

Vampire nutrition or “I never drink...wine”

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Submitted for your approval.

“The blood is the life”, Deuteronomy 12:23

OK, a quick show of hands. How many of you have ever watched a vampire movie? Thought so. My hand is raised too. The 1931 Universal Studios' film, *Dracula*, starring Bela Lugosi (born, Bela Ferenc Dezso Blasko, 1882-1956), defined the vampire genre for many including yours truly. So much so that every vampire film made since then has inevitably been compared to that first and, considered by many, perhaps the best one. Based on all the many vampire films since then, including those before such as, *Nosferatu* (1926), there are two major features that all vampires seem to have, namely, avoiding direct sunlight and the need for blood, human blood. To dig a little deeper one can then ask the question, how much blood is needed and is all human blood the same? Blood-wise, are some victims more appealing than others and, if so, why? Vampires are a curious lot being nocturnal and blood sucking.

Origin of Vampire

According to folklore the word, “vampire”, has foggy roots. In 11th-century Russia there is a manuscript with the word, “Upir” and the word, “vampire” (or vampyre) is a westernization of this word, Upir (or Upyr). This western use of the word, vampire, appears the first time in English print in 1732 and refers to a returned-from-the-dead corpse to drink the blood of the living. Clinically, blood-sucking vampires can also be called sanguivores with a hematophagous appetite.

Bela the teetotaler

When any film sets a trend then features from the film also infiltrate popular culture. For example, movie dialog and certain phrases frequently make it into society's language and are often quoted (“Go ahead, make my day” is such an example). For us scary readers one phrase high on our frequently quoted sayings list is, “I never drink... wine”, as masterly intoned by Lugosi in the 1931 film, *Dracula*. This oft-used phrase is essentially now a cliché. However, such a rich and full-bodied comment deserves a closer look. If Dracula never drinks wine, and by inference, that list probably also includes, beer, spirits, sodas, milk, tea, juices, and maybe even water, then how does he sustain himself? One obvious answer is gorging on blood, but after some analysis there must be more than that. In the vampire film genre we never see any vampire enjoying normal

food so this really does beg the question, how does Dracula get enough nutrition to sustain himself? Before we get to that some analysis of what the nutritional needs of humans, including vampires, are and what components in blood are important for sustenance will be investigated. Dracula's metabolic needs will dictate his nutritional needs.

Natural occurring elements in the human body

Life is made up of molecules that in turn are made up of atoms or elements. There are currently 92 recognized elements such as oxygen (O), sodium (Na), carbon (C), and iron (Fe). Combining elements creates compounds, like sodium combined with chloride (Cl), makes sodium chloride (NaCl) or table salt. About 25 of the 92 elements are essential for life. Only four of these, carbon, hydrogen, oxygen, and nitrogen (referred to as CHON), make up about 96% of living matter. Most of the remaining 4% consists of sulfur (S), phosphorous (P), calcium (Ca), potassium (K), and a few others. The rest are referred to as trace elements, the best known example being iron (Fe), which is needed by all forms of life. The CHON elements combine to form amino acids that in turn combine into proteins. Some other metabolically active biomolecules include vitamins, electrolytes, organics, and metals (copper, magnesium, zinc, etc.).

In decreasing order our bodies are primarily made up of the elements oxygen (65%), carbon (18%), hydrogen (9%), nitrogen (3%), calcium (1%), phosphorous (1%), potassium (0.4%), sulfur (0.3%), sodium (0.2%), chlorine (0.2%), and magnesium (0.1%). Trace elements are those below 0.01% and examples are boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (Va), and zinc (Zn). All of these elements need to be in our diets. The question now becomes how much of these are needed by vampires? Most likely, all of them are. If vampires subsided solely on blood then all of their nutritional needs, all of the above elements, must come from blood so an analysis of blood and blood components will provide a breakdown of what they get in their "liquid diet".

Nutrients humans need

The list of key nutrients that humans need is well understood and fundamentally not all that complicated. Unfortunately, getting these nutrients and feeding everyone is more of a challenge than it needs to be. Way too many humans are undernourished or malnourished. Simply stated, humans need a source of protein, vitamins, minerals, fiber, and some lipids (fats) and carbohydrates (sugars). With a balanced diet all of these nutrients are readily available and a healthy human need not worry about the metabolic details since our bodies naturally take care of that. Overeating is a real problem that appears as obesity and in some areas is nearing epidemic proportions. Obese people do not have a healthy diet. Important for this conversation is that what humans need nutritionally is not in blood such as, vitamins, fiber, and minerals.

