Bloodsuckers: Legends to Leeches

Descriptive Audio Tour

Stop 1 - Welcome & Learn to live with them

Welcome to the Royal Ontario Museum, and thank you for visiting *Bloodsuckers: Legends to Leeches*. I'm Doug Currie, the ROM`s senior curator of entomology, or insects. And I`m Sebastian Kvist, the curator of invertebrates —that is, animals without backbones—at the ROM. Together we curated the exhibition you are about to visit.

The word bloodsuckers might make you think of mosquitoes, leeches, or even vampires. This exhibition examines all of those. You'll learn how real animals evolved to feed on blood, their value to their ecosystems, and the ways they have inspired humans for millennia. As you explore both the science and culture of bloodsuckers, you will encounter stories from across disciplines and continents.

We hope that you enjoy the diverse and fascinating objects from the ROM's collections, and that you leave the exhibition feeling empowered and amazed. We can't promise that bloodfeeding pests won't bite you after today. But we can promise that you will understand why they do.

Are you ready to brave the bloody world within? Don't worry—there's no actual blood. Just the creatures who feast on it. Enter now and find the next stop to learn what makes blood so tasty.

Stop 2 – Blood 101

The first thing you need to know is this: blood is nutritious. Mammals, birds, reptiles, amphibians, and fishes all depend on this fluid to survive. It sustains us by providing nutrients and transporting oxygen throughout our bodies. Blood is mainly full of protein, which is also why bloodfeeders need it.

Really, they only need one part of it—the red blood cells, which carry most of the nutrition in blood. In front of you is a plastic model of red blood cells. The cells are smooth, round, and bright red, with a depression in the middle like a donut. Each model cell is about the same size and shape as a partially-deflated beach ball. That is about 50,000 times bigger than real red blood cells, which are too small to see without a microscope. This model includes over a dozen such cells, arranged vertically on strings and stretching about four metres high, as if they are floating through a vein. If you pause this audio guide, you might even hear the sound of blood pumping.

Below the model is a raised line diagram that you can touch. Go ahead and feel it. The diagram illustrates all of the components in blood. There are four main components—red blood cells, white blood cells, platelets, and plasma. The plasma is a liquid that brings nutrients to cells so they can function. It also helps the blood clot to heal from an injury. Platelets do this too, by joining together to form a clot and prevent blood from being lost. White blood cells are part of the immune system—they destroy invading organisms that cause infection or disease. Red blood cells carry oxygen through the body. They are made of protein, which is what makes them so valuable to bloodfeeders.

Vertebrate blood is missing one important component though—B vitamins, which all animals need to survive. Bloodfeeders have evolved a way to deal with this. They get these vitamins from bacteria that live inside their bodies. Without these microscopic bacteria, bloodfeeders wouldn’t be able to survive by eating blood alone.

To learn more about how certain animals have evolved to feed on blood, continue to the next stop in the exhibition.

Stop 3 – Evolution

In the evolutionary tree of life, dozens of branches include bloodfeeders. But they didn't all evolve from a single bloodfeeding ancestor. They can be traced back to six different groups – called phyla – that evolved bloodfeeding on their own. Since then, strategies for feeding on blood evolved independently along different branches—this is called convergent evolution. Today, there are dozens of groups that have evolved bloodfeeding, even after the ability was lost in some of them along the way. There must be something extremely beneficial about feeding on blood for it to have evolved so many times independently.

Black flies have lived on Earth for 145 million years, meaning that the earliest bloodfeeders probably fed on dinosaurs! In the case in front of you are some black flies that have been fossilized in amber from 45 million years ago. Each smooth piece of ancient amber is between 1 and 2 centimetres in diameter and glows with a translucent golden colour. Deep inside the amber is a tiny fly, no bigger than the head of a pin. They are so small, it's almost impossible to make out their thin, spindly legs or the menacing mouthparts on their round heads. The flies were trapped in sap from a tree, which solidified and hardened, encasing them for millennia. When studied under a microscope, it's clear that some of the flies have wider bellies than others, meaning they died with a stomach full of blood. But fans of a certain prehistoric movie franchise shouldn't get too excited—there's no blood left in these flies.

Just ask the ROM's curator of entomology, or insects, Doug Currie. He studies these fossils to understand the evolution of black flies and how the animals they feed on changed over time. To learn more about his research, launch the video beside the fossils.

When you're ready, continue through the exhibition and find the next stop in the section about feeding on blood.

