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The origins of zoopharmacognosy: how humans learned about self-medication from animals

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Abstract

The term zoopharmacognosy was first introduced in 1987 as a multidisciplinary study of the self-medication behavior of many kinds of animals. Humans and non-human animals have been observing and interacting with each other since prehistoric times and learning about nature together. Humans have probably been aware for a long time that animals used specific substances in certain ways when they were sick and that this sometimes helped them to heal. Thanks to zoopharmacognosy, we are beginning to learn more concrete aspects of this relatively new branch of science that deals with how animals treat disease with organic or inorganic substances that they find in their environment. In some cases, they even seem to use plants or other natural items as drugs in a very similar way to ourselves in order to treat the very same symptoms that we do. Although zoopharmacognosy is a young science, in this study we searched for and analyzed the relevant early data and precedents in published papers and from historical sources that endorse the remarkable antiquity of the attention and concern of humankind for it.

Keywords: Zoopharmacognosy, self-medication, human-animal interaction

Introduction

Animal self-medication is referred to as zoopharmacognosy and has only been considered a legitimate scientific discipline since it was first formally introduced in 1987 [1]. In brief, it describes the process by which animals select and use plant secondary metabolites or other non-nutritional substances for preventing and treating diseases [2]. Since prehistoric times, man has looked to wild and domestic animals for sources of herbal remedies and early humans may have selected medicinal plants by observing the behavior of animals. Animals also learned about which plants and other substances to use for self-medication by watching other animals [3], a phenomenon that has been studied in both inter- and intra-species interactions.

Since the introduction of zoopharmacognosy as a scientific discipline, many new drugs that are now in use were found by studying animal self-medication behavior [1]. According to some authors, self-medication can be classified in two distinct forms—prophylactic and therapeutic. Prophylaxis serves the purpose of prevention or reduction of the likelihood of a pathological condition, and can be utilized by healthy and unhealthy individuals alike. On the other hand, therapeutic self-medication is the curative use of anti-parasitic, antitumor, antiviral or antibiotic substances by already diseased individuals to fight or eliminate the affliction [4]. In other words, animals try to treat and heal themselves just as humans do.

One of the most common health problems that animals have to face is parasitism. Although there are multiple ways in which an animal can self-medicate, one of the most effective ways to prevent parasitism or fight a parasite is by changing foraging habits. This daily and necessary practice may ameliorate the impact of parasitism in three ways: hosts could (1) avoid foraging in areas contaminated with parasites, (2) select diets that increased their resistance to parasites, or (3) select foods containing anti-parasitic substances [5]. In this case we could say that behaviors 1 and 2 are part of the prophylaxis form of self-medication, whereas behavior 3 could be either prophylactic or therapeutic, depending on the presence or absence of parasitic infection in the animal.

Ingesting plants for nutrients and as medicine are means to the same end--staying well--and this behavior applied to ancient humans as well as animals [2]. Food selection by herbivores can be interpreted as the constant quest for substances in the external environment that provide a homeostatic benefit to the internal environment [6]. Herbivores not only seem to be able to maintain homeostasis and learn to avoid certain foods because they lower their fitness, but also learn to ingest other substances in the environment as drugs to prevent or treat disease [2]. There is evidence of self-medication in a great number of animal groups, from arthropods [3, 4, 7, 8], to bears, geese, leopards, dogs [9, 10] and, above all of them, the observation of great apes could provide the clearest scientific evidence of self-medication [1, 3, 8, 9, 10, 11, 12]. None of these cases should really be a surprise, since preservation of health is a basic principle of survival for both humans and animals. Many traditional human societies around the world are still very much dependent on plants for both food and medicine [3]. In this paper we tried to picture what the historical background of zoopharmacognosy was like, long before the word was in use. It is very likely that among the comments and observations that naturalists, philosophers and scholars from past ages left reflected in their manuscripts, there were some discoveries of certain therapies that proved beneficial to human health that came from watching what animals did when they were sick. Our work aims to be a way to show that the study of animal self-medication is not just a recent invention. Clearly, it has developed concurrently with many other sciences as we found in our examination of the historical record. Ours is not the first attempt to explore the history of self-curing among animals. Magyar [13] examined the historical background of this behavior among a selected group of animals that were mentioned in ancient manuscripts along with their self-curing habits. Although he cited some classical authors like Aristotle and Pliny, the study focused mainly on evidence from the 16th and 17th centuries. We tried to update this research to fill in some of the gaps, and also to find contemporary explanations, new records and behavioral observations throughout the scientific world coinciding with the birth of zoopharmacognosy.