Food science

About 20% of the human body is made up of proteins. Amino acids, the building blocks of proteins, can be found in the blood and are a direct correlation to the body's health and perhaps disease risks. Also, what we eat is coursing through our blood vessels so compounds in individual diets do influence body health. And many cultures have food products unique to them that are also found in blood. These food products help to enhance taste and these products do find their way into our blood system so when blood is taken along comes what the person eats (see below). Like normal humans, delivery of nutrients to vampire's absorption and digestive systems is key so a vampire should be able to digest a blood meal in the same manner as any food product.

There is more to metabolism than calories

If blood is a food for a vampire then what kind of food is it? As far as nutrition goes human blood is a poor nutrient source so feeding on blood is a tough way to get nutrition. Blood is about 60% plasma by volume and only yields about 900 calories per liter. To maintain proper nutrition and (assuming) a normal 2000-calorie per day diet a vampire would have to drink about 2.5 liters of blood per day. If this 2.5L blood meal came from the same victim this could almost be considered an exsanguination, meaning the removal of enough blood to cause death; however, if, say, 500ml (0.5L) were taken per victim then 5 victims would be necessary to get 2.5L and in such instances the victim should be able to survive the blood loss (for example, the Lugosi Dracula visited Mina a few times over consecutive nights so he must have taken just enough blood to help his craving while leaving her still alive, though weak). Calories from protein miss those provided by glucose (sugar) and lipid (fat). Blood contains a negligible amount of lipid (most of which is used for energy) so an excess of blood is needed to get enough of it. To survive with enough calories a vampire would have to drain a victim each day and as a result would most likely have chronic ketoacidosis (the metabolic breakdown of his own fatty acids (lipids) often found in patients with type 1 diabetes) due to the lack of ingested lipids in blood.

Burning of body energy

So, just how much energy does your body produce and burn? This will serve as a baseline to guide the vampire as to what will be his energy demands, calories burned, and therefore, nutritional needs.

Blood flow generates 0.93 watts of mechanical energy, 0.16 watts of electrical energy, and 0.16 joules of electrical energy per movement (or heart beat). Exhalation generates 1.00 watts of mechanical energy, 0.17 watts of electrical energy, and 1.02 joules of electrical energy per movement (or breath). Inhalation generates 0.83 watts of mechanical energy, 0.14 watts of electrical energy, and 0.84 joules of electrical energy per movement. The upper limbs generate 3.00 watts of mechanical energy, 0.51 watts of electrical energy, and 2.25 joules of electrical energy per movement. Walking generates 67.00 watts of mechanical energy, 11.39 watts of electrical energy, and 18.90 joules of electrical energy per

movement (or step). And finger typing (such as what yours truly is doing now) generates around 7 to 19 milliwatts of mechanical energy, 1.2 to 3.2 milliwatts of electrical energy, and 226-406 microjoules of electrical energy per movement.

It is unknown how much mechanical energy or electrical energy it takes for a vampire to shape-shift to a bat or other forms of life such as a wolf, though no doubt it is significant. This mechanical and electrical energy should be measurable like the above described movements. Nevertheless, this energy or calorie burn would have to be replaced by whatever is in his blood diet. If the vampire is larger than an average human then these energy levels could be significantly higher. Also, if the vampire is smaller than an average man, or a female, then the energy levels will be proportionally smaller. As an example, a professional athlete, such as a football player, would need to consume more calories per day than the average person to balance out the energy burned while performing. Some athletes can consume 5000 calories per day without weight gain so a very active vampire would need more than 2000 calories per day and therefore, more than 2-3L of blood per day. A very active vampire, such as one who shape-changes frequently, may need 5L or more of blood a day for calories so a few victims would be necessary. A higher metabolic rate would require a constant and large intake of energy on a daily basis. So, do very active vampires sweat from the physical exertion? If so, they also need to replace these lost fluids. As such vampires dehydrate and need to rehydrate. Which then raises the question of how many days can a vampire survive without a blood meal? One important consideration for that question is the rate of fluid (i.e., water) loss. All lost water will need to be replaced.

