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Article

Illuminating Our World: An Essay on the Unraveling of the Species Problem, with Assistance from a Barnacle and a Goose

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Abstract: In order to plan for the future, we must understand the past. This paper investigates the manner in which both naturalists and the wider community view one of the most intriguing of all questions: what makes a species special? Consideration is given to the essentialist view—a rigid perspective and ancient, Aristotelian perspective—that all organisms are fixed in form and nature. In the middle of the 19th century, Charles Darwin changed this by showing that species are indeed mutable, even humans. Advances in genetics have reinforced the unbroken continuum between taxa, a feature long understood by palaeontologists; but irrespective of this, we have persisted in utilizing the 'species concept'—a mechanism employed primarily to understand and to manipulate the world around us. The vehicles used to illustrate this journey in perception are the barnacle goose (a bird), and the goose barnacle (a crustacean). The journey of these two has been entwined since antiquity—in folklore, religion, diet and even science.

Keywords: species concept; organic evolution; history of biology; goose barnacles; barnacle geese; Aristotle; Charles Darwin; Linnaeus

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1. Introduction—The Species Concept

Ever since Carl Linnaeus formally established the species concept in 1735, there has been controversy about how a species should be defined [1]. The boundaries between taxa in botany, especially in groups like the grasses, are very permeable indeed, and would be perplexing to most zoologists, who tend to see their species as more robust. But even in zoology there are problems:

decisions may be based on criteria as divergent as biochemistry, genetics, morphology or interbreeding —and which of these is the more appropriate criterion, especially when there is contradiction? Hybridization with viable offspring, between closely related taxa, is not uncommon in invertebrates (e.g., in the Mollusca: Archaeogastropoda), and most of these taxa are afforded full species status. The problem arises because modern species concepts have their origins in the essentialist frameworks developed by Plato and Aristotle [2]; but ultimately this Old World view was shattered by Charles Darwin, who in 1859 recognized the mutability of species [3].

The species concept becomes even untidier when we include that most elusive of parameters: time. For in a palaeontological species, definition is almost always morphological. Further, it is rarely based upon more than a fraction of the skeleton, and although this may seem quite "distinct", the skeleton too is but a portion of the whole. In vertebrates, especially mammals, systematic taxonomy (the system in which organisms are accorded placement into their species, genera, *etc*.) may be based on part of a tooth…

The Greek philosopher Heraclitus once observed, "All is flux". With the species concept, this may be true in two ways—firstly, where a common origin of related species gives them a predisposition to interbreed, *i.e.*, speciation forced by environmental pressures may, with subsequent changes in geography, permit interbreeding between previously disjunct populations, (this is evolution in progress); secondly, because the state of our understanding of natural systems is itself still evolving.

This essay seeks to unravel how we perceive the world around us, and by this labeling, we have hoped to gain some semblance of mastery over it.

2. Development of the Species Concept

2.1. Origin of Species

In 1859 Charles Darwin published *On the Origin of Species by Means of Natural Selection* (hereafter cited as *Origin*), a book generally regarded as initiating a paradigm shift in the ways we understand the nature of life [3]. Darwin arrived at the core elements of his account of evolution by 1838 and by 1844 had written a 235-page paper outlining his conclusions [4]. However Darwin was reluctant to publish it; instead he sealed the paper in an envelope, locked it in a drawer in his study and gave instructions to his wife about what she should do with it in the event of his death. As Darwin told the Rev. Leonard Jennyns in 1844: 'I shall not publish on this subject for several years'. Darwin went on to write:

> I have continued steadily reading & collecting facts on variation of domestic animals & plants & on the question of what are species; I have a grand body of facts & I think I can draw some sound conclusions. The general conclusion at which I have slowly been driven from a directly opposite conviction is that **species are mutable & that allied species are co-descendants of common stocks** [4]. (Stress ours).

Several aspects of this letter and Darwin's reluctance to publish deserve closer attention. Firstly when Darwin says that he has been preoccupied with the question 'of what are species', he is referring to what had become 'the species problem' [2,5]. He defined this as the 'the long standing failure of biologists to agree on how we should identify species and how we should define the word species' [6].

Darwin wrote to Jennyns in 1844, concluding that 'species are mutable' [4][1]. Subsequently, in a letter to Hooker in 1856, Darwin stated that trying to define the 'species' category was 'to define the indefinable' [7]. Darwin's *Origin* 'solved' this problem, but in ways that triggered endless controversy [8], and as we suggest here, did so in ways that open up deep questions about the writing of history.

Secondly, Darwin dealt with his reluctance to publish his evolutionary theory by carrying out an eight year long project to examine and classify barnacles. At that time there was no systematic classification of the Cirripedia (*i.e.*, barnacles), and some naturalists still entertained the idea that they might be molluscs [9]. The group thus provided a fascinating diversion as well as the opportunity for Darwin to demonstrate his competence as a biologist [10]. As Stott astutely observed 'The story of Darwin's barnacle work is also the story of how scientific discovery sometimes proceeds through indirection, for Darwin's eight-year voyage into barnacle darkness … was a voyage driven by curiosity and obsession, but also by an instinct for postponement' [11].

