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The Leech and the Physician: Biology, Etymology, and Medical Practice with *Hirudinea medicinalis*

Robert N. Mory, Ph.D.,[1] David Mindell, Ph.D.,[2] David A. Bloom, M.D.[3]

[1]International Institute, College of Literature Science and Arts, The University of Michigan, 1500 East Medical Center Drive, Ann Arbor, Michigan 48109-0330, USA
[2]Department of Biology, Museum of Zoology, The University of Michigan, 1109 Geddes Avenue, Ann Arbor, Michigan 48109-1079, USA
[3]Department of Surgery, School of Medicine, The University of Michigan, 1500 East Medical Center Drive, Ann Arbor, Michigan 48109-0330, USA

Abstract. The history of the word "leech" and the practice of leeching reveal interconnected social histories. We give the linguistic and medical histories of the word, and explore its biology and clinical history. Our historical account extends from the earliest known record of leeching to current research. Despite historical variation in its reputation as a therapeutic technique, leeching remains useful today in a number of applications. Further investigation may well disclose even more uses for the leech, particularly for its enzymes with anesthetic, anticoagulant, and antimetastatic properties.

Word histories often reflect an underlying social history. The Old English verb "thrall" goes back to the Anglo-Saxon period when slavery was a fact of life; the verb meant to place someone in a position of servitude. The modern English verb "enthrall" has a figurative vestige of that original sense: to fascinate or to capture one's imagination. A word with a complex linguistic history is quite likely to have a fairly complex social history as well. Such is the case with "leech." The word "leech" came into use early in the history of the English language and had two distinct meanings: the medical practitioner and the blood-sucking worm. Of course, medical use of the leech antedated by centuries its mention in Old English (the Anglo-Saxon language); the first written reference to leeching seems to be that found in a medical poem by Nicander of Colophon (185–135 BC), a Greek poet and physician [1]. The close association of the leech and the medical practitioner was therefore established early, and it lasted well into the nineteenth century.

Biology

Multicellular animals include numerous worm-like forms. The phylum Platyhelminthes includes about 20,000 species of flatworms, flukes, and tapeworms. The phylum Nemertea includes about 900, mostly marine, species of ribbon worms or proboscis worms; and the phylum Nematoda includes about 80,000 known species of roundworms. The phylum Annelida includes more than 15,000 species of segmented bristle worms, such as the earthworm and its relatives, and about 300 species of leeches in the class Hirudinea. These four phyla are not closest relatives, in an evolutionary sense, indicating that shared similarities in appearance and life history among these worm-like forms may be convergent and due to the effects of natural selection rather than simply being due to common descent (Fig. 1). Although there is lively debate about the exact branching sequence among animal phyla, there is good morphologic and molecular evidence indicating that leeches are more closely related to arthropods and molluscs than to flatworms, proboscis worms, or roundworms. Leeches, flatworms, and proboscis worms appear to be more closely related to vertebrate animals than to roundworms.

Leeches exist in a diversity of habitats. Although their greatest abundance is in ponds and streams of North America and Europe, they can be found in polar seas and desert oases. Leeches are usually hermaphroditic, but each copulates with another individual. Many leeches feed on other small invertebrates, but others are blood-sucking parasites that feed by attaching temporarily to other animals, including humans. Many blood-sucking species are highly discriminating, feeding readily on blood from some species but not others. Some parasitic species use blade-like jaws to slit the skin of the host, whereas others secrete enzymes that digest a hole through the skin, The host is usually oblivious to this attack because the leech secretes an anesthetic. After making the incision, the leech secretes another chemical, hirudin, which keeps the host blood from coagulating.

The name *Hirudo medicinalis*, assigned by Linnaeus in 1758, reveals a long association with human use. *H. medicinalis* lives in freshwater and grows to 12 cm in length, although its resting size is usually only one-third its stretched length. A total of 102 annuli are divided into segments, usually with five annuli per segment [2]. A small anterior sucker serves for feeding, with three jaws that attach and bite through human skin (Fig. 2). A large posterior sucker is used for crawling.

Lent and Dickinson observed that hungry leeches rest at the edge of a pond and swim with amazing accuracy toward sources of waves [3]. A single neurotransmitter, serotonin, seems to control

Correspondence to: D.A. Bloom, M.D.