Components of blood

For any amount of blood removed the blood plasma is about 55% to 60% of that volume while cells (red blood cells (RBCs) and white blood cells) and platelets are the other 40% to 45%. Water is about 92% of blood plasma with all the other components (most being proteins) being dissolved. The cells are of two major types: erythrocytes (red blood cells or RBCs) and leukocytes (white blood cells). About 99% of blood cells are RBCs. The primary job of RBCs is to carry around oxygen due to the iron containing hemoglobin inside RBCs. (Think of hemoglobin as an oxygen-magnet that grabs up all oxygen molecules.) RBCs are shaped like a biconcave disk that is flattened in the middle since they do not have a nucleus. RBCs are very homogeneous and are made in the bone marrow at an astonishing rate of 2 million per second (and to maintain a constant homeostasis this means that about 2 million are destroyed each second!); this is normal body recycling physiology.

The other types of cells in blood, the leukocytes or white blood cells, are very heterogeneous and are divided into several major groups, such as lymphocytes (which in turn can be further divided into subgroups like T-cells and B-cells), macrophages, neutrophils, plasma cells, granulocytes, and basophils. Heterogeneous indeed. It is these white cells that constitute our natural immune

system. And this brings up an interesting point. These lymphocytes are quite specific for each individual with some being more immune active than others. Does the vampire need these white blood cells to help supplement his own immune system? Are all of the white cells important or just some of them? If so, then they certainly represent a nutritional requirement. Furthermore, vampires may have an inadequate immune system and could be susceptible to infections not to mention cancers and autoimmune diseases so they may have a need to supplement their own immune system with victim's blood cells. As such, the vampire also inherits the victim's immune response by way of the white cells that could do either nothing, dampen, or enhance his own immune response.

Blood fun facts

A 200lb man would have approximately 4.5 to 5.7 liters (1.2 to 1.5 gallons) of blood per person and a woman would have less. To keep it simple there are about 5L of blood in males and 4L in females. It should be noted that blood volume varies from person to person depending on height and weight (for example, Glen Manning, the Amazing Colossal Man, would have more blood than the Mayor of Munchkin Land.) Taking this to the natural end, a vampire would not choose a dwarf as a victim simply because the little person would not have enough blood. And the same goes for adolescents since there is not enough blood in them either. Therefore, if the average female (victim) has about 4L of blood and the vampire takes about 2.5L of her blood then in all likelihood the victim will not survive since humans cannot survive after losing more than half of their blood. With excessive blood loss the victim would die from electrolyte shock (body metabolism would shut down).

Unit of blood

When humans donate blood they typically donate a "unit" of blood, which is approximately 500ml or half a liter (0.5L). So you gentle scary readers know, a unit of blood is measured by weight and not by volume. A unit of blood weighs approximately 471 grams, which is about 500ml, though this can vary a few milliliters depending upon the donor and iron content in their blood. (It should be noted that blood is 6% heavier than water.) A unit of packed red blood cells (RBCs) typically contains around 70% red cells and 30% liquid, mostly plasma, which begs the question of what does the vampire need, red cells or plasma, or possibly both? If a unit of blood is from an average female then it contains between 174 and 222 ml of packed cells and if the unit of blood is from a male then it contains between 194 and 250 ml of packed cells. There is a significant difference in blood between males and females, with males having more of just about everything, not to mention the hormonal differences. It should also be noted that there is significant variability between person-to-person, even of the same sex.

Blood junkie

How long would it take to drain 2 to 3 liters of blood from a body? This would certainly be easier with an active, pumping heart so better if the victim were alive.

With no heart pumping (victim is dead) then the vampire would have to exert extreme sucking action to get that much blood out from a single person (assuming the blood is not coagulated, which occurs rapidly upon death). Also, for living people arteries have a higher pressure so blood would drain faster than from the lower pressure veins (see below). In practical terms, if the vampire hit a vein he would need a stronger sucking action to drain the needed blood. That or just take longer with the lower pressure. The higher pressured arteries would let more blood drain in a shorter time. Draining 2 to 3 liters of blood would take many minutes and during the end the victim's heart rate would slow down dramatically thereby decreasing the blood pressure so the vampire would have to suck harder to finish the blood meal he needs.

