**Mark:** [00:00:00] Welcome to the Endless Knot Podcast,

**Aven:** where the more we know,

**Mark:** the more we want to find out.

**Aven:** Tracing serendipitous connections through our lives

**Mark:** and across disciplines.

**Aven:** Hi, I'm Aven.

**Mark:** And I'm Mark.

**Aven:** And we're back with the Endless Knot podcast. Woo hoo! Today we're going to be talking about ecology through the ages and food webs. But first, we have a big apology, which is sorry we disappeared for four months, or five, I don't know, a lot of months. It was unplanned. The hiatus was not intentional.

It just, life crept up on us. Many parts of life, nothing massively bad, our lives are fine. No

**Mark:** like single catastrophic event, just things became difficult and busy.

**Aven:** So we're very sorry that we just dropped off the face of the earth. And hope that this episode will, you know, get us back on track and that [00:01:00] we will be new year, new podcast, new episode, because this is also a new season.

Should have started in September, but this is season nine. Yikes. And we've never missed this long before, which is not an auspicious start to a new season. But anyway, hopefully we will pick it up from here. So those of you who've stuck with us, those of you who might be coming to us new, thanks for sticking around and I hope you enjoy.

So, as I said, we're going to talk about ecology. We have one new patron to thank first. Lynn Fotheringham has just become a new patron. And given that we are also not producing very many long videos, by which I mean any though we are producing a lot of shorts and we hadn't produced any new podcast episodes.

Thank you, Lynn, for your faith in us. We really appreciate that. Thank you. So we will get started in a moment. This is a video. Do you want to explain about that or should I talk about the cocktail first?

**Mark:** Yeah, why don't I start by explaining the video. So this was from a group collaboration on [00:02:00] YouTube of video creators who are part of the WeCreateEDU collective, in which it was a sort of a great knowledge swap kind of thing.

And so those who participated, everyone sort of assigned someone else a topic that was from their own kind of wheelhouse as a sort of challenge to the other person to do something outside of their normal topic. And so I was assigned this topic about food webs by someone who does ecology the Roving Naturalist.

So if you know the Roving Naturalist channel, it's a great channel. And so she assigned me this topic about food webs, and in doing so, I decided not only to talk about, the concept of the food web, but also the history of the food web and where the, ecology terminology comes from.

**Aven:** And crucially, people put these videos on the original creator's channel. [00:03:00] So this video never went up on our channel. So if you are a completist, who thought you had seen every Alliterative video out there. You might not have seen this one. It's up on Sheryl's channel on the Roving Naturalist channel. so we'll play that audio later, but that's where, if you want to see the video, that's the way you'd have to go.

And of course we'll put the link in the show notes. So that's the video. And then we're going to talk more about the history of ecology, right? And so the cocktail that I've chosen, it turns out that looking up ecology or ecological and cocktails just gives you a lot of people making cocktails with organic ingredients or no waste cocktails.

All of which are good. But that wasn't quite what I was looking for. And green cocktails also does not get you what you think you might be looking for. So what I went for is a cocktail called the Golden Chain. You may think, what on earth does that have to do with ecology, but Mark will explain later.

**Mark:** Well, you probably are [00:04:00] aware of the term food chain, which is an earlier model of what became the food web.

**Aven:** I guess I was also thinking of the great chain of being, which I think comes up in this video. It does. Yeah, that's what I thought. So this cocktail is called the Golden Chain.

I'll put a link in the show notes to the recipe, of course. So cheers. Here's to getting back into podcasting and remembering how to do this.

That's better than I thought it would be. I thought it would be too sweet. I

**Mark:** thought it would be too vanilla y. It's

**Aven:** got a lot of lime in

**Mark:** it. That balances out the vanilla nicely.

**Aven:** So it's lime, juice Galliano, hence the vanilla, brandy, and the dash of yellow chartreuse. And it's nice. I mean, it's still sweet, don't get me wrong, but it's got a lot of lime and that really dries it out and makes it tart.

**Mark:** It's nice to finally have a cocktail after four months of not having a cocktail because we were on hiatus.

**Aven:** I'm sorry to tell you that Mark is beginning our new season by lying through his teeth at you.[00:05:00]

It is nice to share a cocktail with our audience. Yes. That is what is nice. So, all right, well, we'll sip at that and let's start then by listening to the audio for the food web. And then we'll come back and talk more about the history of ecological thinking.

**Mark:** Most people are probably more familiar with the concept of the food chain, which shows the chain of organisms starting with producers like plants --also called autotrophs, but we’ll get to that later-- which draw energy from the sun and nutrients from non-organic sources --such as carbon dioxide in the air--, to herbivores that eat the plants, to carnivores that eat the herbivores, and so forth, all the way up to an apex predator. So essentially it shows the flow of energy and nutrients. But a food chain only shows one part of the story of how this works. Any given organism might have multiple consumers, and any given predator might have multiple types of prey. So a food web is [00:06:00] the interaction between many different food chains, and that interaction can be enormously complex, which may require complex math like combinatorics and network theory and complex diagrams to understand. The decrease in numbers of one organism in a food web can have multiple effects in other parts of the same web. Now to more fully understand this bare-bones description of the food web and food chain, we need to backtrack a little and explore how scientists developed these ideas over the years and where the various terms and concepts came from.

 Let’s start with the basic origins of the terms. The concept of the food web was first formally proposed by the highly influential ecologist Charles Elton in his 1927 book Animal Ecology, though as we’ll see there were forerunners who were thinking along the same lines. But Elton didn’t use the term food web, instead calling it a food cycle, a term that had already been used in the 19th century. A little after Elton’s book in 1932, Warder Clyde Allee, [00:07:00] also a pioneering ecologist, used the term food web to describe this concept, and that’s the one that stuck. Both terms are apt in their own way as the word cycle from the Proto-Indo-European root word \*kwel- which meant “to revolve, move around” refers to the nutrients being drawn from the soil and air by producer plants, to the consumer animals, and being returned back by the decomposers. But the complexities and interconnectedness of these systems is also well expressed by the word web, which comes from a root that means “to weave, move quickly” and is thus related to the English word weave, metaphorically making clear the difference between a food web and a food chain. The word food, by the way, comes from the root \*pa- meaning “to protect, feed” and is related to such words as feed, forage, pasture, and pantry. As for the term food chain, Elton again had a hand in its popularization, though it was first used in print in 1920 by Scottish marine zoologist and oceanographer William Abbott Herdman, [00:08:00] secretary of the Challenger Expedition Commission which basically kicked off the modern field of oceanography --and eventually lent its name to the Space Shuttle Challenger-- and whose father-in-law botanist David Douglas lent his name to the Douglas fir. The etymology of the word chain, by the way, is uncertain, but it seems to come from the Latin word catena “chain” and may be related to Latin cassis “hunting net”, and ultimately from a root that means “to link, weave” — so, not so far from a web!

Now speaking of chains, the organization of organisms into chain structures goes back a long way, as in the medieval notion of the Great Chain of Being, known in Latin as scala naturae “ladder of nature”, which organized all of creation from God at the top through angels, humans in their social hierarchy, animals, plants, and minerals at the bottom. Conceptually this would lead to the phylogenic tree or tree of life, fundamental to Charles Darwin’s evolutionary theory. As early as the 8th to 9th century, [00:09:00] Arabic writer al-Jahiz presaged the ideas of both food chains and the idea of the struggle for existence which is a foundation for evolution through natural selection --in fact that’s the title of a chapter of Darwin’s On the Origin of Species-- when he wrote of how each animal is eaten by another in turn. In the 18th century, naturalist Richard Bradley similarly noted how parasitic insects prey upon each other in turn, an observation which was rendered into verse by satirical author Jonathan Swift as a metaphor for lesser writers when he wrote: “So, Nat’ralists observe, a Flea / Hath smaller Fleas that on him prey, / And these have smaller yet to bite ‘em, / And so proceed ad infinitum.” Bradley, by the way, was a pioneer in other ways as well, as he was also an early researcher into the pollination of plants by insects, was the first to publish recipes featuring pineapples in English, and invented an early form of the kaleidoscope for use in designing gardens, later perfected for less practical purposes by [00:10:00] optics expert David Brewster, who in his turn was also a photography pioneer. Another 18th century scientist who described food chains was Carl Linnaeus, famous for inventing binomial nomenclature for the categorization different species, giving both a terrestrial and an aquatic example.