Historical Precedents: 4th Century BCE – 14th Century CE

***Historia animalium* (History of Animals)**

Aristotle (384-322 B.C.) was a pioneering philosopher and scientist who wrote about geology, physics, psychology, medicine and biology among other subjects. In *Historia animalium* he investigated the differences in specific animal body parts and organ systems (Books I to IV), differences in reproductive strategies (Books V, VI and VII), and differences in certain characteristics, habits of animals and relative intelligence (Books VIII and IX). In particular, the eighth volume explores the behavior and habits of animals, what they eat, how they migrate, their health and diseases, etc. Arguably, some of the most ancient descriptions of animal self-medication are found in Book VIII of Aristotle's *Historia animalium* [14].

For instance, in Book VIII Aristotle wrote about the wolf (*Canis lupus*) that "in extremity of hunger, it will eat a certain kind of earth". This behavior is known today as geophagy, and is displayed by humans and animals alike. It is thought to be either a form of nutritional supplementation

or detoxification, and many other examples can be found in the animal kingdom [15, 16]. Aristotle then continues explaining that "these carnivorous animals never eat grass except when they are sick, just as dogs bring on a vomit by eating grass and thereby purge themselves". Many studies suggest that it is a way to fight stomach distress, but other reasons include improving digestion, treating intestinal worms or fulfilling some unmet nutritional need, for example, the need for fiber [17, 18].

In regard to the hibernation of bears (*Ursus* sp.), he observed that:

The bear hides for at least forty days; during fourteen of these days it is said not to move at all, but during most of the subsequent days it moves, and from time to time wakes up (...). There can be no doubt but that during this period they eat nothing; (...) It is also said that from no food taken the gut almost closes up, and that in consequence the animal on first emerging takes to eating 'arum' (common name for several varieties of lily) with the view of opening up and distending the gut.

The early Swedish settlers around Philadelphia, USA, called the lily known today as skunk cabbage (*Symplocarpus foetidus*), bear-weed, because bears relished the plant as an important early spring source of food [19].

About the domestic pig (*Sus domesticus*), he claimed that they:

Never take this disease (measles) while they are mere sucklings. The pimples may be got rid of by feeding on this kind of spelt called 'tiphe' (Greek word for a type of wheat known as einkorn or "one-grain"); and this spelt, by the way, is very good as a food grain.

This commentary on one of the animals that shares more history with humankind than many others presents us with the idea that medicine and food are commonly two sides of the same coin.

***Naturalis historia* (Natural History)**

This encyclopedia of natural sciences was written by Pliny the Elder, c. 77-79 CE [20]. It is divided into 37 books, in ten volumes, with topics including ethnography, anthropology, zoology and pharmacology. Book VIII is called "The nature of the terrestrial animals", where several references of animal self-medication can be found.

From this point on, the influence of Aristotle's work was evident in many of the manuscripts that we examined. In his *Natural History*, Pliny the Elder described the behavior of geophagy in animals like wolves and elephants. Regarding the biggest terrestrial mammal, he also wrote that "according to Saint Epiphanius, they eat mandrake (*Mandragora* sp.) first, to wake up the Venus". He makes reference to the aphrodisiac properties of the plant, which has been used since ancient times for both magical and medicinal purposes [21].

It was believed that elks (*Alces alces*) "suffer very usually of a grand mal (*epilepsy*); and for that the remedy is to put its own right hind foot on its heart; because that hoof has so much virtue, that it takes that pain away". Probably due to their resemblance, also the reindeer (*Rangifer tarandus*) was thought to have the same virtue in the hoof. In Sweden and

Denmark, for example, the hoof of an elk is used to cure human epilepsy^[22].

Pliny the Elder suggested a treatment against snake bites: “The most opposite thing to snakes are said to be the crabs, which are used by bitten animals to heal themselves”. He also seemed to know how panthers self-medicated, and according to him “when it is sick, it searches a wild goat to drink its blood, or the dirt from the man, for being this its remedy”.