By 1854 Darwin had completed his four-volume study of the Cirripedia [12–15], his first two volumes winning him the Royal Society's Royal Medal in 1853, confirming his status as a natural historian. In 1864 he was awarded the Royal Society's Copley Medal, in recognition of his contribution to geology and natural history [10]. Even though Darwin's barnacle volumes are arranged in a systematic fashion, much as a modern barnacle worker would choose (and remember the barnacle work was completed at least five years before he published *Origin of species*), he certainly found great difficulty in defining his barnacle species, and in a letter to Henslow in 1848 stated "I have not the smallest idea whether my names are correct" [16].

At the time of publication of his final barnacle volume, he was closer to, but still not resolved to publish his theory of species mutability. Only the shock he received following correspondence from Alfred Wallace, a naturalist working in Borneo, propelled him into publishing his theory of evolution in 1859. What would certainly have concerned Darwin was the progress that Wallace had made in the development of the species concept [17,18].

There are aspects of Darwin's study of barnacles that open up large questions about how the history of a science like biology should be written. The difficulty of understanding the mentalities of those from other periods of time and acknowledging those difficulties is widely recognized [19]; indeed, Reinhart Koselleck draws on categories found in German historiography to argue there are just two basic historiographical questions:

> What are the empirically verifiable conditions that have made possible and are making possible actually occurring history in its temporal extensions? … In what ways do historians constitute their history (Geschichte) when they fix it, orally or in writing and offer it to a circle of listeners or readers? Both… questions concern the mediation of being and saying, happening and recounting, (Geschichte and Historie) [20].

Like Foucault, Koselleck points to a central problem facing those who would write the history of an enterprise like natural history or biology. That problem concerns the interplay between concepts like

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[1] Although some decades prior to this, Jean-Baptist Lamarck had concluded in his *Philosophie Zoologique* (1806) that some organisms might change, it was Darwin who first saw both the universality of evolution and the deep time frame in which it operated.

the 'species' category itself, the empirically verifiable 'substance' of reality and the practices of observers and naturalists.

2.2. The Problem of Conceptual History

In the course of his long journey through 'barnacle darkness' Darwin had occasion, in early 1849, to write to H. E. Strickland. Darwin was perturbed by the difficulties he faced distinguishing between taxa, as well as how to attribute 'discovery' and naming rights to other researchers. He gave Strickland examples of the difficulties he was facing:

> Olfers in 1814 made **Lepas aurita** Linn. into the genus **Conchoderma**: [Oken?] in 1815 gave name Branta to **Lepas aurita** & **vittata** & by so doing he alters essentially Olfer's generic definition—Oken was right (as it turns out) & **Lepas aurita** & **vittata** must form together one genus. … Now I suppose I must retain **Conchoderma** of Olfers: I cannot make out a precise rule in Brit. Assoc. Report for this: when a genus is cut into two I see that old name is retained for part & altered to it; so I suppose definition may be enlarged to receive another species; though the cases are somewhat different [21]. (Stress ours).

In a postscript, Darwin refers to another case involving the barnacle *Lepas anatifera*. He asked Strickland: 'Will you by silence give consent to the following?'

> Linnaeus gives no type to his genus **Lepas** though **L. balanus** comes first. Several oldish authors have used **Lepas**, exclusively for the pedunculate division, & the name has been given to the family & compounded in sub-generic names. Now this shows that old authors attached the name **Lepas** more particularly to the Pedunculate division.—Now if I were to use **Lepas** for **Anatifera**; I shd get rid of difficulty of 2d Edit of Hill & of difficulty of **Anatifera vel Anatifa**. Linnæus generic description is equally applicable to **Anatifera** & **Balanus**, though latter stands first, must this mere precedence rigorously outweigh the apparent opinion of many old naturalists? As for using **Lepas** in place of **Balanus**, I cannot. Everyone will understand by **Lepas Anatifera**—so that convenience wd. be wonderfully thus suited—If I do not hear, I shall understand I have your consent [21]. (Stress ours).

The reference to 'old authors' and to Linnaeus's naming of *Lepas anatifera* is provoking. The barnacle Darwin refers to, as *Lepas anatifera* is none other than the common goose barnacle.

From some time before the 10th century and well into the 18th century, members of Europe's intelligentsia believed that two quite real creatures, one a crustacean called the 'goose barnacle' *i.e.*, *Lepas anatifera* Linnaeus 1758, the other a bird called the 'barnacle goose' *i.e.*, *Branta leucopsis* (Bechstein, 1803), were one and the same creature, albeit at different stages in its life-cycle [9]. As noted by Seide, the barnacle goose 'was destined through a curious comedy of errors to become one of the most famous birds in history' [22]. The reference to *Lepas anatifera* points to a belief central to the medieval worldview that hybrids, marvels or *paradoxia* were an accepted aspect of the natural world.

It is no less provoking that Darwin drew on Linnaeus' nomenclature for the 'goose barnacle' *i.e.*, *L. anatifera*. Linnaeus was a key figure in the Enlightenment and the founder of today's systematic taxonomy and binomial nomenclature. Linnaeus believed that God had created everything according to its kind and that differences in kinds depended on three essential properties—shared ancestry, morphological similarity and reproductive isolation. Simply put these conditions refer to the proposition that all members of a species like *Homo sapiens* L., 1758 had a common ancestor (in this

case Adam and Eve); and that the ancestor had the same morphology and could only reproduce with other members of that species. While understood as inaugurating the modern taxonomic approach, it is interesting that Linnaeus had included in the first (1735) edition of his work a section called *animalia paradoxa* (or 'contradictory animals') which became the taxon 'Paradoxa' in which he placed the goose barnacle along with the hydra, the satyr and the phoenix.[2] Only in the sixth (1748) edition of his *Systema Naturae* was the Paradoxia dropped and in 1758 he acknowledged the existence of the goose barnacle giving it its modern name *(Lepas anatifera)* and thus formal placement in taxonomy. The species (or trivial) name of the organism "*anatifera"* is descriptive—namely 'goose bearing', alluding to what it had long meant. Without either irony or embarrassment, the World Register of Marine Species refers to *Lepas anatifera* Linnaeus, 1758 as the 'common goose barnacle' [23].