Food webs too had their early precursors, with 18th century Lutheran minister and writer John Bruckner even describing nature as “one continued web of life” and pointing out the necessity of a wide variety of plants, animals to eat those plants, and predators and scavengers to eat those animals in order to keep everything in balance. Bruckner also wrote about populations in ways that would later lay the groundwork for the likes of Thomas Malthus and even Karl Marx. Interestingly, Marx was a big fan of Charles Darwin, whose evolutionary writing influenced his own writing, and even wanted to dedicate a book to him [Darwin refused as he was worried Marx’s stance on religion would be detrimental to members of his family]. And Darwin in his turn was a close reader of [00:11:00] Malthus, and so since we’re talking about Darwin again, it may come as little surprise that he too wrote about the food web idea using such phrases as “web of life” and “web of complex relations” and describing a simple food web he observed during his voyage on the Beagle. Darwin also famously described a food chain in his On the Origin of Species in which bumblebees that pollinated red clover were preyed on by field mice, who were in turn kept in check by domestic cats, so that if it weren’t for the cats, the field mice would decimate the bumblebees, leaving the clover unpollinated. Except he didn’t actually write bumblebee but humblebee, which in fact is the older form of the name, with humble probably connected to the onomatopoeic word hum, before becoming bumblebee, bumble also being imitative in sound and perhaps related to the word boom which originally referred to a buzzing sound. Based on Darwin’s chain of connections, a later commentator reasoned with tongue firmly in cheek that if it weren’t for old maids [00:12:00] the British Empire would fall, since old maids had many pet cats, who kept the field mice in check, who preyed on the bees, who pollinated the clover, which fed the cattle, which supplied the beef that fed the British sailors who protected the British Empire. And if you can figure out how to fit women and resisting patriarchy and colonialism and the British Empire into a joke to go here, you’re doing better than me!

Of course these kinds of complex interconnected relationships call out for graphical representations to illustrate them, so the terms food web and food chain are sometimes used to refer to these graphical representations. The first to produce such a diagram seems to have been Italian herpetologist and entomologist Lorenzo Camerano who published a generalized food web diagram in 1880, though no one seems to have picked up immediately on the idea. It wasn’t until the early 20th century when a number of other scientists independently hit upon the idea, that such diagrams began to appear with more regularity, such as a 1912 illustratiuon depicting the boll weevil [00:13:00] complex, which seems to have been the first specific food web diagrammed, perhaps appropriate given that the word weevil comes from the same root as web [in the “move quickly” sense]. This diagram was a proposal to eradicate the boll weevil, which attacked cotton crops, by encouraging its predators and parasites. The next year Victor Shelford, a foundational influence on the modern field of ecology as well as a teacher of Allee and major influence on Elton, published a book containing two food web diagrams which showed how communities tend toward equilibrium, and later Elton’s own book made such diagrams commonplace in the field. Another type of diagram that depicts this idea is the ecological pyramid, which can be used to show the number of organisms or biomass or energy at different levels of a food chain. The idea behind the pyramid comes from the work of 19th century German zoologist Carl Semper, who pointed out that as herbivores convert vegetation into flesh, and carnivores do likewise with the flesh of the herbivores, there is a loss of mass at each [00:14:00] stage due to the oxidization of organic material. Similarly there is a loss of energy as it flows along the chain since some is lost to heat and so forth. The slope of the pyramid may be an indicator of the stability of a food web: the squatter the pyramid the more stable and the taller and thinner the less stable. And these different levels in the pyramid are called trophic levels, which is the next concept we need to turn to in order to understand food webs and food chains.

So up till now I’ve been using the term producer to refer to organisms like plants, which grow and metabolize by using energy from the sun and non-organic elements from their surroundings like the carbon dioxide in the air, and consumer to refer to herbivores and carnivores which get their food by eating other organisms. Those terms come from the work of August Thienemann, a German limnologist, limnology being the study of inland aquatic ecosystems, and by the way he also produced one of those early food web diagrams in 1926. In addition to [00:15:00] producer and consumer, he also used the term reducer to refer to organisms that decompose dead organic matter as their food source. American ecologist Raymond Lindeman picked up on these terms, replacing reducer with decomposer, further developing the idea of trophic levels or levels in a food chain. The word trophic comes ultimately from Greek trophe meaning “food”, with the phrase trophic level being first used in Lindeman’s 1942 paper “The trophic-dynamic aspect of ecology”. Already in use for some time since the 19th century had been the terms autotroph, basically equivalent to producer, from Greek autos meaning “same, self”, heterotroph, equivalent to consumers, from Greek heteros meaning “other”, and mixotroph, which refers to things such as carnivorous plants which derive their food from both photosynthesis and consuming other organisms, from Greek mixis “mixing, mingling”. Now though these terms ultimately come from Greek, they were actually coined in German by German scientists, such as botanist [00:16:00] Albert Bernhard Frank, who, in addition to introducing the term autotroph, also coined the term mycorrhiza, the symbiotic relationship between a fungus and the roots of a plant, and attempted to find a way to cultivate truffles for the king of Prussia. As for heterotroph and mixotroph, they may come from the work of one Wilhelm Pfeffer. In addition to, and I suppose in aid of, his biological work, Pfeffer was also something of a cinematography pioneer. He had been inspired by the chronophotography work of French physiologist Étienne-Jules Marey. Basically chronophotography is taking a series of photographs in quick succession in order to study movement. Marey famously used this technique to study the cat righting reflex, in other words why cats always land on their feet. Well, Pfeffer extended this idea, inventing time-lapse photography, so films could be produced showing things like plant growth so it could be studied. Time-lapse photography came to public attention when naturalist and nature documentary pioneer Percy Smith along with his producer Charles Urban, who made a [00:17:00] career out of making documentaries and educational film, began using the technique, which is now a mainstay of nature documentaries. And these early educational films are the forerunners of educational YouTube videos like the one you’re watching right now.

Now before we wrap this up, let’s zoom out a bit and consider the field of ecology as a whole, since food webs and trophic levels are key concepts to this field, and because as with food webs it’s important to understand all the complex interrelations. And let’s start with some concepts related to the food web. So, an ecological niche is the position of an organism within an ecosystem, with reference to things like its food sources, predators, competition, and other environmental conditions. Of course different ecologists have understood this concept in different ways, but unsurprisingly food web pioneer Elton stressed the ways in which an organism impacts its interconnected environment. English gets the word niche, originally meaning a “shallow recess in a wall”, from French, but its ultimate origins are [00:18:00] debated. It might come from Italian nicchio “seashell” from Latin mitulus “mussel”, or it might come from Old French nichier “to nestle, nest, build a nest” from Latin nidus “nest”, in which case it is related to the English word nest. Latin nidus from the root \*ni-zdo- literally means “sit down” from the Proto-Indo-European roots \*ni- “down” and \*sed- “sit”. By the way, that root \*ni-, in another compound form \*ni-mno-, may come into Greek as limne “lake, pool”, the root of the word limnology, which you’ll remember Thienemann was studying when he produced one of those early food web diagrams and coined the terms producer and consumer. We get the word limnology, and really the field itself, from Swiss scientist François-Alphonse Forel, whose other claim to fame was, along with Italian scientist Michele Stefano de Rossi, developing the Rossi-Forel seismic scale for describing earthquake intensities, one of the first such scales, now superseded by the Richter scale devised by American seismologist and [00:19:00] physicist Charles Richter.

 The terms ecology and ecosystem are also Greek-derived. Greek oikos meaning “house, household” from a root that means “clan” is the first element of not only ecology and ecosystem but also economy when combined with the Greek word nomos meaning “custom, law”. In ancient Greece an oikonomos was the manager of a household and oikonomia meant “household management”, which was the original sense of English economy too, until it broadened to mean the management of a nation’s resources in the 17th century. So the word ecology, with the second element coming from Greek logos meaning “word, speech, story” but often used as the English ending -logy to mean “the study of”, is the study of the metaphorical house of living organisms, and ecosystem with the second element Greek systema “a whole compounded of parts” literally meaning “stand together” emphasises how all component parts in a natural environment are interconnected and work as a whole. The concept [00:20:00] of the ecosystem was developed by British botanist and ecologist Arthur Tansley, and the name was coined at Tansley’s request by British botanist Arthur Roy Clapham. Tansley, by the way, put his botanical work on hold for a while to study psychology under Sigmund Freud and wrote a bestselling book aimed at a popular audience bringing the work of Freud and Jung to a general audience. The first pop psychologist?

