What you may not know about...

Moths

Scientific classification
KINGDOM: Animalia
PHYLUM: Arthropoda
CLASS: Insecta
ORDER: Lepidoptera

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At roughly 160,000, there are nearly ten times the number of species of moths compared to butterflies, which are in the same order. While most moth species are nocturnal, there are some that are crepuscular and others that are diurnal. Crepuscular meaning that they are active during twilight hours. Diurnal moths are active during the day.

It is very difficult to differentiate moths from butterflies at a glance because they physically resemble each other very closely. There are two ways to distinguish a moth from a butterfly; behavior and anatomy.

BEHAVIOR

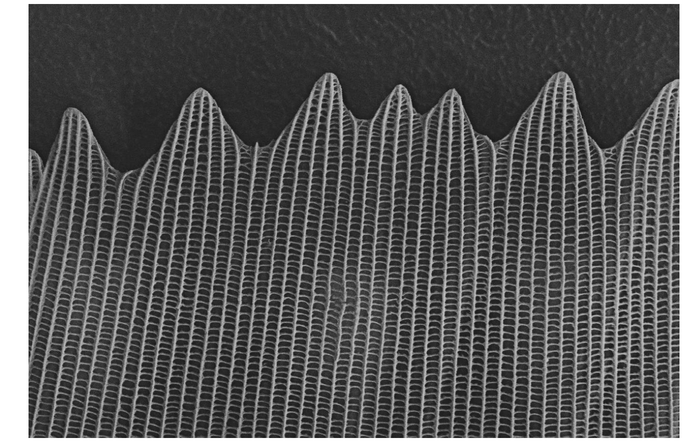
The main way to know if you are looking at a butterfly or a moth is whether it is day or nighttime. Butterflies are only known to be diurnal insects and moths are mostly nocturnal insects. So if the sun is out, it is most likely a butterfly and if the moon is out, it is definitely a moth.

A subtler clue in butterfly/moth detection is to compare the placement of their wings at rest. Unless warming themselves, butterflies hold their wings upright and folded together, perpendicular to their backs. Most often moths will be found resting with their wings draped down their backs or spread out to the side.

ANATOMY

Moths frequently have antennae that are feathery. Butterflies have slim antennae that are wider at the tips, which resemble clubs. Some species of moths have thin butterfly-like antennae but they lack the club ends.

above: scales on moth wing, shot at 2x



above: SEM image of individual wing scale, 1500x

Moths utilize a wing-coupling mechanism that includes two structures, the retinaculum and the frenulum. The frenulum is a spine at the base of the hind wing. The retinaculum is a loop on the underside of the forewing. This mechanism connects the forewing to the hind wing. Butterflies also have fore and hind wings, although they lack this wing-coupling mechanism.

WINGS

Moths are in the order lepidoptera, which is latin for 'scaly wing'. Moth wings are constructed of thin layers of a protein called chitin. The chitin is covered with thousands of tiny scales, many smaller than .25mm wide. Some types of scales have chemical pigments that produce brilliant colors. Other types are comprised of microscopic ridges and bumps that reflect light in various angles that create iridescent coloring.

It is common for moth wings to have patterns that are not in the human visible light spectrum. Moths have the ability to see in ultra-violet wave lengths. Ultra-violet wing patterns occur more in nocturnal lepidoptera. Birds often utilize their ability to perceive ultra-violet light in search for prey. The lack of ultra-violet wing patterns in crepuscular and diurnal moths assist in attempts to avoid predation. Reflection of ultra-violet light in moth wings is usually associated with the colors in the human visible spectrum like white, blue, and yellow, while dark colors more often abosrb ultra-violet light.