The Dracula diet

If blood is their only source of nutrients then a vampire's actions and behavior are dictated solely by these nutritional needs. Vampires must get their nutrition from blood proteins such as hemoglobin, albumin, fibrinogen, and globulins. The breakdown products of these proteins are amino acids that are composed of many nitrogen atoms. Too many nitrogen atoms can combine into ammonia that is toxic so the body must eliminate as much nitrogen as possible. This is done via the compound, urea, which is composed of several nitrogen atoms per molecule and is excreted in urine. Perhaps as much as 25% of the blood volume could be excreted as water, via urine, within the first hour of the blood meal. From a 2.5L blood meal at least 2L of that is water! (Imagine drinking three 750ml soda bottles all at once!) Without being too delicate what do humans naturally do when we consume a large volume of liquid? We head for the bathroom to urinate. In addition to the large fluid volume, with all the sodium vampires consume from a blood meal then this could act like a diuretic causing excessive urination. And too much urination can cause dehydration so there must be a homeostasis between blood volume intake and urination output. This also brings up the question whether vampires sweat not to mention normal water loss during breathing via exhaled breath. All this water loss must be replaced to maintain proper body homeostasis. Remember, all the vampire's water comes from his blood meals.

If a vampire snacked on a unit of blood what would he get? Based on the above discussed volumes he would need about 5 units or bags per day to sustain himself. Typically, units of blood, or bags of blood, have a preservative fluid consisting of citrate, phosphate, and dextrose plus an anticoagulant and preservative (helps extend shelf life). If a vampire drinks a unit bag of blood he gets all these other ingredients, such as anticoagulants, which he may not want and could even be harmful. Which is better, a unit of blood or blood directly from a victim? By going directly to the source, jugular veins of victims (see below), then such ingredients are missed.

Can a normal human survive by only drinking blood? No, since there are not enough key nutrients plus too much sodium in blood that will cause problems

(sort of like trying to drink sea water; as eloquently stated by Samuel Taylor Coleridge from the *Rime of the Ancient Mariner*, “water, water everywhere and not a drop to drink”). Also, there is too much iron that will affect liver functions so to have a diet solely based on human blood the vampire will need some sort of filtration mechanism to get rid of all the extra iron plus the ability to metabolize all the ingested sodium. [Note: if too much iron builds up in the kidney then a condition known as hemochromatosis can develop that can cause kidney damage.] Furthermore, there are not enough nutrients in blood like, fiber, minerals, and essential vitamins to provide a healthy well-balanced diet. By surviving only on blood meals will result in being malnourished which may help to explain why vampires appear emaciated and ashen of color. Related to this we can then ask why aren't there any fat vampires? One answer is their basal metabolic index would be high compared to ingested calories such that they would lose weight over time due to their liquid only diet.

How much blood does it take for a vampire to gorge himself? After a large blood meal, say about 2.5 liters (maybe more), the vampire's stomach would be bloated and sloshing, and he may have difficulty changing into a bat since he would be sluggish from the digestion needed to process such a large liquid volume. Furthermore, with a large liquid diet then the vampires would be urinating all day (or night) long.

Since most of a vampire's victims appear to be female this raises the question if whether the vampire needs female hormones for any nutritional requirements. Estrogen is the main female hormone and it is unclear why a male vampire would need estrogen. Also, it is not clear why the blood of a virgin would be preferred over someone who is not. Another interpretation is the vampire needs a hormone rush from endorphin-soaked victims and a frightened (virgin) female could release more endorphins than a male.

So, for the 'Dracula Diet' when he says, “I never drink...wine”, perhaps he should. It could make for a much more vital and energetic vampire. So, why not wine? It is because there are no RBCs in wine or it tastes bad or maybe something more fundamental like alcohol poisoning? What about mixing blood with wine? Another possibility is that alcohol, no matter the form, provides no nutritional benefit and might even have no taste at all.

Vampire digestion

We are what we eat so what we eat must be digested and this digestion process primarily occurs in the stomach and intestines (our stomach breaks down the food and the individual components are absorbed by our intestines). In humans there is very little nutrient transfer directly from the stomach to the circulatory system and we assume the same for vampires. Digested nutrients are transferred (absorption) via the intestines. More blood vessels supply and drain intestines than the stomach, which reflects this digestion process. Those ingested compounds that are not broken down are passed through while some

are absorbed into the circulatory system through natural processes. Vampires are most vulnerable after a large blood meal (bloated with 2.5L of volume) so they must shed the excess water volume as quickly as possible and this is naturally done by urination. In all practical terms vampires must urinate soon after a meal since water makes up about 80% of ingested blood volume. Excess water is carried to the kidneys for elimination (urination). In terms of digestion the vampire gastrointestinal tract would be full with blood soon after a meal. Lastly, there must be some sort of vampire body waste, but we won't go there; it's too scary.