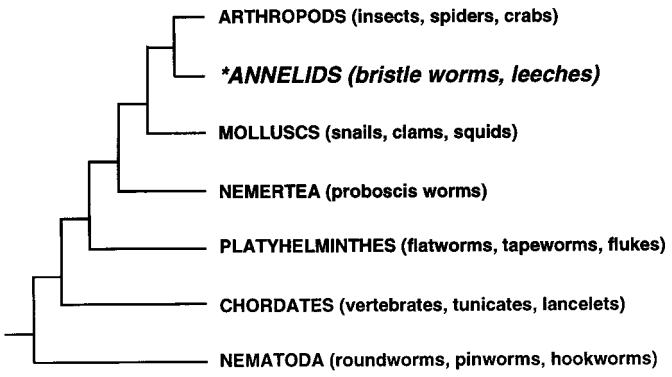

Fig. 1. Phylogenetic hypothesis showing the evolutionary relation of leeches (which are annelids) to other animal taxa. Note that worm-like forms have arisen independently on multiple occasions. (Adapted from Brusca RC, Brusca GJ. Invertebrates. Sunderland, MA, Sinauer, 1990.)

feeding behavior; and it is abundant in the leech's largest neurons, the Retzius cells. Leech feeding is stimulated by mammalian temperature and by sodium and arginine in blood [4]. Chemicals in leech saliva include hirudin (a 65-amino-acid peptide that functions as a potent anticoagulant), hyaluronidase, collagenase, fibrinase, hementin, plasminogen activators, bdellins, eglins, elastase, cathepsin B, antihistamines, and apyrase. These secretions serve to maintain access to blood and prevent clotting. Hirudin, the most potent natural anticoagulant known, inhibits thrombin-catalyzed conversion of fibrinogen to fibrin. The secretions of a single leech can prevent in vitro coagulation of 50 to 100 ml of human blood [5]. A typical ingestion is 5 to 10 ml, and some leeches ingest nine times their body weight, which may constitute an entire year's meal. Once the leech is full, which usually occurs within 10 to 30 minutes, it loosens its grip and falls off the host. Host attraction and biting do not recur until the leech gut is empty. The bite site on the host may bleed for 24 to 48 hours in the case of *H. medicinalis*; thus the leech's phlebotomy value far surpasses its individual meal volume [6]. Blood is digested in the *H. medicinalis* gut, where symbiotic bacteria, principally *Aeromonas hydrophila*, carry out the digestion. No gut enzymes have been identified. Water is extracted from the blood meal and excreted through 17 paired nephridia. The process of digestion in *H. medicinalis* lasts as long as 3 months.

Etymology

Given the close association of the worm and the medical practitioner, it was natural that "leech" became a synonym for doctor early in the history of the word. Surprisingly, however, as one explores the histories of the English word leech, we find it has two distinct origins or etymologies, one each for the two basic meanings, the worm and the doctor. That is, they are indeed two different words. It is for that reason that etymologic dictionaries give two entries for leech. In brief, the Old English "laece," meaning the worm, came into use sometime before AD 900 and was cognate (a word related in origin) with Middle Dutch *lieke*, or leech. Its earlier origin is unknown. The other Old English word "laece," meaning physician, came from Germanic languages, including Old Frisian *letza*, meaning physician, Old Saxon *laki*, and Old High German *lakki*. Its first use in Old English was around AD 900; its probable origin can be traced back to Indo-European language, the original source of most modern European languages.

The fact that "leech" had two forms and meanings early in their histories means that the joining or relating of the two meanings was a later development and an artificial one. This type of linguistic development, in which an apparently logical connection is used to explain (or is understood as) the development of one meaning from another, is an example of folk etymology. It is the use of an apparent connection between two words to explain the origin of the second one.

Ancient Leeching

Bloodletting is an ancient therapy with origins that are suspected to go back as far as the Stone Age. Healers attributed many illnesses to inappropriate, excessive collections of blood. Hippocratic concepts of disease included the notion that veins can be the site of pathologic humors. To quote directly from a Hippocratic text, "Ardent fever (causus) takes place when the veins, being dried up in the summer season, attract acrid and bilious humours to themselves; and strong fever seizes the whole body, which experiences aches of the bones and is in a state of lassitude and pain" [7].

Phlebotomy by venesection, or cupping, was advocated for a wide range of diseases. Leeches, however, did not seem to be a part of the Hippocratic armamentarium, although Hippocrates mentioned that a hidden leech in the throat can cause bleeding [8]. To turn again to Hippocrates: "Bleed in the acute affections if the disease appear strong, and if the patients be in the vigour of life, and if they have strength. If it be quinsy or any other of the pleuritic affections, purge with electuaries; but if the patient be weaker, or if you abstract more blood, you may administer a clyster every third day" [7]. Hippocratic concepts of disease of virgins, supposedly caused by impaired menstrual flow, lasted until the sixteenth century. The recommended treatment for disease of virginity was venesection, or relief of the virginity.