As for the term ecology, it was coined by the German zoologist Ernst Haekel, of dubious legacy. Haekel was the first person to use the term “first world war” which believe it or not he used in 1914. He was also responsible for the now discredited recapitulation theory, which argues that stages of embryonic development recapitulate the evolutionary history of an organism so that earlier stages of an embryo resemble more “primitive” organisms, with the famous phrase “ontogeny recapitulates phylogeny”. And though Haekel was a big supporter and popularizer in Germany of Charles Darwin, [00:21:00] he actually subscribed to Lamarckism, the theory of Darwin’s rival Jean-Baptiste Lamarck, which proposed that an organism can pass on characteristics it gained during its lifetime to its offspring, even stating that the social sciences were instances of “applied biology”, an idea that was later influential on Nazism. Furthermore, Haekel expressed his scientific racism in his theories of polygenism, that the different human races evolved independently, unsurprisingly judging that white Europeans were the most advanced. Again these ideas would later become influential on Nazism. Haekel’s idea of polygenism also had a linguistic component, influenced by the idea of the polygenesis of language put forward by August Schleicher who believed that the world’s languages could not be traced back to one original language. For Haekel, who believed in Lamarckism remember, that meant that the “best” languages conferred superior qualities to the “best” races, and I’m sure you can guess which languages he favoured. [00:22:00] For his part, Schleicher claimed that he came to his ideas of the evolution of languages before he had even heard of Darwin’s ideas, but in any case began to arrange languages into genealogical trees inspired by the phylogenic trees used to show the evolutionary process. Schleicher, who was the first to attempt to compose a text in the reconstructed Proto-Indo-European language, now known as Schleicher’s fable, was also one of the first to use this tree model for language. Of course it turns out that this tree model doesn’t tell the whole story of language development as it doesn’t account for things like lateral transmission due to borrowing or language contact and the fact that languages don’t always develop from single isolated dialects but a from a range of dialects present at the same time. Nevertheless, the language tree still works fairly well to represent a simple model of language development.

So it’s interesting that we began this investigation into food webs by considering the impulse to arrange things into chains, and have kind of ended up in the same [00:23:00] place with languages. Along the way we’ve used the etymology of words to help us understand concepts central to ecology, and their historical development, and how like food webs, all of these elements are arranged in interconnected webs. And I hope that, like the process of moving from a food chain to a much more complex, but more accurate, food web, this video has helped you gain a better understanding of the marvellous complexity of ecosystems and the ways we study them.

**Mark:** So food webs, there you go. Now I mentioned briefly some of the earlier forerunners of these ideas. I mentioned the the Islamic scholars the Islamic scholar Al Kindi and, his ecological concepts. And I mentioned the great chain of being and that some of these ideas can even be traced back to ancient Greece.

But I didn't go into a huge amount of detail there. And so that's what we're going to do now.[00:24:00]

So the main source for what we're about to talk about now and an important source for much of what was in that video is a series of articles written by Frank N. Egerton, who's a historian, summarizing the history of ecology, and this series of articles is sur titled, A History of the Ecological Sciences.

**Aven:** And we'll list the bibliographical information for it in the show notes.

**Mark:** So we're going to start off in early Greece. which is at least the earliest written evidence that we have of some of these ideas, and I would say that potentially one of the omissions, I guess, in this series of articles is it doesn't really look to cultures beyond Europe.

Europe and the Near East. Yeah,

**Aven:** no, it's, it's very, [00:25:00] very old fashioned in that. It doesn't talk about Chinese or Indian or Indigenous or any of those kinds of concepts.

**Mark:** So it's got Greek and Roman and then Medieval Europe and beyond. And it also has the Islamic scholarly tradition in there as well.

But it does not have ecological ideas from outside of that. But that being said the earliest at least written account of these ecological ideas goes back to early Greek writers. So for instance there's Thales who was around from about 460 to 547 BCE who posited that all things come from water.

Right. So a basic ecological concept, life, you know, and all. It's really about

**Aven:** the elements. The elements, yes. This is a part of a lot much larger discussion about what makes up matter.

**Mark:** Mm hmm. A younger contemporary of his named[00:26:00] Anaximander disagreed with Thales. He held that water was only one of several pairs of opposites.

And instead focused on process instead of the material. He nevertheless said that life came from the sea and that humans evolved from some species that matured more rapidly. The similarly named Anaxamenes who flourished around 545 BCE said that water was not the most basic thing in nature, because one cannot get fire from water.

So here's that early element theory coming out. He said that pneuma in other words, wind or air is a basic thing. One can rarify it by blowing on combustible material and coax a flame. But also pneuma also condenses into rain.

So you can get both [00:27:00] fire and water from air. And water can condense or expand into ice. He derives all of these basic elements from that. But moving a little bit forward to Pythagoras who was around from around 560 to 480 BCE. He focused on quantities and patterns rather than on substance and process.

So Pythagoras, this may not come as as much of a surprise, believed that there are numerical harmonies in nature and mathematics is the key to finding them. So he was all about just the math of nature. Alcmaeon, who was born around 535 BCE, applied this Pythagorean notion of harmony in nature to medical thought.

So he talked about body forces: hot cold, sweet bitter, you know, these, these sort of binaries that are in [00:28:00] balance when one is healthy. And so illness is the result of that those pairs going out of balance.

**Aven:** Basic humoral theory that gets developed further later.

**Mark:** Yeah. So this is where that humoral theory comes from.

So after 500 BCE, this becomes the idea of humors and physicians' concern that people live in healthy environments, eat healthy diets, get adequate exercise. Mm hmm. And so physicians at the time noticed that living near marshes caused fever, which we now know is the result of malaria or something like that, in the summer whereas people get colds mainly in the winter.

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**Aven:** 10 So the idea of the environment is having an effect

**Mark:** on your body. If you don't have the concept of germ theory, you can just jump to the conclusion that it must be those environmental factors directly causing these things. So then we come to what's known as the Hippocratic [00:29:00] Corpus, which, certainly in the ancient world was attributed to Hippocrates.

**Aven:** And to his students. Even in the ancient world, it was seen to be writings of people from his school.

**Mark:** But it certainly seems to be the work of many people broadly. Hippocrates was around from 460 to 370 BCE. And one of the works in the Hippocratic Corpus is called Airs, Waters, and Places.

And in this work we see the correlating of diseases in a community with changing weather conditions. And the identification of environmental factors that determine racial characteristics. Mm

**Aven:** hmm. And I'm sure we've talked about this in other

**Mark:** episodes. We have. Yeah. So the belief was that essentially your race changes if you move your environment.

Like your, you know, your skin color might be determined by where you live, but if you relocated to a different environmental

**Aven:** [00:30:00] Mm hmm. You or your children, at least, might, would develop different characteristics. Yeah.

**Mark:** And so that was that became the view of race in the ancient world, which is, as we've talked in those other contexts, a very different thing from what we now talk about as race. So now coming to Herodotus, who died around 425 BCE. Herodotus is of course a historian, the father of Greek history or whatever. Father of lies. Yes. But he's interesting for ecological reasons because in his history, he makes observations about both Greece and of foreign locales.

And so this includes information about

**Aven:** Egypt, Egypt, most famously, but other places as well. Scythia.

**Mark:** And so he had a certain interest in Plants though mostly for kind of practical reasons. But including reports on things like pollination of date palms and fig trees, which is important [00:31:00] ecological observations for the time. Also there were reports on animals, including the natural history of wild species. And some of these accounts are ecologically significant. He also has observations and discussions about geography which are ecologically relevant as well. And as you said there's a lot of information in there about Egypt. He spent four months in Egypt. He says. He says. And so he talks at some length about the Nile, which flooded in summer rather than in spring. Mm hmm. Which was different from the pattern of rivers in Greece.

Mm hmm. And so he found the various theories as to why this was, and that people were proposing, and he found that the evidence for the north blowing winds as the cause to be very weak, His own speculation that a change in the pathway of the sun from summer to winter, [00:32:00] however, is not really any better.

No, but he was trying.

**Aven:** He was trying.

**Mark:** He reported on crocodiles that allow sandpipers you know, Egyptian what are they? Spur winged

**Aven:** plovers. Absolutely the name he gave them, I'm sure.

**Mark:** To eat leeches from inside without biting on the birds or whatever in appreciation for the, the help that they gave them.

**Aven:** What we would call mutualism now, but of course, not theorized that way.

So yeah, this is

**Mark:** seemingly the earliest instance of describing mutualism. Mm hmm. And so this is an early report of also of what we now call the balance of nature concept. He made astute observations about the ratio of predators and prey. Mm hmm. So he talks about the rapid breeding of hares and why that is a thing.