Stop 4 – Feeding

Bloodfeeders must achieve three basic steps to get their meal—they have to find blood, they have to get to it, and then they have to keep the blood flowing. The strategies to accomplish this are intricate and innovative, and they aren't all the same. This diversity is one of the most fascinating things about bloodfeeders. So, how do they do it all? Let's find out. In front of you are two large models in cases—on the left is a larger-than-life mosquito head. On the right is the giant head and neck of a leech. Behind these are three tables illustrating the steps.

Step one: find blood.
Because blood is inside the body, it is difficult to sense. So bloodfeeders follow body temperature and chemicals emitted on breath and through skin to find a blood-carrying host. Bloodfeeding insects, like mosquitoes and black flies, have hairs on their antennae that contain receptors to sense these and other chemicals. Leeches have bumps on their bodies called papillae that also sense cues from a host, including water movement. Past the mosquito model, on the table to the left, there are two touchable models that illustrate these features—go ahead and touch them.

Step two is to get to the blood. This is the most variable part. Bloodfeeding animals bite, pierce, scrape, or saw through the skin. But overall, there are two main strategies. Some bloodfeeders insert their mouthparts into the skin to suck out the blood within, while others cut the skin's surface and allow blood to come out. Sounds painful, right? But several bloodfeeders possess mild pain killers in their saliva so the host doesn't feel the bite and the bloodfeeder can get away undetected.

Let's circle back to the two larger-than-life models we mentioned earlier. The mosquito head is about the size and shape of two basketballs placed side by side—that's more than 1,000 times life size! Real mosquito heads are less than a millimetre wide on average. Those two big lobes are its eyes. Extending up between them are two long, curved antennae. The feeding parts extend downward. A long, thin tube curves toward the front of the case as it reaches down to the floor. This is the mosquito's main feeding tube, called a proboscis. It has a protective

sheath that bends back to reveal separate needles within—these are what enter the skin to suck out blood. There are five in total, some with serrated edges to cut into the skin like blades.

Beside the mosquito is a leech, about 100 times larger than life. In reality, a leech's mouth is less than a centimetre on average, but this model is the diameter of a small car tire. The circular mouth is framed by a fleshy suction-cup rim, which the leech uses to attach to its host. When ready to feed, this rim pulls back to reveal three jaws, with hooked ends that point toward the middle. The jaws are arched like mounds and lined with hundreds of razor-sharp teeth. When feeding, these saw back and forth to cut the skin. Then the leech stays attached with its sucker and drinks up the blood.

Other animals have very different mouthparts. Lampreys are a type of bloodfeeding fish—they have hooked teeth arranged in circular rows around a sharp tongue that scrapes the skin. Vampire bats have fangs at the front of their mouths that pierce through skin. These teeth are so small that the host doesn't even feel the bite. Bloodfeeding flies like horse flies, deer flies, sand flies, and more, have mouthparts that slash skin in different ways. Then there are vampire snails, vampire moths, and proboscis-bearing leeches, which all have a single feeding tube that extends only when needed. You can feel large photos of some of them on the tables against the wall in front of you. While you're there, check out the videos that explain how a mosquito, leech, and black fly feed using their complex mouthparts.

The last step is essential—keep the blood flowing.
When skin is cut, the body starts a process called coagulation to clot the blood and heal the wound. Some bloodfeeders inject chemicals to interrupt this process so the blood keeps flowing. These are called anticoagulants, or blood thinners. It's a complicated process, where chemicals in blood react one at a time to produce a protein called fibrin, which clots the blood. At the same time, platelets bind with collagen to solidify the clot. Bloodfeeders have a variety of anticoagulants that attack different parts of the process. Some leeches, for example, are highly-specialized—they have 20 different blood thinners in their arsenal so they can drink until they get their fill.

When you're ready to continue exploring the exhibition, find the next stop in the section about the diversity of bloodfeeding species.

Stop 5 – Diversity

There are 30,000 different species of bloodfeeding animals. You've probably heard of vampire bats, mosquitoes, black flies, and leeches. But there are also fishes, birds, moths, snails, and others that survive on blood.

Bloodfeeding animals are found worldwide, on every continent and in every ecosystem. They live on land, in freshwater, and in oceans. Some are incredibly important for the ecosystem because they occur in high numbers and are vital food sources for birds, fishes, and mammals. The wall in front of you contains a small selection of these bloodfeeders. Each case highlights a different species. One is an oxpecker, a bloodfeeding bird with brownish-grey feathers, round eyes, and a beak that is half yellow, half dark orange. The oxpecker is shown feeding on the leg of a cow. This bird uses its beak to pick away at the skin of other birds and lap up the blood. Another one is a frog-biting midge, a tiny insect that follows the mating call of male frogs in Panama to find a host.