De natura animalium (On the nature of animals)

In comparison with Aristotle’s and Pliny’s works, Claudius Aelianus (2nd-3rd century CE) gathers in a total of 17 books an unordered list of anecdotes and stories regarding the animal world^[23]. Nevertheless, he seems to have attributed self-medication behavior to more animal species than any other author that we considered.

To begin with, he stated that:

Thanks to a mysterious and admirable natural instinct, even the ‘irrationals’ protect themselves from the evil eye of sorcerers and witches. For example, I heard someone say that, in order to prevent against witchcraft, common wood pigeons peck at the young laurel sprouts and put them afterwards in their nests as a protection for their chicks; kites (Milvus spp.) bring codeso (Adenocarpus spp.); falcons, bring picris (Fam. Asteraceae); while turtle doves bring iris fruit; ravens, monk’s pepper (Vitex agnus-castus); but hoopoes (Upupa epops), bring Venus’ hair-fern (Adiantum capillus-veneris); (...) carrion crows (Corvus corone) bring vervain (Verbena spp.); (...). Eagles take the stone that is named after them, which is the ‘eagle stone’ (Aetites). It is said that this stone is good for pregnant women, because it helps to avoid miscarriage.

Concerning one of the most frequently discussed birds we found, the swallow (*Hirundo rustica*), Aelianus wrote that “also cockroaches (probably *Stenopteryx hirundinis*, a parasite of swallows) damage their eggs; that’s why mothers protect their chicks with celery leaves (*Apium graveolens*) and, by doing so, they turn out to be unreachable to them”.

In addition, the author stated that, to his understanding, “the most admirable gift offered by nature to swallows is as follows: in case their eyes are pierced by a brooch, they recover their sight”.

A whole paragraph is dedicated to the elephant (Fam. Elephantidae), with the title “Medicine in the Heroic Age. Elephant self-medication”. It represented the first literal mention of animal self-medication we found in our study. In this case, when the elephant “is hit by spears and a bunch of arrows, it eats the olive tree’s flower or drinks olive oil, and gets rid of every projectile thrown against it, and remains completely healthy”. In his review, Magyar^[13] considers that “Aelianus wrote *oil* instead of *aloe* possibly because of a wrong version of the word”. If this is true, the excerpt we just quoted about elephant self-medication actually describes the use of *Aloe* by these animals. However, due to the well-known medicinal properties of most parts of the olive tree (*Olea europaea*), we cannot confirm or refute the allegation.

Not only does Aelianus acknowledge self-medicating behavior in a wide range of animal species, but he also claims that we humans learned from them: “Egyptians say

that it was not the human wisdom that discovered enemas and intestinal purges, but consider the ibis (possibly *Geronticus eremita*, the northern bald ibis) to be the master who taught this remedy to us”.

Another situation, this time regarding falcons, which:

When suffering from the eyes, they go straight to a stone wall and pull a wild lettuce; then they put it above their eyes and let the styptic and bitter juice pour into their eyes, which ensures them health (...). And men don’t refuse to call themselves the bird’s disciples, confess it.

The wild lettuce referred to by Aelianus seems to be *Lactuca scariola* or *L. serriola*, known for the medicinal properties of its latex; in particular its use against eye ulcers and inflammation^[24].

Continuing with birds, and going back to the swallow (whose name in Spanish is “golondrina”):

Chicks are slow in opening the eyes (...), but swallows collect and bring a herb (Chelidonium majus, called in Spanish “golondrinera” in a reference to their ancient relationship, and known as “celandine” in English^[25]) and with it step by step they get to see; (...). Men burn with desire to owning this herb, but they didn’t achieve their purpose yet.

A short paragraph further on summarizes the subject of our investigation nicely: “Natural medicines used by animals”. Here Aelianus says that “it seems that Nature has provided dogs with an herb to cure their wounds themselves. If they are tormented by worms, they eliminate them by eating wheat greens. And it is said that when they need to evacuate both stomachs (stomach and intestine), they eat certain herb and they vomit the undigested food, whilst they excrete what is left. It is said that, from this dog’s behavior, Egyptians learned the habit of purging. It is known that partridges (*Perdix* spp.), storks (*Ciconia ciconia*) and turtledoves (*Streptopelia turtur*), when injured, they crush oregano and, afterwards, putting it on the wounds, they cure their bodies and have no need, at all, for the medical art of men”.