Right. And I will quote a bit of him here. "The wisdom [00:33:00] of divine providence has made all creatures prolific that are timid and fit to eat, that they be not diminished from off the earth by being eaten up, whereas but few young are born to creatures cruel and baneful. The hare is so prolific for that it is the prey of every beast and bird and man. Alone of all creatures, it conceives in pregnancy. Some of the unborn young are hairy, some still naked, some are still forming in the womb, while others are just conceived." Right,

**Aven:** as if they can keep getting pregnant even when they're already pregnant.

**Mark:** Obviously, you know, the science of this is a bit screwy, but the basic premise is right. But he really blows it when he comes to making a rather faulty observation about lions, quote, "But whereas this is so with the hare, the lioness, a very strong and bold beast bears offspring, but [00:34:00] once in her life, and then but one cub, for the uterus comes out with the cub in the act of birth. This is the reason of it. When the cub first begins to stir in the mother, its claws, much sharper than those of any other creature, tear the uterus, and as it grows, much more does it scratch and tear, so that when the hour of birth is near seldom is any of the uterus left whole."

**Aven:** To be fair, how close do you get to a lioness giving birth?

**Mark:** How could you, the observational, you're not tracking the, one lion throughout its lifetime,

**Aven:** I guess. Well, and the observational abilities of observing a hare, giving birth are mm-Hmm. You know, the opportunities are, greater, shall we say, than the opportunities to watch a lioness give birth.

**Mark:** So as is often the case Greek reasoning is let down by the failure to actually look at things. Which I think is a fair

**Aven:** point.

Yeah. Aristotle's great problems, for instance. Yeah.

**Mark:** [00:35:00] but even leaving aside the sort of collecting of data Herodotus ought to have been able to work out the obvious math here that leads to extinction. If every lioness can only have one, have only one, then the species will go extinct.

**Aven:** The reason is simple, basic math. Yes. But historians they're not mathematicians. I don't know what you're requiring of him.

Look, I mean, come on.

**Mark:** Similar observations about winged serpents. Quote, "It is so too with vipers and the winged serpents of Arabia. Were they born in the natural manner of serpents no life were possible for men. But as it is, when they pair the male is in the very act of generation the female seizes him by the neck, nor lets go her grip till she has bitten the neck through, thus the male dies.

But the female is punished for his death. The young avenge their father, and gnaw at their mother while they are yet within her, [00:36:00] nor are they dropped from her till they have eaten their way through her womb. Other snakes, that do no harm to men, lay eggs and hatch out a vast number of young. The Arabian winged serpents do indeed seem to be many, but it is because, whereas there are vipers in every land, these are all in Arabia and are nowhere else found."

So, a place that he hasn't been to, the only place you can find these dragons or whatever they are. And the reason you don't find them anywhere else is because they would kill us all and they can't reproduce in great numbers. Right. It's the balance

**Aven:** of nature. Yeah.

**Mark:** All right. Let's move forward to Aristotle.

Everyone's favorite. Aristotle and Theophrastus? Mm, yes. Very much linked. Yeah. So Aristotle lived from 384 to 3 22 BCE. He is credited with inventing logic and pioneered science. Formal,

**Aven:** formal logic. You have to say the word [00:37:00] formal logic. Aristotle did not invent logic in the layman's use of that term.

 I did say he's credited with. No, but inventing formal logic. I mean, admittedly, Herodotus didn't cover himself with glory, in terms of logic in your previous excerpts, but I'm just saying.

**Mark:** As well as pioneering science writing. He founded the Lyceum in Athens, his school, in 335 BCE.

And as I say, we also have to kind of talk about him and Theophrastus of Eresos, who live from around 3 71 to 2 87 BCE. So Theophrastus met Aristotle either at Mytilene. On the island of Lesbos, or at Assos on the Asia Minor coast.

Aristotle ran this school, the Lyceum for only a dozen years until Alexander, Alexander the Great, died [00:38:00] in 323, and he was forced to flee because he was perceived to be a Macedonian spy.

But, Theophrastus continued the school and ran it for three dozen years, so he is, very important in the

**Aven:** transmission of Aristotle and Aristotle's

**Mark:** continued work that comes out of the Lyceum. Absolutely.

**Aven:** and he's very, very important to the natural history. That was what he focused on.

**Mark:** So Aristotle's biological writings may have actually come from Theophrastus. There's a lot of info on marine biology that comes from observations in Lesbos and Aristotle visited there, we know, but Theophrastus grew up there, so he would have had really good first hand knowledge of these marine life forms and so forth.

And there may have been other editors or recorders involved as well. Ultimately the biological writings that [00:39:00] are associated in some way with Aristotle, or the production of the Lyceum generally, not just Aristotle. So here, here's a little description, a quote from the article by Egerton. "Instead of explaining reproductive rates of prey species as being higher than those of predator species because they were designed that way to prevent predators from exterminating their prey, the Lyceum explained reproductive rates as a function of physiological necessity. A mouse can produce more young per pregnancy than can an elephant because there is a little matter to organize in a mouse embryo and much matter to organize in an elephant embryo."

**Aven:** Sort of. That's logic. Yeah.

**Mark:** Also we see the idea of animal morphology being based on function and ecological niche.

So, for instance, there is a discussion about birds having either spurs or talons. So like chickens have spurs, a kind of [00:40:00] spiky thing on their leg. Whereas other birds like birds of prey have talons. So again, quote, "The same bird never possesses both spurs and talons, and the reason is that nature never makes anything that is superfluous or needless.

Spurs are of no use to a bird that has talons and can fly well. Spurs are useful for fights on the ground, and that is why certain of the heavy birds possess them. While talons would not be merely useless to them but a real disadvantage, they would stick in the ground and impede the birds when walking, and in fact all crook taloned birds do walk badly, and they never perch upon rocks.

This state of affairs is the necessary result of the process of their development. There is earthly substance in the bird's body which courses along and issues out and turns into parts that are useful for weapons in offence. When it occurs, when it courses [00:41:00] upward, it produces a good hard beak, or a large one.

If it courses downwards, it produces spurs on the legs or makes the claws on the feet large and strong, but it does not produce spurs and large claws simultaneously, for this residual substance would be weakened if it were scattered about."

**Aven:** Right. The observations in this case are reasonably sound.

The mechanism is speculative and incorrect,

**Mark:** obviously. Yeah. Distributing matter, but, but yeah.

And there's a similar observation about deer lacking incisor teeth because they have antlers, right? It's like

**Aven:** one or the other. There's like only enough substance for one, not both.

**Mark:** We also see Herodotus's story about lion reproduction explicitly dismissed. So again, quote, " the story which is told about the lioness losing your uterus in parturition is nonsense, and was made up to account for the scarcity of [00:42:00] lions, which are not found in many places in the whole of Europe. It occurs only in the tract of country between the rivers Acheloos and Nessos. The lioness's cubs are so small when born that at two months they can barely walk. Lions in Syria bear five times, five the first time, then one fewer each succeeding time. After that, they bear no more." However the credibility that the Lyceum gained by dismissing Herodotus's story is lost by accepting the inaccurate Syrian report.

So

**Aven:** it's a less fanciful, so one could imagine, you know, like it seems more plausible. So they're working towards plausibility, at least.

**Mark:** We also see a parallel drawn between plant parasitism and brood parasitism. So mistletoe growing on other plants as compared to cuckoos laying eggs in other birds nests.

**Aven:** For more on the [00:43:00] cuckoo. Do watch our video on, or listen to our episode on, cuckolds.

**Mark:** And somewhere, I think I talk about mistletoe as well, so.

**Aven:** In the Christmas yeah, one of the Christmas episodes, yeah.

**Mark:** Also we see in the Lyceum writings questioning about unexplainable features, and what we now would call spandrels.

Would we?

**Aven:** I don't know what a spandrel is. Tell me what a spandrel is.

**Mark:** A spandrel is, so it hasn't come on the podcast yet, but it was I talked about it in a video before. It's this concept that came from Stephen Jay Gould. These are basically morphological features of animals that no longer serve a purpose.

So they presumably at one point had an evolutionary purpose to evolve, but no longer serve that purpose and just hang around. And the word spandrel comes from an architectural feature of a certain kind of what becomes just sort of a design element that continues beyond its, you know, [00:44:00] necessity.

So, for instance the question is asked about what the purpose of tides are or what the purpose of the male nipple is.

**Aven:** Perfectly parallel questions.

**Mark:** And, they question whether fire is really the same sort of element as earth, air, and water. Mm hmm. So there's some critical Thinking, thinking going on. So, leaving behind Ancient Greece we come to the Hellenistic period. And so one of the notable things about the Hellenistic period is the concentration of information at the Museion in Alexandria. Mm hmm. So, there was great scientific progress that occurred at the Museion but relatively less of ecological significance compared to the work of the Lycian.

Right. But, for instance, among the the Hellenistic scholars, we see the first attempts at the calculation of the size of the earth. Yes. And we get Two calculations, one of which [00:45:00] is surprisingly accurate, the other one is wrong. And unfortunately, the wrong one seems to be the one that's stuck.