Behind you is an aquarium containing live lampreys. They are long and thin with fleshy grey skin that makes them resemble eels—but don't be fooled, lampreys are not eels! Each lamprey is about the length of a ruler and as thick as three fingers. They are attached to the glass of the tank with the suction cup rim around their mouths. Inside the pinkish mouth are circular rows of razor-sharp yellow teeth. Each tooth is a triangle about a millimetre wide, with a harsh, hooked end so the fish can attach to its host. The teeth get larger toward the middle of the mouth, where it has a tongue that is also covered in tiny, sharp teeth to scrape through skin. Lampreys use their fierce mouths to attach to other fish and suck out their blood. They feed on the same host for several months.

You likely won't have to worry about lampreys feeding on you, but what about mosquitoes? These flies are the most common bloodfeeder. In northern Ontario, mosquito populations can reach over 12 million individuals per hectare. Wonder what that feels like? Enter the room beside you to hear the buzz and conquer the dread. When you've had enough, continue exploring the exhibition and find the next stop in the room about vampires… if you dare!

Stop 6 – Folklore

Vampires are so ingrained in our world that we've named several bloodfeeding animals after them—there are vampire bats, vampire snails, and vampire finches. But *human* vampires? We all know those don't really exist. So where did the stories come from?

Behind you is a video that outlines the history of vampire lore. Feel free to enjoy it. What it boils down to is this—belief in vampires came from a fear of the unknown. It arose in eastern Europe in the 1700s, where the first documented vampires were villagers who had died of unknown causes. When their bodies were exhumed, people misinterpreted the natural process of decomposition. Bellies bloated with gas and blood at the mouths were taken as evidence of the corpses reanimating to feed on blood. Without scientific understanding, the legends spread.

Over time, hunting vampiric corpses became as real as the witch hunts in Salem, USA a century earlier. Villagers staked dead bodies into the ground, beheaded them, or burned garlic to keep suspected vampires away. The hysteria didn't end until Empress Maria Theresa of Austria dispatched a physician to investigate, and later passed a law to prohibit grave tampering. But the stories had staked their place in our imaginations. In western Europe, vampire superstition continued and gave rise to some of our most well-known characters.

Creatures that feed on blood appear in many cultures around the world. Some take the form of animals, while others are entirely supernatural. Each seems to stem from different fears of their time and place—like colonialism, otherness, greed, and infant mortality—and many act as cautionary tales, particularly for children.

In front of you is a life-sized model of a legendary Chupacabra. Stories of this bloodsucker emerged in 1995, when goats were found in Puerto Rico completely drained of blood with no evidence to explain what happened. Alleged sightings of a mythical creature called a Chupacabra, or “goat sucker” in Spanish, spread throughout Central America. It is described in many different ways. The sculptural model here is about the size of a large dog. It stands facing you on four crouched legs, as if ready to attack. Its gnarled face is bent down and to the side, with vicious teeth protruding over a wrinkled mouth. Its eyes glow red. Down its back, long spikes protrude up from a ratty greyish brown body. It is clear why people are so afraid of the legends.

Scientists have studied many animals that are claimed to be Chupacabras. Based on the size and description of the creatures in the stories, the examiners believe that the animal is actually a coyote suffering from mange—a skin disease caused by parasitic mites. Mangey coyotes experience severe itchiness, which leads to hair loss, scabs, sores, and lesions.

Can you separate the fact from the fiction? Continue onto the next stop in the section about bloodsuckers in pop culture to learn how vampires have been imagined in books, movies, and more.

Stop 7 – Pop culture

There is something about bloodfeeding that has inspired us for centuries. Vampires have appeared in literature, theatre, artwork, film, television, video games, comics, music, and even on cereal boxes. They don’t always have the same characteristics, but there are some standard types that we’ve come to know—vampires can be fearsome, they can be funny, some are charismatic, and some of them even sparkle.

