular images, this book includes an audio CD and detailed range maps. It was a real bargain for $19.95 and is now available from Amazon for less than $14.00.

Songs of Insects -- http://www.songsofinsects.com/

Another great reference from Lang Elliott and Will Hershberger.

*Crickets and Katydid, Concerts and Solos*, Vincent G. Dethier (Harvard University Press)

In this book, Vincent Dethier writes of his experiences in the 1930s working as a field assistant gathering insects so that their songs could be recorded and analyzed. Currently out of print, new and used copies are still available online. This is an inspiring book and one of our favorites.

Singing Insects of North America -- http://entnemdept.ufl.edu/walker/buzz/

A terrific online reference.

**Bioluminescence**

Bioluminescence is the production and emission of light from living organisms. These organisms contain a luciferin, small organic molecules that can emit light. With one of the enzymes called luciferase acting as a catalyst, luciferins undergo oxidation in the presence of oxygen to release energy in the form of light. This release of energy generates little to no heat and is termed "cold light" because the biochemical reactions are very efficient. Many marine animals (such as fish, jellyfish, crustaceans, and dinoflagellates or plankton) and some fungi (known as foxfire), bacteria, and terrestrial invertebrates are bioluminescent.

Fireflies -- Tennessee has many species of firefly beetles. Each gives a different flash code to attract a mate. Male fireflies fly through the woods or fields flashing their identity in search of a mate. Female fireflies wait on vegetation or the ground. When the female sees the flash of her species, she flashes a code back. Larvae and sometimes eggs glow as well to caution predators against their bad taste. Fireflies require two additional substances - calcium and adenosine triphosphate (ATP) - to produce their light. Not all fireflies produce light. Western species use pheromones as signals.

*Photinus pyralis*, the common eastern firefly, creates a single, slightly sustained flash of yellow-green light in flight producing an upward "J" shape. It prefers a more open habitat and is the familiar firefly in backyards at dusk.

*Photinus carolinus* is the famous synchronous firefly of the Smokies. It produces multiple quick flashes (5 to 8) followed by about 10 seconds of darkness. When one beetle begins to flash, they all start flashing and stop at the same time. They are found in hardwood forests near creeks or rivers after dark.
*Phausis reticulata*, blue ghost fireflies, don't really flash. These tiny beetles sustain a faint, but steady bluish glow that continues for 30 seconds or longer followed by a brief pause. They fly low to the ground in moist forests near streams in the southeast after dark.

*Photuris* spp. are larger beetles and predatory. Females mimic the flash responses of other species' females to attract unsuspecting males and eat them. Males of the genus produce a series of single flashes of white light reminiscent of a flash bulb. They favor more open areas.

**Fungi** -- Known as foxfire, a small number of fungi are bioluminescent and can be seen in optimal conditions on very dark nights. The mycelium or vegetative body of the honey mushroom, *Armillaria mellea*, is bioluminescent. In the forest, the strands of mycelium may be uncovered to emit a glow. Two other fungi, *Panellus stipticus*, bitter oyster, and *Omphalotus illudens*, jack-o'lantern mushroom, are also bioluminescent, glowing from the gills of the fruiting body.
V. Astronomy

Of course, you can’t talk about nocturnal excursions and interests without exploring the vast and exciting realms of astronomy. You don’t have to have expensive equipment to get started in astronomy. A first step is learning some of the brighter and more recognizable constellations, and learning the locations of the brightest stars in the sky. Then you can work your way out to the fainter surrounding areas.

A good reference to start with is the *Peterson Field Guide to the Stars and Planets*. You can also go to the Leaps website, where each month’s star map is available on the *Natural Calendar* pages. Follow each constellation through the seasons. Watch how they “move” across the night sky. A constellation can look very different when it is setting in the west than when you first learned it in the eastern sky. You may also choose to invest in a Star Wheel such The Miller Planisphere. These are available at most outdoor stores.

At first, sky phenomena might pique your interest. Here are some naked eye sky phenomena to look for.

**Halo phenomena** – Halos form around bright objects and are caused by light refracted and reflected by water droplets or ice crystals. A common halo is the 22 degree halo that forms around the Sun or Moon. You can measure 22 degrees by placing your thumb over the Sun or Moon with your fingers separated as widely as possible at arms length. The tip of your little finger will touch the halo. Colorful circumzenithal arcs can sometimes be seen directly overhead on days with wispy cirrus clouds.