**Aven:** It's the one that Columbus used, right? Yes, yeah.

**Mark:** So Eratosthenes of Cyrene, who was around from around 276 to 195 BCE, correctly calculated the circumference of the Earth, he calculated and it was incorrectly calculated by Poseidonius of Apamea. He was around from 135 to 51 BCE. He gets it wrong. And unfortunately, that's the one that was more influential. Yeah. So Columbus, as you say, he unfortunately followed Poseidonius' calculation. Hence, he thought he would get round to Asia

**Aven:** before his food ran out.

Before his food ran out. And didn't think there was room for another big continent

**Mark:** We also see amongst the Hellenistic scholars, observations about [00:46:00] the relationship between the sun and the seasons and the, the moon and the tides and the menstrual cycle. And This also led to further astrological belief that other heavenly bodies might influence things, right? If the Moon is affecting the tides and the menstrual cycle, well, other heavenly bodies could affect other things.

Why not? We also see a lot of Hellenistic medical and pharmacopoeia texts containing detailed descriptions of plants used for medications and so forth. Other descriptions and observations about various living species and various sources including in books about hunting. So that's another important source for ecological information is hunting manuals and so forth.

And Alexander of Aphrodisias who flourished in the 100s and 200s CE he became the head of the Lyceum and in his writings we see a discussion of the differential longevity being a factor[00:47:00] tending to preserve the balance of nature. So species that can only produce a few young at a time tend to be long lived so they can keep reproducing. And species that can produce many young at a time tend to be short lived.

**Aven:** Which is a true relationship, generally speaking. Again, mechanisms may be being different, but

**Mark:** So some still important ecological ideas coming out during this period, but not quite the, the burst of thought on this topic as it was in ancient Greece.

**Aven:** Okay, well, let's move to Rome, which obviously overlaps with Hellenistic period, but really the people I'm going to talk about are from, most of them from later. So Egerton talks about five Roman treatises that Survive that are on natural history. So really natural history is the term that would be used for anything that would encompass ecology.

You've already used it a few times, but you know, obviously the term ecology didn't exist. Not even as a type of thinking, [00:48:00] it's subsumed under natural history. So he talks about five Roman treatises that survive, and then there's a number of other figures who wrote on things that could be talked about as being related.

So, Cato the Elder, Marcus Porcius Cato, 234 -149 BCE. He's known as the Elder because there's a famous grandson, the one who lived around Caesar's time, Julius Caesar's time, Cato the Younger, who is important as one of the assassins of Caesar. But there were many other Catos. So we just use those elder and younger now, and we're going to have a similar one with the Pliny's later.

He was a prominent Senator and he wrote *De Agricultura* about the cultivation of fields. And so it's a farming text, but you know, a farming manual is obviously about how animals and plants interact and how to maintain what we would think of as an ecological harmony or balance.

**Mark:** Like hunting manuals. I mean, they're concerned with these things because of their sources of food.

**Aven:** Because they're practical. [00:49:00] They're practical. Yeah. And they're observational. if you're a farmer, you spend an awful lot of time even, even if you're a farmer with your estates run by enslaved people, you still spend a lot of time thinking about this. So, he wrote that, and it survives.

Marcus Terentius Varro, 116 to 27 BCE, so he's about a century later, he wrote the *Res Rusticae*, which is also a farming manual, essentially. I mean, really, it's just Country Matters is what the title means, but it's essentially also a farming manual. On the same lines, though not counted as one of these five treatises by Egerton, is Virgil, Publius Vergilius Maro, 70 to 19 BCE, who wrote the *Georgics*.

So this is a poem, and it has lots of other things on its mind beyond observations of nature, but it is a poem, the *Georgics* means the farming, a farming work. So it's, it is about, ostensibly, it is a farming treatise, just in hexameters. And so it too has lots of description of [00:50:00] how animals and plants live and the ways that groups of animals function and has almost an entire book on bees and how they exist and how the hives work and stuff.

So definitely some of that thinking going on. The third Roman treatise is by Lucius Junius Moderatus Columella, so known as Columella. Floruit, we don't know the dates exactly, but about mid first century CE. He also wrote a work called *Res Rustica*, so it's the same as Varro.

And he also wrote a much briefer *De Arboribus*, about trees. So, Columella wrote a lot about gardens in particular. So if you remember Victoria, when we had Victoria Austin, she talked about, Columella is an important source for gardening and the cultivation of nature for purposes of aesthetics and philosophy and enjoyment, not just agriculture, was important. Then another person who I didn't know at all, and he has, you can tell he's in the 4th century because he has too many names, and [00:51:00] they're silly. Rutilius Taurus Aemilianus Palladius. I say silly because they're not the standard Roman names. He wrote a manual called *Opus Agriculturae*, a work on agriculture.

I don't know that one particularly. It's late. And then the fifth and the one I'm going to talk about most is by Gaius Plinius Secundus from 23 to 79 CE. This is Pliny the Elder, in spite of the fact that he has Secundus in his name. He was a provincial from Novum Comum. His *Natural History* is the longest work to survive from the Roman Empire.

This is why people cite him so much. It's because there's a lot of him to cite. There's a heck. I mean he's also bizarre and wonderful, but there's a lot of him that survives and I'll come back to his work 'cause it's really important and influential. The other two people Egerton mentions are Claudius Aellianus, who's 170 to 235 CE.

He wrote natural histories, but Egerton says he wrote them less to inform than to [00:52:00] entertain, and so he was a Roman, but to show off, he wrote his *On the Characteristics of Animals* in Greek, because this is in the, this is in what, what's called the Second Sophistic, a period where they got really into reviving classical Athenian Greek and philosophy.

So this is sort of

**Mark:** Later people show off by writing in Latin, but if you're already, if Latin is your actual language, then You have to show off

**Aven:** by doing Greek. Yeah. So this is in a period when he's trying to be the second, Theophrastus is sort of what he's trying to do. I think.

And then the other person that he interestingly points out is Cicero, Marcus Tullius Cicero, 106 to 43 BCE. Egerton says, one of the few, I always love it when people love Cicero, one of the few men in history who were both leading statesmen and leading authors. I mean, he's not wrong. But it's just funny.

And this is interesting because I would never have thought of this as an ecological text, but Egerton's not wrong. His *De Natura Deorum*, *On the Nature of Gods*, was "the most important synthesis of providential ecology or [00:53:00] the balance of nature", because it's about why the world is the way it is and what are the mechanisms by which the world maintains its equilibrium or doesn't.

Because really it's about how do we like deal with the gods so that things don't go terribly wrong, which is about what are the mechanisms by which the world is the way it is? And so I thought that was interesting because I wouldn't have thought of that as being ecological. Okay, now I'm going to get back to Pliny because he's the best.

So Pliny uses Aristotle's division of nature into animal, vegetable, and mineral to recreate the natural world in literary form. So rather than presenting compartmentalized standalone entries arranged alphabetically, like we might if we were writing, because in many ways Pliny is writing what we In later periods would think would be an encyclopedia, something that is encyclopedic.

It's trying to gather all the information about the world into one compendious source, but he doesn't list it in alphabetical or even sort of topic [00:54:00] division, really. Instead, "his ordered natural landscape is a coherent whole, offering the reader a guided tour."

So, after an initial survey of cosmology and geography, Pliny starts his treatment of animals with the human race, " For whose sake great nature appears to have created all other things". So that basic premise that the world exists for the purpose of humans, which is not by any means universal in the ancient world, not everyone thinks that the world was created for humans. So his premise is distinct from modern ecological theories, obviously but it does reflect a fairly common sentiment of his time. So the components of nature are therefore not just described in and of themselves, but with a view to their role in human life.

So human life is centered even in discussion of other animals. All right, that's all I want to say in a general way about this treatise. Now I want to give you weird Pliny stories. And there are a million, so I cherry picked totally just some random ones. [00:55:00] So here are some things Pliny said.

This is all this is going to be. Shit Pliny says. Shit Pliny says. " Elephants are produced by Africa, beyond the deserts of Sidra, and by the country of the Moors, also by the land of Ethiopia and the cave dwellers, as has been said, but the biggest ones by India, as well as serpents that keep up a continual feud and warfare with them, the serpents also being of so large a size that they easily encircle the elephants in their coils and fetter them with the twisted knots.

In this duel, both combatants die together, and the vanquished elephant, in falling, crushes with its weight the snake coiled around it." Balance of nature right there. " The Hippopotamus stands out as an actual master in one department of medicine. For when its unceasing voracity has caused it to overeat itself, it comes ashore to reconnoiter places where rushes have recently been cut, and where it sees an extremely sharp stalk, it squeezes its body down onto it and makes a wound in a certain vein in its leg, and by [00:56:00] thus letting blood, unburdens its body, which would otherwise be liable to disease, and plasters up the wound again with mud".