References to the 'barnacle goose' (hereafter referred to as the barnacle-goose) run from the Middle Ages through the Scientific Revolution beginning in the 17th century, to our own era of advanced scientific rationality. Such a periodization is conventionally understood as a narrative arc of epistemological progress. In this narrative arc what was once a miasma of medieval superstition, mysticism, and the kind of teleological scholasticism which Aristotle's 'species essentialism' licensed, gives way to the 'scientific revolution' and the application of scientific method. The latter is empirical, based upon careful observation, operationalization, and the use of experimental and mathematical procedures to produce predictive and explanatory laws.

Yet as historians of ideas and science have argued, this convenient narrative misleads [24–27]. It fails to explain the widespread capacity of most human communities to generate functional knowledge that is both rich and permits comprehension of the perceived patterns in their world *i.e.*, it is much more than simply an expression of culturally idiosyncratic factors. As Attran notes, humans share a common cerebral architecture that leads most human communities to accurately grasp that:

> …the world of everyday experience is made up of natural chemical and biological kinds whose exemplars manifest definite colors, change in time and are locally distinguished by their relations in time [28].

All known human communities seem well able to generate basic folk categories to describe the life-forms in their worlds, making 'groups within groups' that can be applied to local flora and fauna… indeed, humans impute taxonomic stability to their schema on the premise that species of plants or animals are stable entities [28]. Attran also suggests that in local communities there was generally no need for sophisticated distinctions between species and genus[3]. This distinction only assumes 'a modern character in connection with Europe's *Age of Exploration* in the context of a search for a worldwide order' [28].

This story melds into the modern conventional approach to the history of biology that argues that the discipline was shaped by an Aristotelian essentialist concept of species. Historians of science and philosophers and have long argued that Aristotle was responsible for a model of 'species essentialism' which held that species were *eternally* fixed forms, and that any individual *necessarily* becomes what

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[2] In his fourth (1744) edition of his *Systema Naturae* Linnaeus described the barnacle goose thus: BERNICA: seu ANSER SCOTICUS & CONCHA ANATIFERA e lignis putridi, in mare abjectis, nasci a Vetribus creditur. Sed fucum impsuit *Lepas* interanis suis penniformibus, & modo ahaerendi, ac si verus ille Anser *Bernicla* inde oriretur

[3] This changed in the late 20th Century, when increasing mobility and trade led to a greater need to recognize subtle differences between species, e.g., to identify invasive and poisonous taxa and to enhance (or restrict) interbreeding.

it is by virtue of its species-specific properties'—a conclusion apparently derived from Aristotle's 'method of Logical Division' [5,29–32]. This understanding is underpinned a narrative about natural history that states:

> The taxonomy of living things that Darwin inherited was…a direct descendant via Aristotle of Plato's essences…In Darwin's day species of organisms were deemed to be as timeless as the perfect triangles and circles of Euclidean geometry [32].

Nonetheless, Aristotle did recognize a hierarchy, which could presumably provide an opportunity for transmutation [33].

Darwin's intervention in 1859 disposed of the species essentialist story, and barnacles and geese play a small but vital role in this. Darwin's decision to devote time and effort to researching barnacles began in Chile in 1835, during his voyage around the world on HMS *Beagle*. On a beach in Chile, Darwin discovered a curious, minute burrowing barnacle in a mollusc shell that he nicknamed 'Mr Arthrobalanus'. 'Mr Arthrobalanus' was anomalous *prima facie* because the conventional wisdom was that barnacles had shells of their own, yet this individual did not.[4] Darwin was troubled by a basic taxonomic question: what makes a barnacle a barnacle?

Darwin's barnacle project raised all sorts of questions about the classification systems used by zoologists. Darwin had wondered aloud in his letter to Strickland about 'the question of what are species' [21]. It is striking that it was in 1844 as he pondered the wisdom of publishing his paper on evolution, that Darwin returned to consider the bottle containing the pickled remains of 'Mr Arthrobalanus' [11]. Darwin was confronting a question crucial to zoologists both then and now:

> …when there is so much variation within a group like the barnacle what—in terms of size, mode of reproduction, and life cycle—common features hold the family together? [11].

The question of what Darwin meant by the word 'species' has long teased, and this is surprising given the central role played by the word 'species' in *Origin*. Darwin's 'mystery of mysteries' is resolved in part by 'dissolving the problem' [3,34]. In terms that have puzzled and provoked a good deal of later scholarship, Darwin came to think that the very category of species and any attempt to specify the difference between species and varieties was an arbitrary exercise [35,36]. Indeed, Sober goes so far as to suggest that Darwin's book is better understood as explaining 'the origin of diversity by means of natural selection' [34].

Without engaging all of the very large questions about Darwin's intervention there is one question we do want to address here: how well does the story that Darwin inherited a taxonomy of living forms from Aristotle, via a line of naturalists and theologians, stand up to scrutiny? In particular how well does it make sense of the beguiling story of the barnacle-goose represented all too frequently as a 'myth' or a 'comedy of errors' but which demonstrated surprising longevity? [9].