**Aurora** – We have experienced the Aurora Borealis or the northern lights in Tennessee! On November 5, 2001, the skies to the north glowed an eerie red, orange and green in Franklin, TN. The northern lights are the result of collisions between molecules in the Earth's atmosphere with charged particles in the solar wind. Variations in color are due to the type of gas particles that are colliding. The connection between the Northern Lights and increased sunspot activity was first suspected around 1880. To learn more visit Northern Lights Center -- http://www.northernlightscentre.ca/northernlights.html.

**Comets** – Comets are always fun to observe. To see comets well, leave the lights of the city and find the darkest skies possible. Otherwise light pollution (sometimes referred to as the ‘aurora commercialis’ by amateur astronomers) will wash out the sky and decrease your ability to see comets, stars, galaxies, and other celestial objects. Bright comets we have seen include Comet Hale Bopp (1997), Comet Holmes (2007) and Comet Lulin (2009).

Other sky astronomical phenomena include lunar eclipses, such as the one in February 2008.
Moon

The moon is always a spectacular object to view, especially with children. Here is a simple chart to help you learn the phases of the moon.
Telescopes

Telescopes are of three basic optical designs – refractors, reflectors and catadioptrics. The best telescope for you is the one that you will use the most. Large scopes may not be best for a general audience as program participants’ expectations often exceed what the atmospheric conditions allow.

Aperture: A 6-inch aperture or an 8-inch aperture is a good starting point. This is also a good size for astronomy programs. The ability of a telescope to resolve fine detail is proportional to the aperture of the telescope. The ability of a telescope to gather light is proportional to the square of the aperture. Theoretically, any telescope can achieve any power – the highest useful power is around 30X – 60X per inch of aperture.

Dobsonian reflecting telescopes allow large optics to be very transportable. These telescopes excel for faint objects like galaxies and star clusters, and for planetary imaging.

The following are types of astronomical objects that one can observe with a telescope under a dark sky: Earth’s moon, planets, Messier objects, Emission Nebulae, Open Star Clusters such as the Pleiades (also known as the Seven Sisters), Globular Clusters, Galaxies, and Supernovae.

Know your telescope. Assemble your scope for the first time in daylight. Line up the finder scope in the daylight.

Always practice with a scope before giving a program to a group of people. Make sure that all fittings and accessories are present. Explain the basics to a group – planets are small and far away, they will appear small in the eyepiece – most deep sky objects won’t show color.

Star Gazing Tips

- Learn the brightest stars and constellations first.
- Learn to locate the North Star, also called Polaris, to give you a sense of direction.
- Avoid light pollution. Find dark skies.
- Use averted vision – look to the sides of faint objects. This allows the light to fall on the rod cells in your eye, making them more visible.
- Use a good pair of binoculars to find faint stars and clusters.

Additional Nocturnal Resources
Tennessee Wildlife Resources Agency, Tennessee’s Watchable Wildlife
http://www.tnwatchablewildlife.org/
Star Lore

The following constellations, asterisms, and other interesting stars are easily viewed in our area, and their associated Greek (or other culture) stories are fun to share with groups of children and adults alike. This list is divided based on easy seasonal viewing at approximately 9:00 p.m. central time in Tennessee. Please refer to a star chart or field guide for finding them in the field.

Important Words to Understand

- Horizon – Also called skyline, it’s the apparent line that divides the earth and the sky.
- Zenith – an imaginary point directly above any given location. When stargazing, it’s the point directly overhead.
- Elliptic – the apparent path of the Sun in the celestial plane.
- Zodiac – a belt of 12 divisions with constellations that correspond closely with the elliptic.

Constellations versus asterisms

There are 88 officially recognized, Greek-based constellations in the northern and southern skies. Asterisms are like constellations as they are pictures created from groupings of star patterns, but are not officially recognized by the International Astronomical Union (IAU). The most commonly recognized asterism in the US is the “Big Dipper,” part of the constellation Ursa Major.