**Mark:** Wow. Self surgery.

**Aven:** Yep. Hippopotamuses know how to do bloodletting, which as we all know, is the way you cure everything. So yes, that's the hippopotamus. Now. This one is quite well known, I think, but it's so great I'm going to say it anyway. " The hyena is popularly believed to be bisexual, and to become male and female in alternate years, the female bearing offspring without a male, but this is denied by Aristotle.

Its neck stretches right along the backbone like a mane and cannot bend without the whole body turning round. A number of other remarkable facts about it are reported, but the most remarkable are that among the shepherd's homesteads it simulates human speech, and picks up the name of one of them so as to call him to come out of doors and tear him to pieces.

And also that it imitates a person being sick to attract the dog so that it may attack them. That this animal alone digs up graves in search of corpses. That a [00:57:00] female is seldom caught. That its eyes have a thousand variations and alterations of color. Moreover, that when its shadow falls on dogs, they are struck dumb, and that it has certain magic arts by which it causes every animal at which it gazes three times to stand rooted to the spot".

Hyenas, man.

**Mark:** I'm glad you, you included that because I'm going to have some stuff about hyenas.

**Aven:** Hyenas are, people are fascinated by hyenas, there's so much hyena stuff. "The sea eagle only compels its still unfledged chicks by beating them to gaze full at the rays of the sun, and if it notices one blinking and with its eyes watering, flings it out of the nests as a bastard and not true to stock, whereas one whose gaze stands firm against the light, it rears."

Totally random, but I just liked it. He does do some sort of basic observations of the kind of idea of Ecology and ecological niches, or habitats. So he talks about, he says, "In this connection it is surprising that nature has not only assigned different animals to different [00:58:00] countries, but has also denied certain animals to some places in the same region.

In the Mesian forest in Italy, dormice, of which we are now speaking, are only found in one part. In Lycia, the gazelles do not cross the mountains near the Sexi". I didn't say that word out loud until now. Sexy. "Nor the wild asses, the boundary dividing Cappadocia from Cilicia. The stags on the Hellespont do not migrate into unfamiliar districts, and those in the neighborhood of Arginusae do not go beyond Mount Elaphus, even those on the mountain having cleft ears. In the island of Pordoselene, weasels do not cross a road. Similarly in Boeotia, moles that undermine the whole of the fields in Archimenus nearby, when imported into Lebadea, are shy of the very soil". So I'm sure many of those are not particularly true, or not true for the reasons he says, but the basic idea that there are animals that are suited to one area don't leave that area, even though there's no sort of obvious reason why they couldn't. There's no barrier like a river or a mountain or something that would [00:59:00] stop them. which, of course, is a true thing.

And then one last thing, which is sort of the theorizing that we've been seeing, right? Like an observation, and then a completely bonkers theory about why. So this is about why there are so many large animals in the sea. " There are, however, a considerable number of these that are larger even than land animals. The obvious cause of this is the lavish nature of liquid".

And I mean, he goes on, and as you'll see, it's not completely bizarre. Not, not the whole answer, shall we say, but "in the sea lying so widely outspread and so yielding and productive of nutriment because the element receives generative causes from above and is always producing offspring." I mean, the sea is fertile.

There's a lot of food in it. That is true. But not quite for the reasons he's saying. "A great many actual monstrosities are found. The seeds and first principles intertwining [01:00:00] and interfolding with each other, now in one way and now in another, now by the action of the wind and now by that of the waves, so ratifying the common opinion that everything born in any department of nature exists also in the sea, as well as a number of things never found elsewhere.

Indeed, we may realize that it contains likenesses of things, and not of animals only, when we examine the sea grape, the swordfish, the sawfish, and the cucumber fish, the last resembling a real cucumber, both in color and scent."

**Mark:** Is he saying because, like, cucumber ness falls into the sea that it produces

**Aven:** I think that the seeds of everything.

So this is the premise that life comes from seeds. It's sort of atomic theory. It's not exactly, but it's sort of connected to that. The idea that there are little tiny generative pieces of everything. And so since they're scattered, the sea has all of them and they get mingled up and mixed up and so they produce.

everything

**Mark:** in the sea. Okay. I can see cucumber seeds falling into the sea and producing

**Aven:** Not [01:01:00] cucumber seeds, seeds of cucumbers. That's different. Seeds of everything, like every kind of matter. There are seeds of everything. Swords

**Mark:** come, produce swords. Like wouldn't they just be seeds of metal or something?

**Aven:** I don't know. Maybe when seeds of metal, seeds of metal combined with seeds of fish, you get swordfish. Anyway, that is weird shit Pliny says. And now I'm done. It is by no means the end of the number of weird shit that things, I mean, Pliny on medicine is this whole other world, but we aren't doing medicine today.

So I won't get into that, but a lot of his discussion of animals and plants, like you were talking about with some of the Hellenistic stuff is focused on medical uses because he has a lot of stuff on medicine. And that makes sense. As Egerton was saying that he's interested in the animal plant life to a large part in how they're useful to humans.

So of course, medical uses is, is important, but he's great. I love him.

**Mark:** Well, I guess [01:02:00] we then move on to Byzantine natural history. And the executive summary of this is that the Byzantines contributed little new ecological information or insight. I will expand on that basically by giving one example. But to state what is important about this period, I guess, is it's mainly important for preserving and sometimes synthesizing and transmitting ancient Greek material, first to Arab scholars and later to Western Christian scholars.

So it's a question of transmission, really. But I will mention one writer Timotheos of Gaza, who flourished between 491 and 518 CE who was a poet and armchair zoologist.

**Aven:** New Life Goal Unlocked. Poet and armchair zoologist. His

**Mark:** interests could be called ecological, but his judgment was uncritical, according to Egerton.

 But I will quote one little summary of [01:03:00] Egerton on his writing from the first chapter on animals, specifically on the hyena. Gotta love a hyena. " He claimed sometimes mated with wolves or bears, producing lone wolves that prey on men or animals.

It steals decomposing bodies from graves, it sees equally well during night or day. It vomits up its food to attract dogs, then catches them. If a dog is sitting on a roof, casts a shadow in the moonlight, the hyena. Catches the shadow and uses it to pull the dog off the roof.

**Aven:** He, that's cool.

**Mark:** Hyena bile improves eyesight.

His book did not advance zoology and it illustrates how far public understanding had declined".

**Aven:** I don't know, to be fair, I don't think anything he said about the hyena was any less sensible than what Pliny said about the hyena.

**Mark:** But that's about the best of it. So, so moving on quickly [01:04:00] to Arabic language science. I'll start off with Egerton's article on origins and zoological writings, and then we'll move on to other areas of ecology. But again a lot of the importance here is on transmission and synthesis.

And a lot of it was largely. uncritical, but there were some notable exceptions. So the greatest achievements of Arabic language science were in mathematics, astronomy, alchemy, physics, and geography. So it's not that they weren't doing good science, it's just that they weren't particularly doing good ecology kind of science.

Right. But it is important for the transmission of Greek texts and they were certainly interested in learning and copying the stuff out and working with it. So the third Abbasid Caliph ordered a collection of Greek treatises and the fourth established in 828 CE a House of Wisdom to sponsor translations from Greek into Arabic. Mm-Hmm. . And so the most notable [01:05:00] writer about ecological ideas was al-Jahiz. He was around from about 776-868/869 And I mentioned Al Jahiz in the video.

Right. So basically I'm giving a little more information about him. Al Jahiz is actually not his real name. That was a nickname, literally meaning "goggle eyed". So not a terribly flattering nickname it seems. His, his actual name was Abu ‘Uthman ‘Amr ibn Bahr al-Kinani al-Basri and he had access to Arabic translations or paraphrases of the Aristotelian work *Historia Animalium*.

And he himself wrote the work *Kitab al-Hayawan* which means Book of animals. It's an encyclopedia containing stories of about 350 kinds of [01:06:00] animals containing some original observations of his own. And he, in fact, had some proto evolutionary ideas, including recognizing the effect of environmental factors on animal life and the struggle for existence.

He was also, as I noted in the video, the first to describe a food chain. And so I'll read a little more of that passage that I just very briefly included in the video. Right. So, "the rat goes out for its food and is clever in getting it, for it eats all animals inferior to it in strength, and in turn it has to avoid snakes and birds and serpents of prey who look for it in order to devour it, and are stronger than the rat.

And then also the mosquitoes go out to look for their food as they know instinctively that blood is the thing that makes them live. As soon as they see the elephant, hippo hippopotamus or any other animal, they know that the skin has been fashioned to serve them as . food. And falling on it, they pierce [01:07:00] it with their proboscises, certain that their thrusts are piercing deep enough to and are capable of reaching down to draw the blood.