Making sense of the longevity of the barnacle-goose saga across the second millennium in Europe requires a capacity to reflexively grasp the relationship between the writing of history and the role played by sense-making categories available both to the historical actors—and to the historians writing about them. The difficulties are formidable as neither the language categories (*i.e.*, the discursive

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[4] As Stott shows, only in the 1840s did Darwin discover how absolutely anomalous this barnacle was.

practices of a given community), nor the historical events, nor the practices can be used to adjudicate historical claims that a particular phenomenon was either 'rational' or 'irrational', or 'sensible' or 'nonsense'. Importantly, this relationship cannot be subject to some kind of Archimedean adjudication relying either on the rationality of the language categories or on the facticity of historical events or practices to secure a stable epistemic basis for such adjudication. This is because we cannot quite escape:

> …awareness of a gap between historical events and the language used to represent them—both by the agents involved in these events and by historians retrospectively trying to reconstruct them … [37].

In short there are fundamental conceptual and hermeneutic problems involved in writing history—and these arise because history is to varying degrees a discourse of past reality rather than an assemblage of verifiable facts.

At stake here is what kind of practice a critical historical consciousness might look like.

This general observation requires us to identify both what the case of the barnacle-goose represents, and what Darwin's solution to the 'species problem' represents for the kind of reflexive critical historical consciousness involved in this hermeneutic exercise. In particular we explore what and how Europeans thought about the barnacle-goose and the extent to which ideas about species were at stake. We begin by reflecting upon the way the 'barnacle goose/goose barnacle' nexus unfolded in European natural histories over the last two millennia.

3. The Case of the Barnacle-Goose

While there is a good deal of evidentiary material testifying to the 'existence' of the barnacle-goose, establishing the point of origin in the idea that a barnacle tree grew fruit-like barnacles from which geese burst forth to take to the air is complex. In 1928 the English chiromancer, historian, and psychic, Edward Heron-Allen (1861–1943) published a delightful text that reviewed the history of the 'barnacle tree in myth and nature' [38,39]. Like Lankester who published similar observations in the previous decade [39], Heron-Allen claimed that the first clear references to the barnacle tree were in the second half of the 12th century [38].[5]

Nonetheless, Heron-Allen attributes equivocal accounts, made during the 11th century, of the creation of birds from trees to Fr. Pietro Damiani, then Bishop of Ostia (the harbor city of Rome) [38]. Damiani described birds 'bursting fully fledged', from apple-like fruit on a tree that grew on an island in India. However Heron-Allen claimed that the Bishop did not make any explicit barnacle-to-goose link and claims priority for the story belongs to Gerald of Wales [38]. More recently it has been argued that the Venerable Bede, the father of English history (673–735) *may* have recorded the story of the barnacle-goose in his 8th century work on natural history, *De Natura Rerum* [40]. In that text Bede observes that the goose 'Barliata' grows on rotten wood by the sea where it hangs by its beak until it falls.

What is clear is that by the 12th century the barnacle-goose was well attested. There are at least three accounts of the barnacle tree, each of which appeared in the late 12th century: by Rabbi Isaac ben Abba Mari, Gerald of Wales, and Alexander of Neckham [41]. The first account *circa* 1170 by Rabbi

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[5] Although Heron-Allen spent some time reviewing images of birds and other animals on Mycenaean pottery (*circa* 1600–1100 BC) he concluded that it was unclear that the Mycenaeans were claiming any biological relationship between geese and barnacles.

Mari in Marseilles, noted the advice of another Rabbi called Jacob ben Meier Tam, who had directed that barnacle-geese 'should be slaughtered after the Jewish fashion and sent this decision to the sons of Angleterre' [42]. Medieval Jews were fussed by the strange nature of the barnacle-goose. It mattered very much to them whether the creature was a bird or a shellfish.[6] Jewish dietary laws forbade eating the latter; but they could eat the former after ritual slaughter. This anxiety helps us to date the development of the story of the barnacle-goose to the 11th century. This text locates the account of the barnacle-goose in England, and prior to Gerald of Wales, since Rabbi Tam was dead before the invasion of Ireland in 1188. Later, in 1245 an anonymous Hebrew translator of the French cosmography called '*Image du Monde'* writes of geese growing on trees in Ireland and of people with tails in Brittany. He is the first Jewish author to locate the birds on Irish shores.

By far the best-known early account of the barnacle-goose was offered by the monk Gerald of Wales (1146–1223) who accompanied the invading armies of Henry II to Ireland and whose account of the barnacle-goose in *Topographia Hibernica* can be dated to 1188. Gerald believed the barnacle-goose to be unique to Ireland:

> There are here many birds that are called 'Barnacles' [barnacoe] which in a wonderful way Nature unnaturally produces; they are like wild geese but smaller. For they are born at first like pieces of gum on logs of timber washed by the waves. Then enclosed in shells of a free form, they hang by their beaks as if from the moss clinging to the wood and so at length in process of time obtaining a sure covering of feathers, they either dive off into the waters or fly away into free air … I have myself seen many times with my own eyes more than a thousand minute corpuscles of this kind of bird hanging to one log on the shore of the sea, enclosed in shells and already formed… [42].