Tastes great

We have all tasted blood like when we cut a finger and we put it in our mouth to get the blood away (much like Renfield did in the 1931, *Dracula*, when he cut his finger on a paperclip and he put his finger in his mouth). It does have a salty, metallic taste. And maybe this taste could be like a narcotic to a vampire. For humans, there are five major taste sensations on our tongues: sweet, salty, sour, bitter, and umami (food with high levels of glutamate; MSG or monosodium glutamate). Umami is sensed by both the tongue and stomach (this helps prompt vagal nerves to send signals to the brain to stimulate digestion and absorption of proteins). And vampires being vampires may have developed a sixth taste sense for blood, probably one based on 'salty iron'.

There are three factors in food: taste, aroma, and texture and when all three harmonize then food "tastes good". Different cultures have both a biological and social preference for taste so "tastes good" is a relevant term. Perhaps the same can be said for blood in that different cultures probably have different blood compositions. For example, does Japanese blood 'taste better' than European, Asian, or African blood? Which then raises the question are some blood types more delicious and satisfying to vampires than others? Furthermore, there are four main factors for taste or palatability: sensation of deliciousness; food culture as determined by social customs; information on safety and desirability; and the brain's addictive reward system. Perhaps vampires desire that 'metal salty taste' of blood that cannot be obtained from any other source.

Olfactory enhancements

Aromas of foods are important so what role does smell provide in blood meal taste? Food aromas are sensed by the vomeronasal organ located in our nose/tongue region so the vampire may have used this and developed a heightened sense of blood odor, much like a shark that can 'smell' blood from great distances. What sensory systems do vampires have in their ability to smell blood?

Dracula the parasite

If the vampire can be considered a parasite, technically an obligate blood feeder, then weakening victims to the point of death would be considered a maladaptive trait. [To be candid, it would be tougher to constantly hide dead victims than

those who survive the attack.] It would be best if the vampire can serve the role of a true parasite in that he takes advantage of his host without killing the blood source (though, frankly, that makes poor plot sense for our screen vampires). As such the vampire can be both a predator and a parasite. It should be noted that each has different nutritional needs. A parasite has intimate physiological contact with its host and uses/takes just what he needs whereas a predator simply sees the victim as prey.

Types of victim's blood – healthy

In one respect blood is blood but frankly not all blood is equal. When taking blood the vampire also takes everything his victim has/carries in his/her blood. For example, stating the obvious there are significant differences between male and female blood, mostly in hormones and volumes. Also, younger people have different components in their blood than older people, not to mention pre-menopausal or post-menopausal women. Furthermore, what we eat does course through our blood stream and when a blood meal is taken then much goes along with it so, for example, the blood from a vegan/vegetarian would be different from someone with a meat diet which raises the question can a vampire be satisfied with a vegan victim? What about someone with a non-traditional “Western” diet such as curry, Thai spices, Asian noodles, etc.? And how about a Jewish vampire who, due to religious and cultural beliefs, can only take kosher blood? Kosher animals are devoid of blood; what is a Jewish vampire to do whom it is against custom to consume anything before drained of blood?

In older people the arterial system could be damaged by a heart attack resulting in a stroke and would a vampire take blood from a stroke victim? Older people tend to have “iron poor blood” and is this a problem for our vampire? What happens if the blood is too thin? What if the victim takes aspirin daily to prevent clotting or perhaps other anti-coagulants such as heparin, warfarin, t-PA (tissue plasminogen activator)? Perhaps vampires need a natural human immune response so they take whole blood, containing the “liquid organ” of the immune system. They may need these immune cells to fight off infections, viral attacks, the common cold, or perhaps some other diseases.

Lastly, normal people have different blood types, such as A+, O+ blood, classified as the “ABO” blood type (O blood is the universal donor and AB blood is the universal recipient; for those of you who are curious the blood type of yours truly is O+, the most common). Blood types are important for tissue matching and blood donations so the blood and tissues are compatible and not rejected. Even though our vampire digests all ingested blood meals nevertheless it may be important to have matched blood. It may digest better.