Galen prescribed phlebotomy for diverse infirmities including epilepsy, liver disease, melancholy, and pleurisy. There is evidence that he used leeches [8]. By medieval times phlebotomy literature and lore were well established. Siraisi commented as follows [9].

> Practitioners could inform themselves from the technical literature as to conditions for which bleeding was appropriate, together with the correct vein to incise for each. Most commonly, blood was drawn from one of the three major veins of the arm (the cephalic, median, and basilic); but other veins were opened for particular conditions—for example, melancholy might call for bleeding from a vein in the forehead. Bloodletting was normally performed by surgical venesection, although leeches were also used on occasion.

As an alternative to instrumental bloodletting, the leech offered some advantages. The leech's slower, less painful, more quantitatively dependable extraction of blood was favored by many practitioners. In addition, blood loss at the bite site persisted long after the leech released its grip. Also, as Adams noted, certain body sites in need of bloodletting, such as hemorrhoids, rectal prolapse, and vulvar inflammations might preferably be bled by an anonymous annelid rather than a man with a lancet [10]. Avicenna (d. 1037), the great Arabic physician, believed that leeches drew blood from deeper sources than did wet cupping. His *Canon of Medicine* includes several pages of instruction on leeches [11].

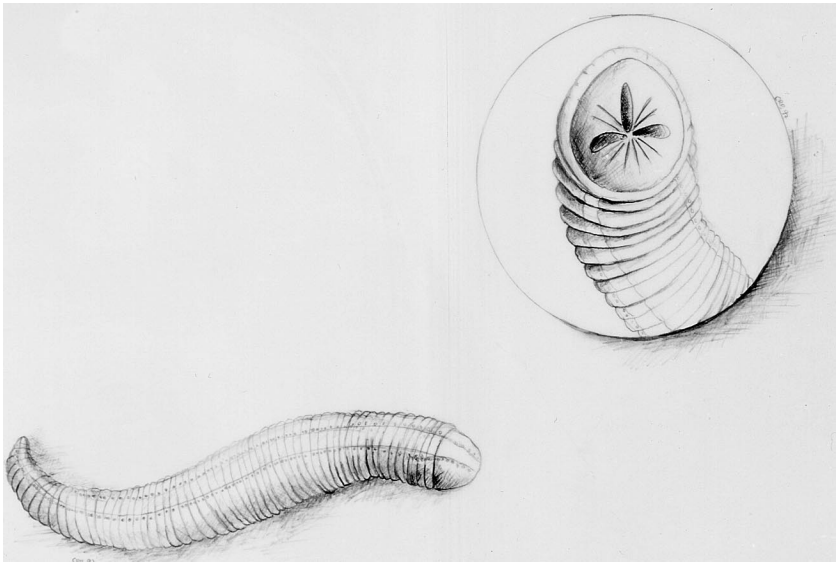

Fig. 2. Leech. (Drawing by Carolyn Barritt.)

One should not employ leeches taken from unhealthy water or those whose excrement is black and muddy, and whose movement immediately darkens water, and renders it offensive in smell. . . . Leeches should be kept a day before applying them, and they should be squeezed to make them eject the contents of their stomachs. If feasible, they should be given a little lamb's blood by way of nourishment. The slime and debris from their bodies should be cleansed off, say, with a sponge . . . the place where the leeches are to be applied must be well laved with nitre water and rubbed till red. Dry carefully. Dip the leeches in fresh tepid water, cleanse and apply [with one's freshly washed hand, or with a soft towel. . . .] The leech must not be let go until it has taken proper hold, as one can tell by the sinuous movements of the neck and from the circumstance that the head forms a right angle to the body. To ensure that they will not crawl into the gullet, or nose, or anus, one must draw a thread through the tail end from above down—not from side to side otherwise one would injure the large blood vessels of the animal.