Finally, towards the end of the 12th century Alexander Neckam (1157–1217),[7] in a reprise of the preoccupation with dietary restrictions, chastised those who ate barnacle-geese at Lent, described the animal as a:

> …bird which is commonly called bernekke [which] takes its origin from pinewood which has been steeped for a long time in the sea. From the surface of the wood there exudes a certain viscous humour which in course of time assumes the shape of a little bird clothed in feathers and is seen to hang by its beak from the wood. This bird is eaten by the less discreet in times of fasting because it is not produced by maternal incubation from an egg. But what is this? It is certain that birds existed before eggs. Therefore should birds that do not emerge from an egg follow the dietary laws for fish any more than those birds which are begotten by the transmission of semen? Have not birds derived their origin from the water according to the irrefutable pages of holy doctrine? [43].

As Donoghue has noted, all accounts assume that knowledge of the barnacle-goose was widespread by the 12th century and address dietary issues for both Christians and Jews—and this implies that these accounts could only have been written after what he calls the 'legend' had been in circulation for some time [41]. Certainly by the early 13th century the story of the barnacle-goose was well attested and is illustrated in Vincent of Beauvais's *Speculum Naturale*, wherein it is observed that at the Fourth

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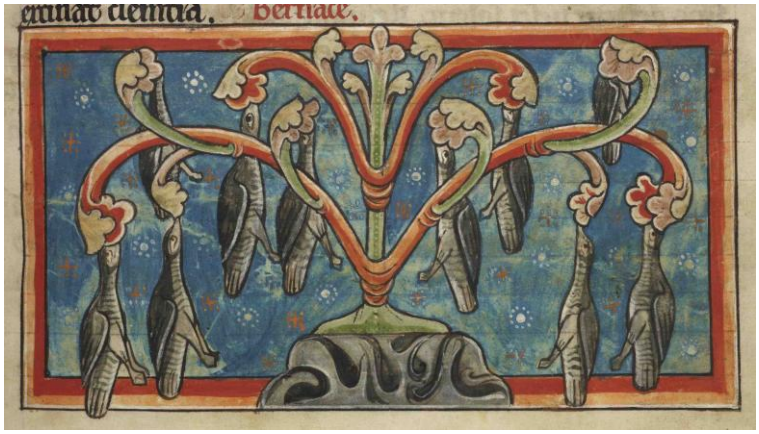
6 In modern parlance, the term "shellfish" exclusively applies to molluscs. Barnacles are crustaceans.

7 In his *De Naturis Rerum* Neckam provides the earliest European notice of the compass *i.e.*, a floating magnet as a guide to seamen.

Lateran Council, Pope Innocent III banned their consumption during Lent. (*Unde et carnibus earum in quadragesima nonnulli etiam Christiani in nostra in locis, ubi auium huiusmodi copia est, uti solebant. Sed innocenti.* (Papa iii in Laterannensi Concilio generali hoc ultra fieri vetuit).

The British Museum has an image from a *Bestiary* held in the British Library, Harley MS 4751, Folio 36r and dated 1235. The genesis of birds from a tree being achieved via a barnacle intermediary, such that in today's taxonomy we would have a plant producing a crustacean that hatched to form a vertebrate (Figure 1).

Figure 1. Bernace or barnacle-geese as described by Gerald of Wales (Giraldvs Cambrensis circa 1146–1223): *Bernace develop from beams in the water and hang from trees enclosed in shells until they can grow feathers and fly*. This Bestiary is held in the British Library collection, Harley MS 4751, Folio 36r; image produced in England, possibly at Salisbury; dated 1235 [9].



As time passed, the story grew, aided by the new technology of printing and printmaking, and Britons seemed eager to claim the barnacle-goose as their own. The 1597 edition of John Gerarde's *Herball*—a comprehensive treatise on plants—includes in the last section, on page 1391, an illustration of his tree, captioned as '*Britannica Concha anatifera*. The breede of Barnakles':

> "This tree had been known for centuries to grow certain shellfish, which falling into the water, doe become foules, whom we call Barnakles… Brant Geese… or tree Geese" [44].

It is Gerarde's tree, or variations of it that abound in the literature up until the late 17th century, by which time, the barnacle tree had migrated to islands to the north of Scotland, or in some instances Ireland [9].

The story of the barnacle-goose was to endure even as the Scientific Revolution gathered momentum. In the 17th century Giralamo Cardano argued in his *Magnes Vive de Arte Magnetica* (1641–1654) that plant-animal hybrids such as the barnacle-goose were entirely plausible [45]. He claimed that some waterfowl drop their eggs into the sea, waves churn the eggs into froth, and the resulting barnacles eventually cling to boats [45]. It is even more surprising that in 1661 the first president of the Royal Society, Sir John Morey gave a paper in which he described a creature that he had personally observed within the shell of an acorn barnacle as 'little birds perfectly shaped, supposed to be Barnacles' [39].

It was not until the middle of the 17th century the weight of intellectual opinion began to turn against the representation of the barnacle-goose—although there had been skeptics, including Frederick II (d.1250), Albertus Magnus (d.1280) and Roger Bacon (d.1294). Albertus insisted, 'I myself and many of my colleagues have observed these birds copulating, laying eggs and feeding their young'. Since Albertus is most unlikely to have ever visited Spitzbergen where the wild birds breed, it must have been domesticated birds that he saw [39]. Cardinal Piccolomini (later Pope Pius II) on a visit to King James II of Scotland in 1435 inquired about the bird and was told he would need to go north to the Orkneys: at which point he noted somewhat acidly 'that miracles tend to always flee farther and farther' [39].