Fall and Winter Skies of Tennessee

Orion and Nearby Stars and Constellations

Seen traversing from the east to west when facing south, Orion may be one of the most recognizable constellations, as it can easily be seen (at least his belt) even among the brighter city locations. His famous belt is spotted right away. Looking at Orion, on the right, he is holding what some call a shield and others say is a lion’s pelt. In his other arm, he draws a sword above his head. His bright red shoulder is the star Betelgeuse (pronounced BET-el-jooze, rather than Beetle Juice), a red supergiant. His other shoulder is the star Bellatrix, and his lower left knee is Rigel. Lepus, the rabbit, is at his feet while his two hunting dogs, Canis Major and Canis Minor, follow behind. At the bottom of
the hanging part of Orion’s Belt, The Great Nebula can be seen by the naked eye, and even better with binoculars.

In one story, he was placed in the sky by Artemis who loved him but was tricked into shooting him with one of her arrows. He was swimming in the sea and Artemis was dared to hit the “spot,” which she didn't know was Orion. When she learned of his death, she was so distraught she asked that he be placed in the heavens as stars.

Back to Orion’s Belt, follow the belt toward the horizon and eastward and you will find Sirius, the brightest star in the sky (of any season). Sirius is the nose of Canis Major, the big dog and one of Orion’s hunting companions, always at his side. Just above Canis Major are two stars that make up Canis Minor, the little dog. Procyon is the brighter star in Canis Minor.

Just above Canis Minor looking higher toward the zenith, you should find the twin stars, Gemini. The stars for their heads are based on the Greek names they were given, Castor and Pollux. Castor and Pollux were inseperable twins, but Castor was mortal like his mother and Pollux was immortal like his father. Castor died in a battle and Pollux asked their father if he could spend half of each day with Castor in the Underworld and if Castor could come to Mount Olympus among the Gods for the other half of the day. Eventually Jupiter honored the twins by changing them into stars to commemorate brotherly love forever.

From Orion’s Belt looking west you’ll find Taurus the Bull, with his V-shaped head. A bit further out you will find a cluster of stars called the Pleiades, Subaru, or the Seven Sisters. In one story, Orion fell in love with one of the Seven Sisters and upon meeting the rest, desired to marry them all. Some of the Seven Sisters were already wooed by Zeus, who was not pleased to hear of Orion’s plans. To prevent Orion from ever reaching them, he placed Taurus the Bull in between Orion and the Seven Sisters. Taurus’ bright red eye star is the red supergiant Aldeberan. The Seven Sisters cluster is actually located in the abdomen of Taurus.
Northern Star Hopping

Looking at the northern sky, you’ll find Ursa Major, the Big Bear, by finding the Big Dipper. With the Big Dipper you can also find the North Star, Polaris. Polaris is the fiftieth brightest star in the sky and has been very useful in navigation. Sailors and travelers have long used the stars to find their way. During the years of slavery in the United States, countless people were able to escape slavery by following the stars to make their way to the North to become free. The big dipper has also been called a “drinking gourd,” a cup carved from a long gourd use to fetch water from a bucket. *Follow the Drinking Gourd* is the name of the song that was used to help people remember how the stars guide them, as well as give them places to hide during the day, and other navigational cues. There are books and lesson plans based on this that can be looked into for further study.

To easily find the North Star, you first find the cup of the drinking gourd. The two stars at the outside edge of the cup are called Merak and Dubhe and they can be used as “pointers” as they point you in the right direction. Raise a closed fist to fit between these two stars, follow out from the open side of the cup the length of “four fists and a little more” and just on the other side of your fist you will find Polaris. No matter what place the Big Dipper or Drinking Gourd is in the sky, you can always find Polaris this way. Since Polaris is the star that is exactly above True North and the north axis from which the world turns, it will always be in the same place in the horizon from your latitude.