MIMICRY

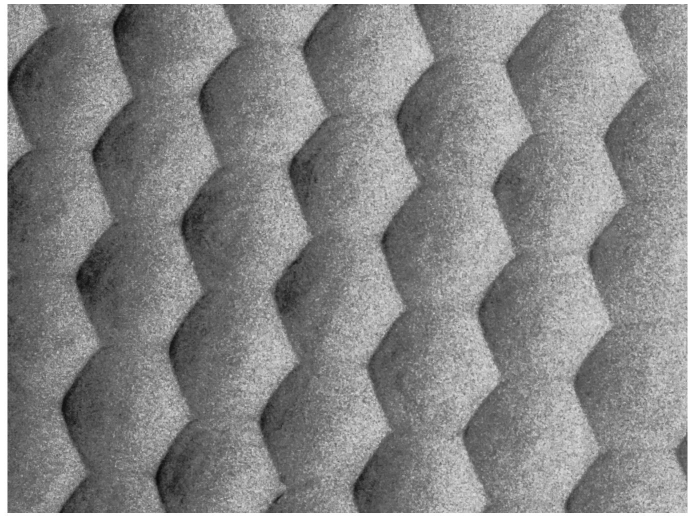
The *Sphingidae* species of moths may be the most gifted in their ability to mimic other organisms. Hemaris diffinis, or Snowberry Clearwing moth (center picture), has evolved to closely resemble a bumble bee. The Snowberry clearwing moth gets its name because it loses the scales on its wings shortly after the pupa stage due to its highly active flight behavior. This moth hovers over flowers in full, creating a buzzing sound with its wings, much like that of a hummingbird. They use their long proboscis to feed from nectar-rich plants, such as snowberry and honeysuckle.

Another *Sphingidae* species called the Dead-Head Hawk moth uses the mimicry of bees to its advantage. They enter a hive whilst producing specialized squeaks that sound a queen bee. Disguised as a queen, the Dead-Head Hawk moth absconds stolen honey away from the hive.

The Bee Hawk moth has also adapted to mimic bees in appearance. If potential predators believe that they can defend themselves with stingers, they will be less likely attacked.

Other species of moths also use sound to avoid predation. Bats are one of the top predators of moths. They utilize echolocation to pinpoint prey in the dark by emitting high-pitched squeaks that reflect off the moth. The sound wave then passes back to the bat's ears, allowing the bat to estimate the distance the wave travelled.To counteract this, many nocturnal moths have evolved ear-like organs which can pick up the sound waves emitted by bats. Their nerve cells are so highly tuned that the displacement of the eardrum the size of an atom will activate the ear. Low frequency background noise that is harmless is ignored and leaves the ears tuned to the important ultrasonic echolocation sound waves of predators.

above: compound eye, shot at 2x



above: compound eye, SEM topographical backscattered image, 500x

EYES

All Lepidoptera have compound eyes. Butterflies have apposition compound eyes, while moths have superposition compound eyes.

In a superposition eye, light reaches photoreceptors called rhabdom through several facet lenses. Rhabdom are transparent, crystalline receptive structures that lie beneath the cornea that occurs in the central visual unit of the compound eye. They are rod-like and consist of interlocking microvilli. Rhabdom contain pigment cells of various kinds that act to regulate the amount of light that is received. Light rays pass through a transparent cone which converges the rays onto the tip of the rhabdom.

Rhabdom are capable of resolving the wavelength and plane of polarization of a light ray. Photons can only be detected if the light-sensitive area of the photopigment molecule is on the same plane of polarization of the photon.

Superposition compound eyes are composed of ommatidia (single simple eyes), where a facet lens and crystalline cone form the imaging optics. Several facets join to relay incident light to a rhabdom, thus making them more sensitive to light than the apposition compound eyes of butterflies. This ability allows the mostly nocturnal moth to navigate in the dark with ease.

Refractive index gradients in the crystalline cones causes the redirection of incident light. Spherical eye shape combined with well focusing crystalline cones in equal sized ommatidia in all eye parts results in the same spatial acuity throughout the compound eye.

In conclusion, this information only strikes the surface of these complex and intriguing creatures. You can continue to find fascinating facts throughout this diverse order of insects.

Refernces:

1 - *http://www.mothscount.org/text/17/amazing_moths.html*
2 - *http://jeb.biologists.org/content/209/10/1904.long*
3 - *http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1560070/*
4 - *http://beheco.oxfordjournals.org/content/15/6/982.full*
5 - *http://science.howstuffworks.com/zoology/insects-arachnids/moth-versus-butterfly1.htm*