Count Dracula has become the model for them all. Bram Stoker’s famous novel was published in 1897 and was the first time a vampire transformed into a bat, appeared without a reflection, and lived in Transylvania. The book in the centre of the case in front of you is a first

edition print of *Dracula*. It is about 13 centimetres wide and 20 centimetres tall. It is 390 pages long. The cover is bound in yellow fabric, which has worn to show its age. The title, *Dracula*, appears across the top in letters red like blood, although those too have faded over the centuries. The book is mounted open to the title page which reads “Dracula - by Bram Stoker – Westminster, Archibald Constable and Company, 2 Whitehall Garden, 1897”.

To your left is the face of the title character, Count Dracula. It is a life-sized bust of Bela Lugosi, who first portrayed Dracula on screen in 1931. His smooth skin contrasts against his slick black hair. His piercing blue eyes seem to stare into your soul under dark furrowed brows. His shoulders feature Dracula’s characteristic black tuxedo, white shirt, and off-white bow tie. But even more classic is the collar of the black cape that extends up toward his ears. This remains the iconic image of Count Dracula and, indeed, vampires. Even Lugosi’s silky accent has become a staple.

Dracula was first produced as a stage show in 1924, in London, England. It was adapted for Broadway in 1927 where Bela Lugosi starred in the title role. Tod Browning’s film followed in 1931, bringing Lugosi’s character to a worldwide audience. The original trailer is playing at the far end of this room, along with clips from other famous movies featuring bloodsucking creatures.

Our imaginations take bloodsuckers much farther than vampires, though. Mosquitoes are turned into comic book villains, ticks become crimefighters, and leeches are gargantuan monsters. When we see them in these imaginary roles, we find these pests thrilling! Could imagining them this way help us appreciate them in real life?

When you’re ready, continue to the next stop in the room about how leeches have been used in medicine.

Stop 8 – Bloodletting

Before the early 1800s, particularly in Europe, people believed that many ailments were caused by an imbalance of one of the body's four humours—blood, phlegm, yellow bile, and black bile. One treatment to rebalance them was to drain blood—this was known as bloodletting. It was done by applying leeches and letting them feed, or by piercing a vein with a small blade called a lancet and letting blood drain into a special bowl.

In the 1600s, bloodletting was performed by barbers, because they were skilled with blades. In fact, the iconic red and white stripes on barber poles are a representation of the bloody rags they hung outside their shop after a bloodletting treatment. They also often used leeches to bloodlet a patient. In front of you is a small tank with live leeches. They are European medicinal leeches—the kind that was most used for bloodletting in Europe, so much so, that they became overharvested and were the subject of some of the earliest conservation legislation. The tank is about the size of a large pickle jar, which mimics the earthenware containers the barbers used to store leeches in their shops. Inside, about half a dozen leeches are either stuck to the glass by their suction-cup ends, or swimming in an undulating pattern through the water. They are about the length of your thumb, and half as thin. They are round in the middle and tapered at each end. Tiny ridges cover their blackish skin, with orange stripes and dots along the length. They look slimier than they are.

As bloodletting became more popular, physicians took over the practice. While they still used leeches, they also had a variety of lancets in their toolkit. In the case behind you, farther into the room, there are some examples of lancets on the left side. To pierce a vein, physicians held the thin, straight handle between two fingers and poked the pointed blade quickly into the patient's skin. Blades of various shapes allowed surgeons to open veins of different sizes and in different areas of the body. The ones here are about 2 centimetres long and a centimetre wide, thin and flat with a point at the tip. A good doctor always had lancets on hand. The best doctors had elaborately-decorated handles and cases to advertise their popularity as a surgeon. The case here is gilt in gold and carved with an intricate pattern. It is about the size of a disposable lighter.

Despite the popularity of lancets and other human-made bloodletting tools, it is the influence of leeches that has survived into modern science-based medicine. The bloodfeeders are sometimes applied to patients after they have surgery to reattach fingers, toes, or other small body parts. The leeches feed at the reattachment site and inject their powerful blood thinners to keep the blood flowing freely so the attachment can heal. At the end of this room is a video featuring Sebastian Kvist, the ROM's curator of invertebrates, or animals without backbones, including leeches. Launch the video to learn more about leeches in bloodletting and in modern and future medicine.

When you're ready, continue into the next room to find the stop about diseases spread by bloodfeeding and some research being done to overcome the most impactful one—malaria.

Stop 9 – Disease

Diseases are an unfortunate consequence of bloodfeeding. But they're not caused by the bloodfeeders. They are caused by microscopic organisms that live inside them and get transferred into a host animal when feeding. But not all bloodfeeders transmit diseases, especially to humans. Leeches, for example, don't seem to carry any disease that infects humans. There are also many species of mosquitoes and other flies that cause nothing more than an itchy bump.