With the same angle you used to find the North Star, you can continue in the direction you traveled to find the middle star of Cassiopeia. Cassiopeia is also known as the Seated Queen. She looks like a “lazy W” in the sky. Her daughter Andromeda is the next constellation over from the backside (not the open side) of the “W.” A famous Greek story joins these two and several other constellations in this area.
Cassiopeia was a rather narcissistic queen who often bragged of her beauty. She had the nerve once to say that she was more beautiful than any of the sea nymph maidens, and when they heard that she had said this, the sea nymphs requested that she learn her lesson. The sea king Neptune sent Cetus, the sea monster (also another constellation), to terrorize the shore of the country that Queen Cassiopeia and King Cepheus (another nearby constellation) ruled. This was a huge problem, and King Cepheus cared for his people, thus he went to see an oracle about how to get rid of the sea monster. The oracle said he must sacrifice his daughter, Andromeda, to avenge the maidens who were insulted. Andromeda is pictured in the sky chained by her wrists to the rocks of the shore.

Cetus discovered his offering and began to approach from far out in the sea. Andromeda became very distressed and called for help. As Cetus grew closer, Andromeda began to yell and scream and shake her chains. It just so happened that Perseus, another nearby constellation, was flying over on his winged horse Pegasus, also in the sky nearby. Perseus had just finished slaying the evil Medusa, the woman with snakes for hair and who would turn anyone to stone if they looked at her face. He was carrying Medusa’s head in a bag.

When Perseus heard the cries of the young maiden, he looked out to find Cetus approaching quickly in the sea and the people of their kingdom frantically panicking, he had Pegasus swoop down quickly to fight the sea monster. He drew his sword but could not get close enough to Cetus without being hurt. Thinking quickly, he yelled to Andromeda to cover her face, and he brought out the head of Medusa and held it up to face Cetus. Cetus took one look at the face of Medusa, and turned to stone and sank. Perseus flew back and released Andromeda. The people of the kingdom cheered as the two rode off together on Pegasus.

Since the sea nymphs were not avenged, Cassiopeia was placed in the sky to be punished by being turned upside down for half of every night, as you may notice Cassiopeia’s throne in different positions throughout the night. Having to hang there in a compromising position is a humiliating punishment for a queen who is so boastfully proud of her beauty.
Northern Star Hopping, Part 2

Looking north again, you can find Ursa Major and the asterism the Big Dipper. You can use the handle of the dipper as pointer stars to lead you to a few other stars and constellations. Following the curve of the handle, you continue in that direction and “arc to Arcturus.” Arcturus is the brightest star found in the constellation Boötes. Boötes was a hunter, and Arcturus is part of his waist. He is following Ursa Major with his hunting dogs to make sure the bear stays in his place.

From the star Arcturus and continuing along the same curve from the handle of the Big Dipper, one can “speed on to Spica.” Spica is the next brightest star you will come to and is a blue giant. Spica is the fifteenth brightest star and is located in the constellation Virgo.

Virgo had a daughter who was kidnapped and taken to the underworld. Because Virgo was the Goddess of farming and growing plants, she allowed nothing to grow as she mourned her daughter’s disappearance. Pluto, the kidnapper, was ordered to return Virgo’s daughter, but because she had eaten some seeds of the underworld she could not completely return. The problem was fixed as Jupiter, one of the Gods, worked out a compromise. He allowed mother and daughter to be together for half of the year. During this half of the year, Virgo shines brightly and crops grow well. During the other half of the year, her daughter must return to Pluto and the underworld and Virgo is lonely and the world becomes cold, dreary, and no crops grow.
Spring and Summer Skies

Animals to the South and West
As spring rolls in, Leo grows higher in the sky along the zodiac line as he makes his way to the western horizon by the early evening hours of late summer. Leo the lion can be found easily as the backwards question mark, which is also an asterism known as a sickle. The brightest star in Leo is at the bottom of the question mark and is called Regulus. Regulus was considered by ancient astronomers as a ruler star that kept the other stars in proper order.

In summer, Scorpius the scorpion appears where Orion would be seen in the sky. When Orion is high in our view, Scorpius is on the direct opposite side of the Earth. When Scorpius appears, it remains close to the horizon from spring to the end of summer. On occasion, the rich fields of the Milky Way stretch through the scorpion. It looks like his claws come up wrapping equally around the head of Scorpio, but the curling star pattern to his west is actually Libra, the scales. Antares, the bright red heart of Leo, translates to Rival of Mars in Greek. The Romans called this star Cor Scorpionis, “heart of the scorpion,” and the French also use Le Coeur de Scorpion. The Chinese saw it as the “Great Fire.” In some stories, it is the Scorpion that killed Orion. In others, it was by the arrow of an accidental shot from the tricked Artemis.