Closure of the barnacle-goose saga occurred in the late 18th century, when the French naturalist, Jean-Étienne Guettard (1715–1786) critically analyzed the phenomenon:

> No one who has read this memoir can fail to be amazed that an absurdity such as we have been discussing has occupied the attention of scientists of the first rank for centuries, and that it has taken all this time to establish a truth which a properly conducted observation would have established… it would have been sufficient to have watched the life-history of the s (or) to have made a careful dissection… but that would have required care and attention, and it was more convenient to give a loose rein to the imagination [46].

4. Making Sense of the Barnacle-Goose

On the one hand those who attested to its existence claimed to be good empiricists attending to the way things looked. As Buckeridge has pointed out, goose barnacles look superficially like a miniature bird [9]. The appendages (cirri) are not unlike 'feathers', which when exposed with the remaining soft tissue after removal of the shell, together could be misconstrued as a goose-like body; the peduncle may well show similarity to the long neck of a goose, but alas there is no head, presumably this was yet to develop (Figure 2). Gerald of Wales claimed credibility because he was an eyewitness: *Vidi multotes oculis meis plusquam mille minuta hujusmodi avium corpuscular.* (I have seen more than a thousand instances of these birds with my eyes) [47]. Nonetheless, medieval natural history is not 'necessarily adequately represented by the bestiaries influenced by models like the *Physiologus* of Alexandria which were not reliant on 'first hand observation' [24,47]. A proper appreciation of Gerald's merits begins by acknowledging his powers of observation which in turn necessitates that 'our ideas about medieval zoology may need to be revised' as we develop a better appreciation of the 'actual working knowledge of the medieval man' [47].

The representation of the barnacle-goose was quite unlike the invocation of exotic beasts such as the phoenix or the Scythian lamb in distant lands—for at the time it was an acceptable interpretation of a natural phenomenon. Anglo-Saxons were fairly observant and had a reasonable knowledge of their natural world, *i.e.*, a world in which both barnacles and geese were a part. In 10th-century England, the Saxons thought the bird was flying out to sea to hunt for fish in mid-ocean. (We now know that it does not eat fish; it crosses the sea to northern beaches where it eats plants and invertebrates). The barnacle-goose is migratory; it spends the winter on the Solway Firth, between England and Scotland, benefiting from a milder climate than that found on the cliffs of Svalbard or Greenland.

Since it was never observed mating or laying eggs, medieval Europeans thought it never did so: they simply assumed that it started life attached to a floating log. The representation of the barnacle-goose

as a hybrid form simply served to make sense both of a goose with no known nesting ground and of a crustacean that looks like a goose. It was widely believed that the goose 'generated spontaneously from sap exuding from marine driftwood' with Gerald claiming to have seen minute budding specimens of this bird; importantly, the morphological relationship between adult and embryo was unlikely to have been widely appreciated [47]. The very absence of evidence about this aspect of the bird's life cycle illustrates how people set about reaching an acceptable world-view, and the representation of the barnacle-goose gained traction because it apparently explained observed phenomena.

Figure 2. The stalked barnacle *Smilium zancleanum* (Seguenza, 1876), with plates on the right-hand side removed to show the cirri. The resemblance to a bird's wing is evident, although it clearly lacks a bird's head. Length of barnacle 30mm [48].

None of this implies that Gerald or his contemporaries got it right, for important questions remain: e.g., how did medieval people sustain a belief in things they could see, with things they could not see but believed to exist? This represents a conceptual schema at work in the medieval trope of the world —as the book-of-nature worked to represent the visible world as:

> A vast network of created objects that bare profound theological meanings … made manifest through a contemplative consideration of how they analogously resemble moral and theological truths [49].

Among those truths was the way God allowed for marvels and wonders. In the Middle Ages it seems that as well as visibly present local wildlife and domestic animals, marvels such as sirens, phoenixes and barnacle-geese were accepted as both actual *and* exemplary wonders of nature.

Daston and Park remind us that the conceptual or discursive framework available to medieval communities had its own history [26]. The vocabulary of medieval philosophy and theology for example sustained a distinction between things understood to be marvels (*mirabilia*) and things which

properly speaking were miracles (*miracula)*. The function of *mirabilia* was to show God's omnipotence thereby evoking wonder—a religious emotion or disposition. As Gervase of Tilbury insisted, humans needed to distinguish between *mirabilia i.e.*, those things that have happened or can happen but are rare, and *miracula*, those things that are at variance to nature and are incomprehensible—revealing an omnipotent God who can change or challenge the very laws of nature. The very existence of 'wonders' and 'marvels' was a constant reminder of the Creator's power. Augustine, Vincent of Beauvais, and Thomas of Cantimpre all used *mirabilia* to showcase God's omnipotence, emphasizing the way they evoked wonder—a valuable religious disposition [26]. Gerald used the barnacle-goose to invoke the truth of God's role in creation and maintenance of faith, insisting that barnacles reproduced by spontaneous generation from dead matter and without any assistance from a parent (*i.e.*, abiogenetically). As he noted, 'There are here many birds that are called 'Barnacles' [barnacoe] *which in a wonderful way Nature unnaturally produces*' [26]. (Stress ours). Like others of his time, Gerald understood the larger truth exemplified by marvels in religious terms. The barnacle-goose was valuable because it ameliorated the rigors of Christian dietary restrictions: as Gerald observed 'in certain parts of Ireland bishops and religious men in times of fast used to eat these birds as *not flesh, nor being born of the flesh'*. There was a bonus too, for the barnacle-goose—which apparently reproduced itself by asexual means—was a living argument for the Christian faith… their very existence permitted admonishment of Jews who, in their refusal to grant the Christian doctrine of virgin birth placed their own salvation in jeopardy. He warned the Jews:

> Be wise at length, wretched Jew, be wise even though late. The first Generation of man from dust without male or female [Adam] and the second from the male without the female [Eve] thou darest not deny in veneration of thy law. The third alone from male and female, because it is usual, thou approvest and affirmest with thy hard beard. But the fourth, in which alone is salvation, from female without male, that with obstinate malice thou detestest to thy own destruction. Blush, wretch, blush, and at least turn to nature. She is an argument for the faith and for **our conviction procreates and produces every day animals without either male or female** [26]. (Stress ours).

Gerald of Wales represented the barnacle-goose as both an empirical entity that he had seen a thousand times over *and* as a marvel embodying a theological truth. He thus personifies the flexibility with which medieval people perceived their natural world. Gerald of Wales' claim to have seen something with his own eyes remained the highest standard of credibility. It was accepted that truth was multivalent, and 'could be found on different levels both literal and figurative with moral and spiritual meaning more important than descriptive accuracy' [26].

The same point may be made when contemplating Nehemiah Grew's landmark text *The Anatomy of Plants*, first published in 1682 [50]. For Grew's book advanced what was in effect the first comprehensive programme of botanical research [51]. Yet Grew's book occupies an uneasy place in the history of science… it is at once 'too Baconian in its method to be counted among medieval herbals, but not modern enough to have fully anticipated future discoveries in plant and cell biology' [45]. That equivocal status is represented in Grew's dedication where he argues that animals are plants and plants animals, and both are like books: 'a plant is, as it were an Animal in Quires; as an Animal is a Plant, or rather several Plants bound up into one volume' [45]. It seems that Grew has drawn on a standard trope set loose by St. Augustine which informed medieval thought: *i.e.*, a tradition that spoke

of the book of scripture and the book of nature [52,53]. In the 12th century figures like Hugh of St Victor wrote '… the whole sensible world is like a kind of book written by the finger of God … each particular creature [has been] instituted by the invisible will to manifest the divine things of god's wisdom [49]. In this way representations of animals, plants and stones in medieval bestiaries became bearers of both theological and moral meaning; but it was also a period in transition (or even crisis) regarding the natural ordering of things [49].

Accounts of hybrid creatures continued to circulate into the 17th century and valuably, sponsored experiments in comparative anatomy and embryology. The later Renaissance stalls the continued salience of animal/plant hybrids, such as the 'Scythian lamb' (or 'the vegetable lamb of Tartary') into the early modern period… indeed, Girolamo Cardano used comparative arguments in his 1557 manuscript *De Varietate Rerum* to argue that a hybrid like the 'Scythian lamb' was anatomically inconceivable [45]. Paying attention to Grew's claim that an animal is a plant, a plant and animal, and both like a book, in short points to a way of making sense of the shift away from accounts of wonders like barnacle-geese or 'vegetable lamb' to modern biological science. That in turn connects to the point made by Daston and Park who place the role played by 'marvels' and 'wonders' at the centre of their narrative and in doing so, challenge the traditional historiography of science and philosophy [26]. This involves letting go not only of conventional periodization, which splits 'the medieval' from the 'early modern' study of nature, but also involves rejecting.

> … the much more basic ideas of distinct stages, water-sheds, new beginnings, and punctual or decisive change. These narrative conventions, imported into intellectual history from 18th- and 19th-century political historiography, only distort the nonlinear and non-progressive cultural phenomena we describe. For the most part our story is not punctuated by clearly distinguished epistemes or turning points, but is instead undulatory, continuous, sometimes cyclical [26].

5. The Barnacle-Goose and Species Essentialism

We have noted how the philosophical tradition associated with Aristotle and represented as a tradition of 'species essentialism' has played a central role in the history of biology. How then should we think about the claim that for more than two thousand years Aristotle's model of species essentialism has shaped the way naturalists produced descriptions of living forms? Essentialism itself is a way of thinking about:

> …natural kinds. It holds that each natural kind can be defied in terms of properties that are possessed by all and only members of that kind. All gold has atomic number 79 and only god has that atomic number ... a natural kind is to be characterized by a property that is both necessary and sufficient for membership [34].

More particularly a species essentialist view holds that when thinking about a species like *Homo sapiens* or *Rattus rattus*, 'there is some property which all and only members of that species possess' [54]. It has long been conventional to argue that 'species essentialism' exercised both a baleful influence on medieval philosophers and naturalists as well as producing a long-lasting effect into the modern period by shaping the ways eminent naturalists including Linnaeus, Ray, Lamarck and Darwin's contemporary Lyell thought about species. Indeed, Stamos notes that:

> …species essentialism…has enjoyed a long and distinguished history, being traceable back, broadly speaking, to the views of Plato and Aristotle on the one hand, and the Book of Genesis on the other. The combination of these two traditions found its culmination in Carolus Linnaeus [55].

If the implication is that there is a seamless tradition of species essentialism running from Aristotle to Linnaeus, it is tempting to expect that the medieval period, given the dominance of Aristotelian thought we think characterized this period, would sponsor a species essentialist view—for this would enable a way of classifying life forms like the barnacle-goose. However this supposition is void on a number of grounds.