Types of victim's blood – diseased

What our vampire may not know is whether his victim is healthy or diseased and for many diseases it is difficult to tell. Such diseases as sickle cell anemia, hemophilia, diabetes, and cancer may be difficult to tell just by looking at the

person. If such diseases do not matter to the vampire who sees *all* people as potential victims then any particular disease state is irrelevant. However, if diseased victims are important then how does the vampire know who is healthy and who is not? Can he distinguish amongst such diseases? Perhaps the victim has certain allergies that the vampire also inherits via a blood meal. One interesting option is, as discussed above, whether the vampire needs white blood cells to supplement his own and in this case he would be best served to choose victims who have leukemia or lymphoma (cancers of the white blood cells) so he can get as many as possible since these victims have excessive white cell numbers.

In addition, there are many anemias (lack of RBCs) or polycythemia (excess RBCs) conditions that are difficult to physically tell just by looking at a person so how can the vampire distinguish such conditions? Additionally, blood from someone with atherosclerosis (too much cholesterol lining blood vessel walls), a hardening of the arteries, may make blood drawing difficult.

Furthermore, there are many blood-borne diseases such as HIV, zika, "mad cow" disease, bird flu, and sexually transmitted diseases that need to be considered. Is the victim an alcoholic, as discussed elsewhere in this article? Does the victim have any drugs in his blood? Not only drugs of abuse like cocaine, heroine, marijuana, and alcohol but also regular drugs like caffeine, aspirin, plus a myriad of prescription drugs. If the victim has a transmissible disease (HIV and infections) then it is a fair question to wonder if the vampire will also inherit the disease. After all, there are several blood born diseases that are readily passed on through the blood with AIDS and malaria being two obvious examples.

Blood clotting

Based on the many vampire films it appears, on average, their fangs would measure about 0.5cm wide and about 1.0cm deep and neck wounds would be similar in size. This is important for blood clotting reasons. It does take a while for normal blood to clot (the mechanism behind wound healing) and with holes of that size in the jugular vein would mean it would take a while (several minutes) for the blood to clot to possibly seal the wounds. In the meantime, blood would continue to leak/leak out of the puncture holes. The natural blood clotting mechanisms could be longer if the vampire had natural anti-clotting factors (like heparin, an anti-coagulant) in his saliva. Normal blood clotting involves many chemical cascade steps of which any one can be disrupted by the vampire for his blood meal.

Veins vs arteries

There are 60,000 miles of blood vessels in the average adult human body. There are two main arteries, aorta and pulmonary artery, which branch out into 20 major arteries throughout the body, and sequentially into many smaller arterioles and capillaries. Artery size varies between 1cm to 0.5mm. There are also two main veins, vena cava and pulmonary vein, that also branch out into

major veins on down to the capillary bed. The capillary bed is important because it is the area of oxygen and carbon dioxide exchange (“out with the bad air and in with the good air”). Oxygen is released and carbon dioxide is removed in the capillary bed. Overall, the circulatory system, heart, lung, and blood vessels, delivers oxygen and other nutrients to cells in the body and the same should be true for vampires. The same circulatory system also removes waste products and carbon dioxide.

Are the differences in veins and arteries important? Also, does it matter which vein or artery is used? In this respect it would be useful to compare the two. Though there are structural differences between arteries and veins the most important difference is arteries have high pressure and low volume whereas veins have low pressure and high volume. Due to the pressure difference this then raises the question do vampires suck out blood or does the pressure release due to the punctures cause the blood to spurt out? Artery blood vessels are thicker with an additional muscle layer to withstand the higher pressure than vein blood vessels, which have a lower pressure so no need to be as thick. Arteries carry oxygenated blood to the body whereas veins carry deoxygenated blood back to the heart and lungs for re-oxygenation to keep the cycle going (commonly known as breathing). Depending upon whether the vampire hits a vein (more sucking required though less time required) or an artery (less sucking though it would take longer to get the amount of blood since volume is low) would depend upon how much time is required to get the necessary 2-3 liters of blood. Also, the vampire must prevent the torn blood vessels from constricting, which would reduce the flow of blood. Veins have semilunar valves to prevent blood flow in the opposite direction whereas arteries do not. Furthermore, arteries tend to be deeper in the body while veins tend to be closer to the skin surface.