Flies in their turn, although they feed on many and various things, principally hunt the mosquito. All animals, in short, cannot exist without food, neither can the hunting animal escape being hunted in his turn. Right. And he goes on, Every weak animal devours those weaker than itself. Strong animals cannot escape being devoured by other animals stronger than they.

And in this respect, men do not differ from animals, some with respect to others, although they do not arrive at the same extremes. In short, God has disposed some human beings as a cause of life for others, and likewise he has disposed the latter as the cause of the death of the former. So he extends it all the way to human society. The second article by Egerton on Arabic language science covers [01:08:00] botany, geography, and decline in their later years. There's rather more on botany and geography in medieval Arabic language science than on zoology, but mostly indirectly through interest in medicine and agriculture.

as we've

**Aven:** seen before. Yeah, yeah, so useful, the pragmatic stuff rather than theoretical. So while

**Mark:** Arabic language science flourished in the early Middle Ages from the 800s to the 1100s CE, afterwards it declined into traditionalism. That's the decline that he's talking

**Aven:** about. Where there's an emphasis on authority rather than Than science, yeah.

which is what happens in the Middle Ages, as you will talk about in the Western

**Mark:** world. The study of geography was more highly developed in the Islamic world than in its Byzantine and West European neighbors. And there practical reasons for this. For one thing, Muslim civilization covered a much larger region than did those others.

And [01:09:00] two of the pillars of Islam stipulated that they pray toward Mecca regardless of where they were and that they make the hajj to Mecca. So You gotta know where you

**Aven:** are. I know. Geography becomes real important. And yeah, yeah.

**Mark:** So, we see a translation of Greek language geography by Claudius Ptolemaeus from circa 100 to 178 CE into Arabic in the 800s CE though this used the smaller size of the earth calculated by Posidonius unfortunately.

But he believed that people living in the hot tropics and cold northern regions were savages because of the adverse climates. Civilization only developed in the temperate regions. Which

**Aven:** is absolutely They, well, that's all the way back to

**Mark:** Hippocrates, right? Yeah.

You, you obviously pick the place that you're living in and say it's

**Aven:** the, that's where all the good stuff is. Yep, yep, yep.

**Mark:** And yes, so this specifically reinforced the Hippocratic notions [01:10:00] and influenced Islamic writers including Al Kindi and Al Jahiz. Mm-Hmm. In spite of that later decline.

that I mentioned, Muslims, Jews, and Christians worked on translating Arabic science into Latin. So at least what there is, is being passed on. Arabic language scholars had absorbed Greek natural history and added greatly to it. Though this was too diffuse to become the foundation for an ecological science, the achievements of Latin natural history were heavily indebted to the Arabic language legacy. And as I say, there's a couple of major exceptions. There are a few who did, really make big steps forward.

And so that finally takes us to the Middle Ages. The Western Middle Ages. The Western Middle Ages, that is to say yes. 'cause you've already been there. And so Egerton basically picks two individuals to sort of stand in for A thousand

**Aven:** years of culture. Yeah, but

**Mark:** really there's not a [01:11:00] whole lot else.

**Aven:** There's a real reliance on authority. I mean, Aristotle is all that matters for a big chunk of people for a big chunk of the medieval period.

**Mark:** Yeah. And so, you know, these two writers themselves are heavily indebted to previous stuff. But we do see some new things coming out, but it's coming from, again, those practical things.

So like hunting manuals, some new observations being made there, but they're in that context. And that's particularly the case with the first of these people, so Frederick II, King of Sicily from 1198, King of Germany from 1212, King of Italy and Holy Roman Emperor, most importantly, that's how he's known from 1220,

as well as King of Jerusalem from 1225 due to the Crusades. So he was a, a Renaissance man, if you can describe someone from the Middle Ages with that term.

**Aven:** From the 13th century, yeah.

**Mark:** Interested in literature music, architecture, and science. He spoke six languages, Latin, [01:12:00] Sicilian, High, Middle German, Old French, Greek, and Arabic.

that's pretty impressive. That's pretty impressive. And Sicily at this time was one of the most cosmopolitan places on

**Aven:** earth. Absolutely. Yeah. It really was the meeting place. Mm hmm.

**Mark:** And so Frederick associated with Italians, Greeks, Jews, Muslims, Germans. he knew everyone.

**Aven:** We're still talking about a fairly small portion of the world, but yes.

**Mark:** And I think one of the reasons he may stand out in the Middle Ages is that he discovered that Christians had no monopoly on wisdom, shall we say, and throughout his life his interest in religion was political rather than spiritual, right? He was a Christian in appearance for pragmatic reasons.

But he didn't let it stop him from being interested in, you know, the natural world. And the study thereof. As noted by, and this observation [01:13:00] about him is remarked on by the monk Salimbene who was alive from around 1221 to 1289, and wrote about him. And so a lot of what we know about him is from this source, and being a monk, he is sort of critical of certain aspects of him particularly his, All the fun bits?

Well, yeah, his lack of devotion to Christianity, let's say. He was an avid falconer, so hunting is his thing, and particularly via falconry. He wrote a work called *De Arte Venande Cum Avibus, The Art of Hunting with Birds*.

**Aven:** Yeah, very straightforward title.

**Mark:** He wrote this in the 1240s.

It's a six book work with book one on the structure and habits of birds. So that's where we get the most ecological. Right. The observational stuff. Observational stuff. And then the rest of it is on Falconry proper and technical stuff about that. But there [01:14:00] continues to be observations on ecology and behavior, even in those later parts.

Right. Now *De Arte Venandi Cum Avibus* is judged to be, quote, the first zoological treatise written in the critical spirit of modern science. And this is a view expressed by a bunch of historians. But his influence was limited for centuries. And the reason for that is his royal line died out. And so his manuscripts didn't come to the attention of naturalists until rather later. Right,

**Aven:** because there's no publishing in quite

**Mark:** the same way.

There's no publishing quite the same way. And since he didn't have descendants to promote it, promote it, it just sort of became forgotten. And so it didn't get published in the, in the more modern sense until 1596. And that didn't attract the attention of ornithologists until 1788.

Okay. But he does interesting things like classifying birds [01:15:00] into categories, right? So, and this is leaning towards Linnaeus, right? But hundreds of years earlier. So he breaks them down into categories like aquatic, land, and neutral, which are both water and land. Raptorial or non raptorial. So raptors like hunting birds. He discusses daily habits of birds under these different categories. He talks about the anatomy and physiology of species as being adaptations for its environment. He made generalizations about particular groups.

These group of birds will have these kinds of features. So he was indeed very influenced by Aristotle. But he frequently disagreed with him. Aristotle had claimed that birds that are limited in flight are to an equal extent good pedestrians, but Frederick pointed out the example of cormorants, which are even worse at walking.

**Aven:** They're just clumsy birds. Should have brought up the loon. If he'd only known about loons. Loons are [01:16:00] almost incapable of walking, and barely capable of flying. Boy, can they swim, but everything else, I mean, it's a bit like penguins too. Can't fly, sort of can walk. But loons can't even walk as well as penguins.

**Mark:** Also swans and pelicans can swim and fly well, but rarely leave the water. and rails don't swim or fly well, but are true water birds. So, you know,

**Aven:** the, the categories are a little different. Yeah.

**Mark:** He also noted that some bird habits seemed inherent, but were susceptible to environmental influences.

So many aquatic birds, for instance, depart at dawn for their feeding places and return at the third hour, 9am but may return earlier on a hot day and remain feeding longer if it is cool or cloudy. He talked about why owls hunt at night, and so here's a quote. Not so much because they can see at night and not in the daytime, as Aristotle asserts, For they [01:17:00] have good vision both day and night, but because they feed on the young of other birds.

They are hateful to such birds, and therefore do not dare to hunt during the day. Like certain quadrupeds that possess poor physical armament, they hide by day and seek their food by night, and in this way avoid the harm that might befall them if plainly seen.

**Aven:** Which is not necessarily completely, well, I'm sure isn't completely correct, but owls are mobbed by other birds.

if they're seen. So, it's observational again.

**Mark:** He divided carnivorous land birds into three groups according to their feeding habits. So there were vultures and lammergeiers . don't know how that's pronounced. They do not kill their food but eat carrion, kites and common eagles prefer to eat dead animals but do sometimes kill for food, and true falcons and hawks devour only what they kill and never eat carrion.

He also did experimentation, and so this is some crazy shit here. [01:18:00] He determined that vultures can only find food by sight and not by smell by sealing their eyes and placing food nearby, which they didn't find.