Proceeding now with the behavior of bears, he says:

Due to the excessive wasting, has a wrinkled and compressed intestine. Knowing that on her way out, she eats the herb called “wild arum” (Italian arum – Arum italicum). And as it has flatulent properties, it relaxes and widens the intestine, making it able to receive food. And when she feels full again, she eats some ants and evacuates the bowel.

Continuing, we found another section with an interesting title: “The snake and the poisonous herbs it eats”. Aelianus wrote that snakes used the juice from an herb called *Picris* (probably the same mentioned before to be used by falcons in their nests), when they are about to eat fruit, in order to avoid inflating. Nowadays known as bristly oxtongue (*Helminthotheca echioides*), this herb’s boiled leaves are still used to treat diarrhea in some Eastern Europe countries. Some other paragraphs from Aelianus discuss a wide variety of animals and healing behaviors:

The goat is, without doubt, an expert in curing the

cloudy vision that asclepian doctors called cataracts, and it's said that men learned from it how to cure this disease. The treatment goes as follows: when the goat notices that its vision fogs up, it approaches a bramble and pricks a thorn into its eye. The humor flows out of the eye: the pupil suffers no pain and the goat recovers sight. They don't need the science or treatment from humans, at all.

I understand that unscathed elephants extract javelins and darts from their hurt congeners, as if they were experts on surgery and knowers of the art that handles these issues.

"The dog and its medication": dogs affected by repletion know about an herb that grows on the dry stone walls. By eating it, they vomit everything that causes them pain mixed with phlegm and bile, they have abundant excrementitious evacuations and restore their health with no need of medical assistance; they evacuate, moreover, a great amount of black bile which, if retained inside the body, would provoke rabies, that is a terrible illness for dogs. (...) If dogs are infected by worms, they eat the wheat spikes, as Aristotle affirms. When they are hurt, they use their own tongue as a remedy (...) Nor does the dog ignore that ash tree fruits make pigs gain weight, but it causes it pain in the haunches.

This last sentence is quite remarkable, as it suggests a particular branch of zoopharmacognosy that hasn't been properly explored yet, perhaps because it refers to a capacity difficult to be assigned to non-human animals: the ability to recognize the medical properties of a substance, whether or not they decide to use it.

De mirabilibus mundi (The wonders of the world)

This book is a written compendium of curiosities in which the author, Gaius Julius Solinus (3rd century CE), after a short description of the ancient world, answered several natural history questions among other topics ^[26].

Solinus agreed with Pliny about how panthers managed to heal themselves using human dirt:

*The Hyrcanian people kill them more frequently with poison than with iron, spreading meat pieces with poisonous herb, and leaving them near the crossroads: after eating them, panthers develop tonsillitis, and that is why this herb is known as leopard's bane (*Donoricum pardalianches*), which means leopard strangler: however panthers resist this poison with natural instinct by eating human dirt.*

Another reference appears when the writer described that deer "discovered the herb called dittany (*Origanum dictamnus*), because by eating it, they extract the arrows that were shot to them: they also eat the herb known as *Cynara* against the poisonous herbs from the pasture". Aristotle claimed the same use of dittany by wild goats. As for *Cynara*, the author was probably referring to the artichoke (*Cynara scolymus*), whose leaves are used to treat hepatic diseases and gastrointestinal spasms ^[27], or perhaps to its naturally occurring variant, the cardoon (*Cynara cardunculus*).

Animals were also believed to be able to find antidotes against poisons from venomous animals or toxic plants. The

mandrake was thought to be deadly for bears, and they learned to neutralize its poison by eating ants "to regain health". Furthermore, "if any elephant eats perhaps a chameleon, which is a poisonous animal for them, they heal by eating wild olive tree (*Olea europaea* var. *sylvestris*)".

Etymologiae - De animalibus (Etymologies – About animals)

Isidore, Bishop of Seville (560-636 CE), compiled this encyclopedia by subject providing etymologies for terms ranging from agriculture to city names, rivers and animals²⁸. This work was the preferred reference for most of the following medieval bestiaries. Once again we find the claim that deer use dittany to repel arrows and keep them safe from harm, but Isidore also stated that deer and snakes were enemies, "and when they feel sick, they pull the snakes out of their dens with a snort and heal by devouring them, since the poison makes the sickness disappear".