Go for the Jugular

The jugular vein seems to be a popular target for vampires so let's examine this more closely. There are three jugular veins, internal, external, and anterior jugular and the closest to the skin surface is the external jugular vein so this is the vampire's proverbial target. The jugular veins drain blood from the head, with the external jugular vein draining the outer areas of the head and scalp, and carry oxygen-poor blood back to the lungs for resupply with fresh oxygen. This external jugular vein averages about 3mm to 6mm wide and connects at the base of the throat with the internal jugular. Though a relatively small target that the vampire must hit precisely to draw blood, it should be noted that the external jugular vein could be up to double the size of other neck veins. The wrong angle, even with just one fang, would be ineffective so the neck bite must be very accurate. (And made even more difficult with a struggling victim as a “moving target”.) Furthermore, should one of the vampire's fangs just nick the vein then due to the pressure drop much of the blood would leak out into the neck area that the vampire would not obtain. This would result in a longer feeding time to get the necessary 2.5L blood meal since much would leak out and not be available to the vampire. In terms of the effectiveness of the bite it is important to consider

whether the vampire has dentures or tooth problems such as enamel decay. Dull or chipped fangs would make it harder to penetrate neck flesh and vein walls.

One potential option is for the vampire to target varicose veins that are significantly enlarged so the aim of the fangs need not be as accurate. Varicose veins are primarily located on the lower legs that may prove a challenge for the vampire to effectively bite. Another good vein source is the wrist; though easy to access, the blood flow is slower requiring more sucking time.

Though there is a difference in oxygen-rich and oxygen-poor blood this may not be significant for Dracula. If our neighborhood vampire needs an oxygen boost then he needs to pick an artery but if oxygen is not important then any blood vessel will do. If an artery is important then the vampire would have some sort of ability to sense the higher pressure in an artery, much like the vampire bat senses the heat in blood vessels (see below). In terms of all the other nutrients there is very little difference, if any, between arteries and veins so, truly, any blood vessel will do. If a large volume blood meal is needed as quickly as possible then the largest vein closest to the skin surface is indeed the jugular. If smaller blood meals are what's on the 'menu' then any convenient blood vessel, such as those on the wrist, will suffice.

Blood supplements and substitutes

Since the nutritional benefits from a blood meal are minimal perhaps a blood supplement would be useful. After all, many humans add to their food intake with supplements and substitutes, mostly via vitamin tablets and other additives. Could a vampire take a vitamin supplement to help with his nutritional needs? One obvious example of a vampire supplement is non-human animal blood, which raises the question, at least for vampires, is how much nutrition is in animal blood? With this in mind, how many animals would a vampire need as victims to get his 2-3 liters of blood per day? Moreover, are all animals the same? Would the blood from a dog or cat be as nutritious as blood from a horse or a cow? Taking this further, how about blood from an ape since their blood is about 98% similar to humans? Even so, irrespective of the species, what would still be missing are vitamins, minerals, and fiber, all necessary for proper health.

For a blood substitute it is important to understand what is needed. A blood substitute could provide some nutrition but entirely lacking is fluid volume (i.e., water). If vampires do not drink other fluids then all needed water comes from a blood meal. Therefore, fluid is needed to supplement a blood substitute. Some substitutes need to be reconstituted or consumed with water so the vampire must consider this too. Would he reconstitute a supplement concentrate with blood? In addition, how often would the vampire need to use a substitute, one or more per day, depending upon concentrate and volume, or perhaps twice or three times a week with a high enough concentrate? Is there the equivalent of a vampire "5-hr energy drink"? If so, what would the ingredients be such as low salt, high caffeine, low fat drink?

It is assumed that supplements and substitutes are taken at room temperature. An easy question to then ask is what about refrigerated or frozen blood? Does a vampire need fresh, warm blood or can blood be frozen and thawed when needed? This way the vampire could thaw a meal when hungry.

Vampire bats, real blood meal drinkers

There are parallels between vampire bats and the behavior of human vampires so an examination of vampire bats is in order. After all, vampire bats are mammals too and since they solely subsist on blood meals, like Dracula, this may help us better understand what human mammal vampires do. (Note: though there are other examples of blood-drinking creatures, such as the leech and the very pesky mosquito, their blood needs are different from our vampire.)