The wandering leech was a feared clinical dilemma: a swallowed leech could be flushed through by drinking copious amounts of salt water; a leech that found refuge up the anus could be removed by salt water enema. Avicenna suggested that one might wish to detach a leech before satiety to prevent fainting or cramps. He admonished against forcible removal of leeches and recommended a sprinkling of salt, pepper, or snuff. The site should then be sucked by cupping to remove toxins. If bleeding persisted, Avicenna employed a dusting of burnt galls, quicklime, ashes, cobwebs, ground earthenware, or alum. Failing these, he suggested cautery. He acknowledged the particular vulnerability of children and recommended watching them overnight after leeching.

Medieval Medical Practitioners in England

In England, during the early Medieval Period, the first record of medieval medical practice (that survives) is called the *Leech Book of Bald*, written probably between AD 900–950. (The title comes from the colophon, i.e., the scribe's remarks, at the end of the book.) It thus antedated the great influx of texts from Arab sources and, in fact, draws most of its information from native Anglo-Saxon (Germanic) sources and from classic Greek and Roman sources. Its contents are mainly descriptions of diseases and ailments and treatments for them. The term "Leech Book" refers to the medical origin of the word and means "a book on medicines." Its owner was named Bald, of whom we know nothing; but we can speculate that he was probably a medical practitioner.

During this period in English history, physicians were trained primarily in monasteries or monastery schools. Somewhat later, when the church was better established, they would be trained at cathedral schools. Although bloodletting or venesection was practiced, most often it was a prophylactic measure. One reference extant from Medieval England refers to bloodletting by leeches in a Latin text, written by Aldhelm of Malmsburh (AD seventh or eighth century) in his Enigmata, a series of Latin riddles. The riddle under discussion may be translated thus: "I bite unfortunate bodies with three-furrowed wounds and bestow a cure from my healing lips" [12].

As the Old English period progressed to the Middle English period (1100–1500), subspecialties of medical workers began to develop and formed groups, with their own traditions, specialized knowledge, procedures, and training. Whereas earlier the term "leech" seemed to refer to all medical practitioners, now specialized practitioners needed their own organizations and titles. With the formation of medical schools in the universities (first in Italy, later elsewhere) and with knowledge gained from the translated Arabic medical writers, the term "physicus" came to mean a university-trained physician.

"Physician" entered the language around 1200, from French. The term "doctor" originally meant a religious teacher or scholar and is first recorded in 1303. The word "doctor" was quickly extended to mean one having the highest university degree (medical doctors were at first excluded from university faculties) and eventually to one having a medical degree: This development occurred during the fourteenth century. "Surgeon" was also an addition from French, about the year 1300. Historically the surgeon's art was considered inferior to that of the physician, as shown by the following translated quotation from John de Mirfield's *Florarium Bartholomei* (?1404) [13].

Table 1. Hierarchy of terms for medical practitioners.

Anglo-Saxon (c. 700–1100)
Leech (applied to all types of medical workers)
Middle English (1100–1500)
Doctor of physic, physician, leech
Surgeon (leech)
Apothecary
Barber-surgeon, bloodletter
Midwife

> If I am not mistaken, physicians long ago practiced surgery. Nowadays there is a clear distinction between physicians and surgeons. I fear it has arisen through pride, as physicians loathe working with their hands—though I suspect that this is because they do not know how to operate. Such an unhappy development has made people believe that an individual cannot practice both disciplines. But the well-informed realize that no one can become a good doctor by neglecting all surgery and, on the other hand, that a surgeon is worthless if he is ignorant of medicine.

Despite the attempt (mainly by physicians, it must be said) to keep surgeons in an inferior rank, the great Guy de Chauliac called himself a "physician and surgeon"; and Chaucer's fictitious "Doctour of Phisik" was also so described. Other separate specialties and their approximate dates of appearance in English are "apothecary" (about 1387–1395, in Chaucer); "blood-letter" is from the Old English period; "barber" (i.e., barber-surgeon, one who practiced both hair-cutting and minor surgery) is first mentioned during the early fourteenth century; "midwife" is a coinage in Middle English that dates back to about AD 1300 (Table 1).

By the end of the Middle English period, leech, the Old English term for any kind of medical worker, had become too diffuse in its range of meanings to be useful and was rapidly disappearing from the active lexicon. (Shakespeare, during the next century, used the word only once in his written works.) As it lost its usefulness, its place was taken by a number of newly imported words from French and Latin sources. If we stretch our imaginations, we can see the loss of leech as a kind of linguistic Darwinism by which words become obsolete and disappear because of failure to adapt to a changing linguistic environment. Ironically, the word reappeared during the eighteenth century as a metaphor for an individual who is dependent on the resources of another (i.e., a parasite). From a term of respect early in its history, it had become a term of denigration.