Libra to the west was considered a part of the scorpion in middle-eastern cultures. The scales were seen as claws, which is still easy to imagine, and two of the stars in Libra still have Arabic names meaning claws. Libra in the Greek stories is the “scales” of Themis, the Greek goddess of justice.
Look Up!

In summer, there are three bright stars in three different constellations near the evening zenith that make up the asterism called the “summer triangle.” These constellations include Vega in Lyra the lyre, Deneb in Cygnus the swan, and Altair in Aquila the eagle. Vega in Lyra is one of the brightest stars in the summer sky. Aquila was identified as an eagle by the Arabs, and the Greeks say the eagle belonged to Zeus.

Cygnus is known to many in the US as the “southern cross.” If the Milky Way is visible, you may see it divide into two streams here. There is a dark nebula at the beginning of the division. Some say the swan is in the sky because it loved the music of the lyre and flew to be near it. Because the brightest star is in the tail of the swan, it is called Deneb meaning tail in Arabic.

In a Galaxy Not Far Away

The Milky Way is a spiral of stars with a bright point of radio emissions at the heart. The glowing center is not our sun. In fact, there are other planets and suns within our galaxy, but seeing these, even with telescopes, is very difficult due to clouds of dust and gas. The sun is only the center of our own solar system, and our sun is about 30,000 light years away from the center of our galaxy. On nights when our axis is tipped to look out across the flat Milky Way arms, we can see the star clouds easily. In Greek mythology, Juno was feeding her son Hercules, and droplets of milk floated upwards to the sky and became the stars of the Milky Way Galaxy. When our axis is such that we do not look out across this plane at night, we have the clear evening skies.

Resources

Skymaps.com -- free, printable current monthly map and sky calendar
Stellarium.org -- online and downloadable planetarium. Real-time data and easy-to-use format makes knowing what’s in the sky tonight fun and simple.

Books

Proctor (1972) Star Myths and Stories from Andromeda to Virgo
VIII. Review Questions

1. Less than _____ percent of bats carry rabies.
   a. 0.5
   b. 25
   c. 5
   d. 10

2. Bats are in the order ____________ which means hand-wing.
   a. Rodentia
   b. Carnivora
   c. Chiroptera
   d. Lepidoptera

3. Northern True Katydids call from
   a. low shrubs and thickets
   b. high tree canopy
   c. grasses
   d. house basements

4. When should you not attempt to call in an owl?
   a. in the morning
   b. at midnight
   c. during the nesting season
   d. July

5. What should you do if you find a young owl on the ground?
   a. Feed it.
   b. Capture it and take it to a rehab facility.
   c. Put it back in the tree.
   d. Leave it alone.

6. Owls have seven more vertebrae in their necks than humans and can turn their heads 270 degrees.
   a. true
   b. false

7. Another name for the North Star is ________________.
   a. Arcturus
   b. Polaris
   c. Vega
   d. Spica
8. The Seven Sisters and Subaru are another name for which asterism?
   a. The Bee-hive Cluster
   b. The Big Dipper
   c. The Little Dipper
   d. The Pleiades

9. One of the biggest challenges with stargazing near cities is the occurrence of ______ pollution.
   a. noise
   b. air
   c. light
   d. water

10. When trying to see a faint star or other object in the night sky you can make it more visible by looking ________.
    a. directly at the object.
    b. to one side of the object.
    c. through 3D glasses.

11. The ability to distinguish color _________ at low light levels?
    a. increases
    b. decreases

12. To protect night vision, flashlights should be covered with
    a. a red filter
    b. cheesecloth
    c. fingers, slightly spread
    d. a blue filter

13. The phenomenon of eye shine is caused by
    a. the eye’s iris
    b. the eye’s cornea
    c. the eye’s tapetum lucidum
    d. the eye’s retina

14. The protein that contributes to bioluminescence in organisms is
    a. lignin
    b. luciferin
    c. lumen
    d. lucidulum
15. The moon phase immediately after a full moon is called
   a. waning crescent
   b. waxing gibbous
   c. waxing crescent
   d. waning gibbous

Answer Key
1. a   2. c   3. b   4. c   5. d   6. a   7. b   8. d