The plague, yellow fever, and river blindness are some major diseases spread by bloodfeeding. But they are also three that we have almost completely eradicated through research and treatment. The most important one we're working on now is malaria, which kills over 400,000 people every year. In front of you is a microscope with a real sample of blood infected with malaria. Don't worry—it won't harm you. When examined under the microscope, the red blood cells appear like semi-transparent red rings with pink in the centre. There are hundreds of them in this sample, which is only three millimetres wide overall. In and around some of the cells are smaller purple circles—these are the parasites that cause malaria. They attach to red blood cells and feed on a substance from the cells called haemoglobin, until the cell bursts. That is when the symptoms of malaria appear, which seem like the flu at first. If not

recognized and treated as malaria, the symptoms may worsen. Although there is treatment for malaria, it can result in organ failure, coma, and death.

The malaria parasite is carried by female mosquito species in the genus, or group, *Anopheles*. They occur mostly in tropical and sub-tropical areas. Currently, the best way to prevent malaria is to avoid getting bitten by these mosquitoes, by using mosquito nets, insect repellent containing DEET or icaridin, and wearing thick protective clothing. But research is being done using gene editing, where scientists snip out sections of a mosquito's DNA sequence and replace them with strategically-chosen ones. For example, they are planting a gene in some male mosquitoes that make them sterile, and unable to reproduce, which could eradicate a disease-carrying population. They could also use this technology against the malaria parasite to render *Anopheles* mosquitoes harmless.

With our changing climate, diseases spread by bloodfeeding are starting to appear more and more in North America. As we move forward, preventative measures, including managing bloodfeeders, are our best defence to mitigate the spread of these diseases. In the meantime, your best defence is to be educated about how to avoid and identify bites from bloodfeeding animals.

To learn exactly that, head to the next stop in the exhibition.

Stop 10 – How to

They are pests. But bloodfeeders are also critical to the health of their ecosystems. They are important food sources for other animals, and the diseases they spread help regulate wildlife populations. Most people in North America encounter bloodfeeders on a daily basis. So, what's the best way to withstand them? Be equipped with the right information to avoid them, to assess the risk they present, and to learn why we should appreciate them.

Take black flies. It is partly because of these pests that such large tracts of land remain unspoiled for us to enjoy—they keep humans away. Their larvae are even more important for their ecosystem. Black fly larvae are found in flowing water of all types, from tiny trickles to large rivers. Each larva is tiny—less than a centimetre—and looks like a thin brown worm resting on a rock or leaf. Sometimes there can be up to a million individuals per square metre of stream bed. They feed on food particles that are too small for other animals to eat and eventually eject it as a larger fecal pellet, making those nutrients available to other organisms in the food web. To your left is a video of Doug Currie, the ROM's curator of entomology, or insects. Launch it to learn more about the value of black flies and how their populations are changing in the Arctic.

In front of you is a large case filled with clothes. Wearing the right outfit is an easy and inexpensive way to avoid bites. The case contains a simple nylon shirt. It is white, because biting flies, like mosquitoes and black flies, are more attracted to dark colours than light ones. The sleeves are long to cover more skin. These are worn with dark denim jeans. The dark colour draws biting flies away from the face and the thick denim material creates a thick barrier so it's harder for them to reach the skin below. At the bottom hem, the pantlegs are tucked into thick socks—this is because black flies and other biters can crawl under openings in clothing to find skin. This is also why it`s worth wearing a solid shirt under anything with buttons up the front. When it comes to products for purchase, sprays that contain DEET or icaridin work the best to keep flies away.

Past this case to the left is a series of touchable models showing the bites of different bloodfeeders in North America—you can learn to identify a bite from a mosquito, tick, flea, bed bug, black fly, and leech. Go ahead and touch them. If you ever get bitten, knowing what bit you is important. If you start experiencing odd symptoms, you'll need to tell a doctor what the culprit was. But don't worry about itchiness—everyone experiences a different level of itch based on their own allergic reaction to chemicals in the bloodfeeder's saliva.

How do you feel? A little more empowered to share the world with bloodfeeders? When you're ready, continue out through the exit corridor, which has been dressed to simulate the inside of a vein. As you go through, hear the blood pump around you, and be confident as you imagine what bloodfeeder might be trying to break through the walls to get you.

We hope you enjoyed the exhibition and this descriptive audio guide. Thanks for visiting *Bloodsuckers: Legends to Leeches*!