There are three species of vampire bats all from the order, Chiroptera. The common vampire bat is, *Desmodus rotundus*, and the other two species are *Desmodus diaemus*, and *Desmodus diphylla*. The largest vampire bat is, *D. rotundus*, which weighs in at a whopping 40 grams (about 1.5 ounces). Vampire bats are small for a reason. Anything larger would have major flying issues after a blood meal since it would be too bloated and heavy to fly due to all the water in blood, and if they were as large as some fruit bats then they would not be able to fly after feeding/gorging so they are naturally small due to their sole diet of blood. Vampire bats consume about half of their weight in blood per day (roughly a tablespoon) so they ultimately have a lot of water to deal with. Almost as soon as vampire bats are feeding they are simultaneously urinating to get rid of as much water as possible. Feeding solely on blood is a tough way to live.

The vampire bat is considered by many to be the most specialized of all mammals. Not only can they sense where blood vessels are (see below) they also have anti-coagulants in their saliva to keep the blood from clotting during a meal. On the down side it should be noted that some infected vampire bats transmit rabies to animals in their bites. Vampire bats, after a heavy blood meal, can not jump up and fly away like other bats because they are too heavy but, rather, use different locomotor morphology to begin flight by lifting their wings directly up and down to achieve altitude.

Vampire bats primarily feed on horses and cows (livestock) so it really does not matter the species as long as there is blood to be had. Frankly, any animal will do for the vampire bat which seems to be opposite for Dracula and his kind in that they apparently only take human blood. This suggests totally different nutritional needs. For human vampires, not all blood is equal.

So, after landing on an animal how do these vampire bats know where a blood vessel is? Vampire bats have thermoreceptors (heat sensing protein channels) in their nose leaf region that can detect slight temperature differences in the areas of skin that are warmer where blood vessels are just below the skin

surface. This determines where the bat will bite. Those veins close to the skin's surface are around 38°C (100° F) due to the warm blood and the bat can sense this heat source would be the best spot for feeding.

Taking this information and applying it to human mammal vampires would suggest that somewhere near the nasal-mouth-tongue region they also have thermoreceptors that can sense exactly where the jugular vein is so they do not miss. Multiple bites attempting to target the vein would result with misses and near misses and could be quite messy.

“Blood is a very special juice” – Mephistopheles to Faust

An important question to ask is why does Dracula need blood? We know this is important to him when he tells Renfield in the 1931 film, *Dracula*, “Blood is the life, Mr. Renfield.” Fortunately, we get a glimpse of what may be the cause or reason. In the Universal Studios' film, *House of Dracula* (1945), we get a point-of-view shot down a microscope of Dracula's blood. In this image we see what appears to be either a three or four tentacle organism, a blood parasite, which wraps itself around RBCs. One possible mechanism is these parasites feed off RBCs and consume them in large quantities. So much so that Dracula would be chronically anemic, perhaps short of breath due to the fewer RBCs to deliver oxygen to tissues, and in constant need of a fresh blood meal to replenish the destroyed RBCs by the tentacle parasite. Furthermore, based on this hypothesis, then Dracula would feel invigorated after a blood meal since he replenished his depleted RBCs and after sleeping it off during the day would awaken famished since the last night's blood meal would be 'vampire digested' by the parasites and needing more RBCs. And so goes the cycle. However, there must be more to it than just RBCs since if that were the case then any RBC would work, from any species, and since it appears our vampires do not like non-human blood then other (human) components are important.

Summary

“I never drink...wine” is a powerful comment on vampire nutrition. If a blood meal is their sole diet then all of their nutritional needs must come from blood. Based on a 2000-calorie per day diet and knowing that one liter of blood gives 900 calories then a vampire must consume about 2.5 liters of blood per day to meet minimal nutritional needs. After an analysis of blood and its components then it is clear there must be more to the 'Dracula diet' than just blood. Nutritionally, what are missing from blood meals are fiber, vitamins, lipids, carbohydrates, and trace metals. However, for vampires to maintain a somewhat healthy body there must be some sort of diet supplement, which is currently unknown, perhaps something sinister. After drinking about 2.5 liters of blood, of which 80% is water, the vampire must eliminate the water and the most efficient way is naturally via urination. We also know that Dracula is infected with a blood parasite that feeds off red blood cells and these consumed cells constantly need to be replaced requiring daily feeding. The life of the vampire is a tough one indeed.

Thank you for reading. It's back to the lab for me. Stay healthy and eat right.