**Aven:** Oh dear. He's also, he's also wrong. Just for the record, vultures have incredibly good senses of smell.

That's how they find animals.

**Mark:** And it I mean Is

**Aven:** there a cruelty warning here? Animal cruelty warning? Not just

**Mark:** animal cruelty warnings.

**Aven:** Okay. Skip ahead if you don't, if you don't want to hear this.

**Mark:** It should be noted that experimentation was very rare in natural history during the ancient and medieval world.

Yeah,

**Aven:** like scientifically laudable, but Most people don't do this. But, but, oh dear.

**Mark:** So, as a side note Frederick also experimented on humans, as that monk Salimbene records. He did, he repeated the Baby test. The baby test, the experiment of raising a child in science to see what language Silence.

Silence. Say that again. He repeated the [01:19:00] experiment of raising a child in silence to see what language developed, as mentioned in Herodotus. According to Salimbene, Frederick bade, quote, foster mothers and nurses to suckle and bathe and wash the children, but in no ways to prattle or speak with them, for he would have learnt whether they would speak the Hebrew language which had been the first, or Greek, or Latin, or Arabic, or perchance the tongue of their parents whom they had been born.

But he laboured in vain, for the children could not live without clappings of the hands, and gestures, and gladness of countenance, and blandishments. I suppose the only good thing that can be said about this is that at least he had an open mind about the results as to which language it was, whereas most other people, when they talk about this experiment, say it's got to be this, and it's often their own language or whatever.

**Aven:** I don't think he gets much credit for that. I don't

**Mark:** think so. More horror.[01:20:00] He had a man shut up in a cask to see whether his soul could be detected when he died. He also, in order to discover how deep a man can dive, he had a diver retrieve objects at progressively greater depths until he drowned.

And, to learn whether one should relax or exercise after eating, according to Salimbene, quote, he fed two men most excellently at dinner, one of whom he sent forthwith to sleep, and the other to hunt. And that same evening he caused them to be disemboweled in his presence, wishing to know which had digested the better. And it was judged by the physicians in favour of him who had slept.

**Aven:** Like On the one hand, you admire the way his mind is working, like to ask these questions, but then you have to realize that he doesn't count other humans as humans, and that's a problem.

**Mark:** So he made some major [01:21:00] strides, but they didn't have a lot of effect because no one read his stuff until much later, and he was also a monster. Yeah.

**Aven:** Okay, moving on?

**Mark:** Moving on to Albertus Magnus, who is a scholastic naturalist. Albert the Great, Albertus Magnus was from a noble family born around 1200 CE at the family castle of Lauingen He studied liberal arts at the University of Padua. Against the wishes of his family, he joined the Dominican order. I mean, he's from a noble family and he joined a mendicant order, so I can see how that might not please them. In addition to being a mendicant order, specifically the Dominicans are a teaching order.

So as a result, he was asked to explain in Latin, Aristotle's works. So that was his major life's work to paraphrase and comment on Aristotle. But he also included in these commentaries, his own observations and those of other scholars. So he wrote a number of important works. [01:22:00] First of all, there is the *Liber De Natura Locorum* on geography.

That's one of his earlier works. He reviewed ancient arguments against the possibility of people being able to live at the equator, and he dismissed them. the evidence of this being that Ptolemy and Ibn Sina had reported about people between the Tropic of Cancer and the equator, and there's other evidence and records of, such people living in these places.

So that was it. He still believed that life there would be difficult and held that the poles were uninhabitable. Which

**Aven:** he's not essentially wrong on. I mean, there are some people, but even, even people who live in the Arctic don't really live at the pole. Yeah. Not, Long term.

**Mark:** As he points out, there's day for half the year and night for half the year.

Yeah, it's a problem. It's a problem. And he notes that animals such as bears and lions in polar regions tend to be white. And so, these are extreme environments. He knew that proximity of the sea [01:23:00] modifies climate on land, which we know is true high mountains can have perpetual snow, mountains can also influence climate by blocking wind, also very true depressions of great depth can have noxious gas, as do swamps and some lakes.

And he believed that living beings are influenced by their localities, mountain seas, wood swamps. Right? Later on during the 1250s, he wrote *De vegetabilibus libri*. Based on a work called *De Plantis* by Nicolaus of Damascus for the 1st century BCE which he assumed was by Aristotle, which is why it came under his program but we now know it's not.

But he did note in working with this text that it wasn't as well written as other Aristotle works, but he attributed this to the lack of skill of the translator from Arabic into Latin.

**Aven:** Okay. So he wasn't doing translations into Latin. He was doing commentaries and summaries? Well, he

**Mark:** did. Yeah, yeah. He was, [01:24:00] it was commentaries basically and paraphrases. Okay. Teaching texts, teaching texts. Yeah. So Albert was the Only medieval encyclopedist who added significant observations of his own to supplement what he culled from his sources.

Mm-Hmm. And this particular work *De vegetabilibus libri* was the most important botanical work of the Middle Ages, yet according to Egerton. It does not equal the botanical treatises by Theophrastus, which he never saw. So, to be fair, he didn't have that to build off.

And then the third work I'll mention is *De Animalibus Libri,* which was probably begun between 1256 and 1260. This is his most extensive and influential work. It's partly a paraphrase of the zoological works of Aristotle but it's also partly Albert's additions to to Aristotle. But this, as Egerton [01:25:00] says, it's really a bestiary based on *De Natura Rerum* of his student, Thomas of Cantimpré who lived from 1201 to 1270/ 1272.

Although he doesn't acknowledge this on the title page, and this is significant because Albert cited both ancient and Arabic sources, but not this contemporary Latin source, so it seems that this is an intentional plagiarism.

**Aven:** Right. That he's not telling people where it's from. Yeah. Well, cause to cite from other sources probably adds value and authority, but to cite from contemporaries doesn't because they don't know anything better than you do.

So it it instead makes it seem like you're copying, right? Like copying from the ancients is good. Yeah. Copying from contemporaries is just copying. So I can see that.

**Mark:** Yes. Note to scholars out there, don't steal from your students.

So, in sum, Albert was the outstanding encyclopedist of the High Middle Ages.[01:26:00] There were others who were as widely read or even more, but at best, they were a blend of fact and folklore, whereas Albert had the most first hand info.

**Aven:** And that's where you're going to stop.

**Mark:** That's where I'm going to stop. I mean, there's,

**Aven:** he writes more if you're interested, he has ones about, it goes

**Mark:** all the way up to the, 20th century. A lot of which I talked about in the other stuff, like all that stuff about the later people who actually are doing this. stuff about with the words ecology.

For instance, yeah, that all that a lot of that information is drawn from those articles. Right? There is a bit of a gap between where that, because that really what I talked about in the video mostly picks up in the 18th century. So, there's a bit of a gap there in the kind of early modern. And there, and there is a bit of an explosion of, you know, there's lots of work on parasites and all kinds of interesting stuff there.

That's not really our remit. Yeah. And it, it, it just got too complicated at that point.

**Aven:** Yeah. So if you're interested in that, the links will be in the show notes. You're welcome to read them because they are, well, I will say they're fairly short articles and they're quite accessible. Yeah.

They're [01:27:00] very much history of science. They're not science. Yeah. You don't

**Mark:** need to be a scientist

**Aven:** to understand them. Yeah. So if you are interested in these topics, it's a very digestible way to access it. Well, I think we need to stop there. I don't know that I've, I haven't exercised these muscles in months now.

 We need to work our way up to a two and a half hour episode. This is only an hour and a half of talking plus the video. So,

but thank you again to everyone who has stuck with us. Thank you, especially to those who are our patrons and have stayed with us. No shade to anyone who has lowered or stopped contributing. I'm never, never mad at anyone who does for any reason whatsoever. We are just grateful for any support you've ever given us.

But in particular, when we stopped producing things, I really don't have any reason to complain. But those of you who stuck with us, we really, really appreciate it. And we promise to keep, well, we promise to do our very best to get back to producing more [01:28:00] content because I've really missed this. Yes. I really do enjoy doing this and having the reasons to.

And there will be more interviews coming up too. I say that I haven't organized them, but I have plans. So we'll, we'll get on that. And there

**Mark:** will be more long form videos coming. I am hard at work on a script right now that is just ballooning into ridiculous proportions, but.

**Aven:** So it'll probably end up getting cut into multiple videos almost certainly, but yeah, he has been working.

I promise you, just, it's, it's slow. So, thank you again, and we'll be back. Good night. Bye bye..

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It helps us a lot.

We'll be back soon with more musings about the connections around us. Thanks for listening.

**Mark:** Bye.

**Aven:** Do you remember how to do this? Me neither.