Leeching during the Renaissance and in Industrial Society

Vesalius in 1539 became embroiled in a fierce debate in which Hippocratic venesection for pleurisy from veins ipsilateral to the site of disease was pitted against Arabic venesection, which bled the contralateral side [14]. Phlebotomy in the New World was not just an extension of European practice. There is evidence that some Native Americans, particularly the Great Lakes tribes, practiced it using sharp flints [15]. An early colonial American physician, Thomas Palmer, completed a book in 1698 that may have been the first medical treatise written in New England. He wrote, "In some cases blood-letting saves life and in some cases destroys it. In abundance of blood and in inflamed blood, open a vein" [16]. He did not seem to use leeches and no doubt resorted to sharp venesection. Colonial American practitioners often relied on phlebotomy and venesection. In 1786 the average charge for phlebotomy was one schilling [15].

Leeching ballooned into a medical craze in seventeenth through eighteenth century Europe. The factors behind this included disregard and ignorance of the strict bloodletting rules advocated by Galenic doctrine, an expansion of fanciful indications for phlebotomy, the population growth of industrialized society, and the increased cadre of professional healers. F.J.V. Broussais (1772–1838) was perhaps the most influential advocate of leeching in France. He was a pupil of Marie Francois Xavier Bichat (1771–1802), the founder of modern histopathology. Broussais served as one of Napoleon's physicians and became professor of general pathology in Paris. He promoted some rather arbitrary doctrines, including a therapeutic approach that went beyond conventional phlebotomy—bleeding not just to remove a local surfeit of blood but to create a constitutional weakness. This was his "weakening antiphlogistic regimen" [17]. Broussais applied 10 to 50 leeches at one time to any patient, thereby utilizing hundreds of worms daily in his practice. He treated typhoid fever, syphilis, variola, worms, tuberculosis, or mental diseases by applying leeches to the abdomen [18]. Largely due to his enthusiastic promotion of leeching, more than a billion leeches were imported into nineteenth century France [2].

Von Ronsenstein, in the first printed textbook on diseases of children, advocated leeching for difficult dentition, tooth abscess, convulsion, scarlet fever, pleurisy, or inflamed eyes. The English edition was published in 1776. Regarding disease of the throat he wrote [19]:

> We know very well what an incomparable effect blistering has in a rheumatism, toothache, in the common sore-throat and in all colds or rheumatisms in what place soever; so that there is reason to expect a good effect in this disease likewise. But bleeding and leeches ought, without dispute, to have been used beforehand.

Thomas' treatise on domestic medicine, written in 1822, advocated leeching [20]: "Topical bleeding may be performed in two ways, viz. either by the application of leeches or cupping with previous scarification. Leeches are highly useful, and can be applied to the most delicate parts, as the eyes, gums, breasts, testicles, etc. where cupping cannot be employed." Thomas comments that continued bleeding after the leech drops off is desirable and should be encouraged. Mention of medicinal leeches in Australia dates back to 1824 [21].

Gross' *System of Surgery* in 1859 advocated leeching as a minor surgical procedure [22]: "Abstraction of blood may be effected by scarification, puncture, incision, leeching, and cupping. The fluid is sometimes taken from a vein or an artery; the operation, in the former case, constituting venesection, and in the latter, arteriotomy." Gross commented that applications of leeches (three to five) to the uterus or upper vagina may be accomplished by placing the animals in the speculum, "the parts having been previously well cleaned with water." A Gross disciple, Charles de Nancrede, who became Professor of Surgery in Ann Arbor, mentioned leeches in his textbook, *Lectures on the Principles of Surgery*. The comment went unchanged from the 1889 to the 1905 edition: "Diminution of the contents of the veins may be effected by means of leeches on wet-cups always remembering that to be useful the blood must be drawn from the vein" [23].

Contemporary Leeching

Leeches are valued today for scientific study, largely related to their nervous system, and for several specific aspects of phlebotomy. When free flaps of tissue, ears, or digits are anastomosed, the arterial access may be more dependable than the venous and lymphatic drainage. Thus leeches are currently used for grafted skin flaps, breast reconstruction, digital replants, and periorbital hematomas. Lingual trauma with massive hematoma has also been treated successfully by leaching [24]. Leech decompression and the pharmacological effects of leech saliva, enhance access and egress of blood at the operative site. Gram-negative infection from the leech's surface flora and colonized gut bacteria is a potential concern; and treatment of the host with third-generation cephalosporins or trimethoprim-sulfamethoxisole is effective. Several *Pseudomonas* species populate leech surfaces [25]. The antibiotics sterilize the leech gut, but this is a concern mainly for the worm, as leeches are intended for single use in clinical practice.