Although it is only slightly related to animal self-medication, we found the description Isidore made about beavers (*Castor* sp.) quite intriguing. "Beaver testicles were used in the making of medicaments, and because of that, when they notice the hunter presence, they castrate themselves with their teeth". There is an interesting connection with the testicle myth and the name, *Castor*, which is thought to come from the word *castrare* (castrate). We didn't find any reference about animals using beaver's testicles for self-medication, but there are plenty of manuscripts referencing the belief that beavers were able to understand why hunters were going after them. It is also interesting to discover that this myth continued to be repeated in the bestiaries of the medieval period and up to recently ^[29].

Codex Bongarsianus 318 – Bern Physiologus

This is perhaps the most outstanding of the various manuscripts in the Burgerbibliothek of Bern. It is the oldest known copy of the Latin manuscript, *Physiologus*, transcribed and illustrated in the 9th century, and especially appreciated for its stylistic and iconographic importance ^[30]. Here we found a detailed description of the elephant mating ritual, again using the aphrodisiac properties of the mandrake as we mentioned before:

They don't have a desire for carnal union. When they want to copulate (...) they find the mandrake, which puts the female in motion. She takes it and offers it to the male, and plays with him until he eats it. When the male has eaten it, he mates with the female, and she conceives.

Aberdeen Bestiary

This early manuscript is a compendium of short descriptions about all sorts of animals, real and imaginary, and other components of nature accompanied by moralistic explanations. The Bestiary appeared in its present form in England in the 12th century as a compilation of many earlier sources, principally the Bern *Physiologus*. The colorful and imaginative illustrations representing the natural world are the main attraction, but one should not consider this a scientific reference work ^[31]. We have already seen examples of the belief in self-curing repeated and confirmed by different authors in different ages and cultures, and the Aberdeen Bestiary is yet another source of this evidence.

We chose this work as an example of this type of literature, which deals with an interesting part of animal biology. Here we found again how elephants use mandrake for courtship, the enmity between deer and snakes, and how deer and wild goats use the herb dittany, among others.

Bears don't neglect the business of healing themselves either:

If they are afflicted by a mortal blow and injured by wounds, they know how to heal themselves. They expose their sores to the herb called 'mullein' (the Greeks call it 'flomus') and are healed by its touch alone. When sick, the bear eats ants.

Regarding the birds, the swallow (*Hirundo* sp.) was believed to have a special skill in the arts of healing: "If its young are infected by blindness or pricked in the eye, it has some kind of healing power with which it can restore their vision". Also reptiles had their own way of treating diseases: "The tortoise when it feeds on a snake's entrails and becomes aware of the venom spreading through its body, cures itself with oregano".

El libro de las utilidades de los animales (The book on the usefulness of animals)

This manuscript, # 898 from the Monastery Library of San Lorenzo de El Escorial in Madrid, is basically an encyclopedic description of animals that were useful to human beings in many different ways^[32]. The author Ibn al-Durayhim (1312-1361) was born in Mosul and died in Qus (Egypt). In addition to the ethno-zoological descriptions of most of the animals included, there are details about how they used plants and other substances to protect themselves from parasites and to treat illness.

Among birds, as we have previously seen, one of the most interesting species is the swallow. In this book from the Madrid library, the author gave a twist to its magical healing capability:

When the nestling is in pain, the parents heal it with a medicine that they know (it is said that they heal most frequently with turmeric wood). It is also said that if the nestling's eye is poked with a needle until it goes blind, its parents prepare a medicine for the eye and it recovers from blindness. When it is done and both eyes are recovered and the nestlings are incinerated, becomes from them a very useful medicine for the sight weakness.

The turmeric family, *Zingibaraceae*, includes species like cardamom and ginger with well-known medicinal properties.

The so called *Aetites* or eagle stone is a hollow geode containing loose matter, a smaller stone or sand, which rattles when shaken. According to al-Durayhim:

For the female eagle it is difficult to lay eggs, and when it happens, the male searches for a stone found in some regions of India (which is similar to a chicken egg, and inside it, when it is shaken, you can hear the sound of movement) and he puts it under the nest.

These stones are mentioned by Dioscorides about 69 CE and in the fourteenth edition of Quincey's *Pharmacopoeia*,

published in 1769, among many other documents in-between these dates^[33]. They were used by humans mainly in the form of an obstetrical lapidary amulet^[34].

The examples about mammals are especially interesting, primarily because in some cases they have been observed and proven at the present time. "When the cat smells the scent of lavender, it gets drunk and puts himself into a trance state, gets angry and salivates". In this first example, it is likely that the author mistook catnip (*Nepeta cataria*), a perennial herb belonging to the mint family (Labiatae) for lavender (*Lavandula* sp.). Compounds in catnip have the described effects on wild and domestic cats. The response to catnip is characterized by sniffing, then licking and chewing with head shaking, followed by chin and cheek rubbing and then a head-over roll and body rubbing. Spontaneous vocalization occurs occasionally and has been interpreted as a response to hallucinations. This reaction is similar to estrous rolling patterns and this probably made people think that catnip was an aphrodisiac. The effects must be pleasurable as cats will always find catnip plants and return daily to eat and roll in the foliage^[35].

About the bear, al-Durayhim wrote that it heals its wounds with an herb called *falumas*, which it chews and spits on top of them. North American brown bears (*Ursus arctos*) reportedly make a paste of *osha* roots (*Ligusticum porteri*) and saliva, rubbing it through their fur to repel insects or soothe bites. This plant is locally known as bear root, and contains 105 active compounds that may repel insects when topically applied^[36].

Another example of this sort of self-medication concerns the *tuzāj*, which is the wild goat (*Capra aegagrus*). "When it gets hurt, it seeks the green that grows on the stones, chews it, puts it on top of the wound and heals". This could probably refer to the moss (*Sphagnum* sp. and other genus), which has been used to dress wounds since the Bronze Age. We know nowadays that *Sphagnum* wound dressings combat infection by immobilizing bacterial cells and depriving them of their nutrients^[37].

Currently we are aware of the use that many animals make of mud to get rid of ectoparasites. Al-Durayhim explained that the buffalo "gets hurt by the bedbug and tries to protect himself from it with mud". One of the most common animals that exhibit this wallowing behavior is the domestic pig^[38]. Other species that show this same strategy to clean their hair and skin are wild boars (*Sus scrofa*)^[39], peccaries (*Tayassuidae*), giant anteaters (*Myrmecophaga tridactyla*)^[40], white and black rhinoceros (*Rhinocerotidae*) and elephants^[41].

The importance of knowing and acknowledging conclusion

Among all the written literature that we have inherited, from classical antiquity to modern history, we managed to review a wide range of manuscripts and select a few of them just to show that even though zoopharmacognosy is in fact a young science, the study of animal self-medication behavior goes back at least as far as the ancient Greeks. Since they were profoundly influenced by Egyptian beliefs and practices, it could have arisen much earlier than is thought.

Animals use natural substances to treat and heal themselves and others, and to prevent symptoms and diseases. They are also able to detect the medicinal properties of things in their environment even if they don't benefit from them. And that

is why we think researchers should include the study not only of animal self-medication in zoopharmacognosy, but also the ability inherent in an animal (or acquired by them) to sense the potential use of something as a medicine. Finally, the literature we consulted proves that humans have observed and imitated a wide range of animals living around them^[42], garnering many therapeutic practices and maintaining them over the centuries. That information can help today's researchers discover new drugs and therapies, but also unveil the origins of the many natural medicinal substances used by humans. In this paper, we investigated the origins of this common animal behavior that constitutes an ancient, co-evolutionary link between us and the non-human animals. We looked for the precedents and discussed the consequences of the medical heritage that they unwittingly provided us.

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25. In this regard, Mességué () wrote in his book "Health secrets of plants and herbs" a very interesting anecdote from his childhood: My father introduced me to it (Celandine). He used to say that it was both the best and the most wicked of herbs. He called it swallow wort, and one day he showed me how the swallows took some of the sap to their little ones in the nest, to protect them from blindness. It was not till much later that I learned that the Greek word 'chelidon' does in fact mean swallow (...). In other spheres the celandine also has a dramatic action. It cures chronic eye inflammation and all infections of the eyes (remember the swallows!), 1979.
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