Techniques of leech applications today are not much different from Avicenna's methods. His precise descriptions and logical methods 1000 years ago should humble modern healers, who forget that they stand on the shoulders of a number of giants. Avicenna's insistence on cleaning not only the leech but also the application site and the applicator's hands is common antiseptic sense that Holmes, Semmelweis, and Lister rediscovered for themselves 800 years later and struggled to prove to resistant colleagues.

Leeches may be kept in a hospital pharmacy in a refrigerated jar filled with spring water or a solution of commercially available salts [Hirudosalt Biopharm (UK), Westbury, NY, USA] in distilled water. The worms typically are applied to a flap or digit three or four times daily for the first postoperative days, with the applications tapered off as venous insufficiency resolves. The first application should be deferred long enough to allow the anesthetic to clear; otherwise, the leech does not feed. This phenomenon has been called the "lazy leech syndrome." Lean, hungry leeches should be selected. A drop of glucose solution on the attachment site and anterior sucker encourages attachment. Gloves are worn to prevent a leech from picking the wrong host. Peristaltic motions of the leech indicate active feeding, after which it may drop off. An alcohol or saline swab encourages a recalcitrant leech to drop.

Despite millennia of human progress, the leech can still be a clinical problem, beyond one's sensory displeasure on discovery of hosting an annelid. Serious consequences of leech bites include exsanguination from a pharyngeal leech, nasal infestation, respiratory obstruction, and vaginal infestation [26–30]. Urologic leech injury has been related to rice paddy field work. One young man suffered vesical access with clot retention from an arterial spurter proximal to the bladder neck. Another paddy planter had urethral hemorrhage resulting in shock and a three-unit blood transfusion. In neither instance was there recognition of the leech entry, but in both cases the leech was noticeably expelled well before the clinical crisis [31].

Recent phylogenetic analyses suggest that blood-feeding by leeches may have arisen independently on two occasions [32]. If this is the case, enzymes involved with anesthetizing skin at the feeding site and with preventing coagulation in various groups of leeches are independently derived as well, and further investigation may uncover additional capabilities and applications for those enzymes. Over hundreds of millions of years, natural selection developed a variety of enzymes carried by organisms that have various immunologic, antibiotic, and anticancer effects; and we may assume that this is true for enzymes with anticoagulant and anesthetic properties as well. Leech salivary gland extracts from *H. medicinalis* have potent antimetastatic properties in vitro [33]. New leech species are being discovered, such as the troglobitic leech found in a groundwater system in Romania [34, 35]. The richness of earth's diverse organisms, including leeches, will provide more useful agents than we could find by experimenting with combinations of chemicals from the laboratory shelf [36].

Résumé

Fond: Un riche contexte social entoure le mot «sangsue» et son utilisation. Nous fournissons l'histoire linguistique et médicale de ce mot, et explorons sa biologie et son histoire clinique. Méthodes: Notre rapport historique s'étend depuis le premier enregistrement de l'utilisation des sangsues jusqu'à présent. Résultats: En dépit des interprétations variables quant à sa qualité thérapeutique, l'utilisation des sangsues garde encore aujourd'hui, quelques indications. Conclusion: De nouvelles investigations pourraient mettre en évidence encore d'autres applications des sangsues, en particulier, pour utiliser leurs enzymes qui ont des propriétés anesthésiques, d'anticoagulant et d'anti-métastatiques.

Resumen

Antecedentes: La historia de la palabra sanguijuela y la utilización de este gusano anélido acuático como chupador de sangre en medicina, demuestra la existencia de una historia social interconectada. Se efectúa una historia lingüística y médica de la palabra sanguijuela, estudiándose además su biología y su historia clínica. Métodos: Nuestra revisión histórica abarca, desde los primeros conocimientos recogidos de la sanguisucción, hasta las actuales investigaciones al respecto. Resultados: A pesar de los altibajos históricos en la valoración de esta técnica terapéutica, la utilización de sanguijuelas es útil en la actualidad y tiene numerosas aplicaciones. Investigaciones futuras propiciarán una mayor utilización de las sanguijuelas y, especialmente de sus enzimas con propiedades anestésicas, anticoagulantes y antimetastásicas.

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