Aristotle's work shows that he was not a believer in species essentialism; although he accepted that certain generalized 'species' (*eide*) like 'man', 'animal' and 'plant' (which are closer to modern ideas of *genera)* are in some sense 'eternal' [2,28,56]. Aristotle argued that only when certain environmental conditions are met can the typical *morphe* emerge in a given individual whose underlying nature falls within a given range' [28]. Nonetheless, Aristotle did acknowledge that there were degrees of affinity between organisms and although it would seem a truism to state it today, he saw our closest kinship with animals rather than plants [57]. He also perceived a clear hierarchy in the world around him: his *Scala Naturae* reflected this, and was arranged almost imperceptibly from the lifeless to the most perfect—the rational soul of Man [33]. In light of these observations, and given another decade, Aristotle may well have developed a theory of evolution [58]. His *Scala Naturae* was however not a taxonomy in the way we would see it, rather it was a division of things on the basis of 'movements', with a progressive weakening of movements as one moved from Man, through lower plants to inanimate objects. In his *scala*, the latter group was clearly separated from the living [33]. It is clear that Aristotle's treatment of necessary conditions and essences in connection with species had nothing to do with logical claims, and everything to do with the functional and developmental conditions which members of species enjoyed (or did not), as they developed across their life course [2,28,56].

Medieval representations of the natural world survived without relying on any kind of classificatory system—Aristotelian or otherwise, until the middle of the 15th century [59]. Up to then there was a rich tradition of cataloguing creatures, both real and/or imagined, in bestiaries. Equally, medical herbalists involved in the production of medicines engaged in the study of plants with medicinal properties, producing descriptions, prescriptions and illustrations. As we have noted, these representations of wonders survived for long periods in scholarly texts such as Gerald of Wales' *Topographia Hybernica* without elaborate taxonomic or classificatory schemes or systems. But this is not to ignore the role played by other conceptual schemes like those supplied by theological belief and inscribed in tropes like 'the book of nature'.

Unfortunately, Aristotle's work was not available widely or uniformly enough in Europe to have sustained any species essentialist paradigm until after the 13th century—even if he had promoted such a conceptual scheme. The process of transmission of important Aristotelian texts into Europe via Arabic sources really begins in the late 12th century: a transmission that was superimposed on top of a vibrant, even controversial intellectual culture, in centres like Paris and Oxford. From the 11th century on, 'realists' like St Anselm debated with 'nominalists' like Roscelin and 'conceptualists' like Peter Abelard or John of Salisbury questions like: What if anything were the referents for words like 'man' and 'animal' understood to be 'universals'? Realists insisted that there were real entities or things to

which such concepts referred like really existent species (or Aristotle's *eidos*). Nominalists insisted that universals only referred to concepts or names constructed in the human mind… and conceptualists agreed with nominalists noting that a universal term can be predicated of many individual things but added the idea that as rational agents, humans can grasp real qualities found determined in the real world, and they can abstract or join together the elements that make up a universal. Within European universities, the philosophical and theological discourse towards some formalizing of classificatory systems was impelled by intense philosophical debate and controversy between different kinds of Aristotelian essentialists including the realists, the nominalists and conceptualists; in turn these were inspired by the likes of William of Ockham. Ultimately, it spilled out a process driven by the spread of manuscripts and by new print technologies. As Daston and Park have suggested, the Augustinian framework of the 13th century fell away as their audience diversified and expanded to include lay and vernacular readers [26]. There was less indoctrination via divinely inspired natural phenomena—rather the world around them came to be seen as comprising objects of unadulterated pleasure and fascination.

By the late fifteenth and sixteenth centuries, a classificatory approach dependent on some kind of species essentialism had begun to coalesce. It was led by figures such the humanist Leoncino (1428–1524), herbalists like Brunfels and Brock (*circa* 1530) and the naturalist Cesalpino (1519–1603), the latter developing an Aristotelian taxonomy in his *De Plantis Libri XVI* (1583) [2]; although we should be mindful that Aristotle had rejected this classificatory modality when applied to life forms.

6. Conclusions: Darwin and the Problem of Species

By using the barnacle-goose as a vehicle, this paper attempts to challenge the premise that Darwin confronted a persistent tradition of species essentialism. This is not to deny the greater point wherein Darwin thought that the category 'species' was both indefinable and arbitrary [8]. He clearly thought the species concept was indefinable because he was skeptical of the distinction between 'species' and 'varieties', both of which are used extensively in his 1854 barnacle monograph. Five years later, it is still unresolved... for in *Origin*, he wrote:

> I look at the term species as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety [3].

In other words, he could determine no difference between species and varieties, and there are three good reasons for this [8]:

- That there is no process that distinguishes 'varieties' from 'species'[8].
- That any difference drawn between them sat on a seamless continuum and was made by the observer for pragmatic reasons.
- That the distinction between varieties and species was rejected because it rested on theological frames which relied on ideas about a divine creation rather than 'natural selection'.

Darwin solved the species problem by arguing that the species concept does not exist in nature; nonetheless, he believed we can and should continue to use the species concept in a pragmatic way [8,60].

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[8] Most of Darwin's varieties remain as valid species and although some were subsequently reassigned to other taxa, recent work has resulted in these being returned, close to where Darwin had originally assigned them [48].

Darwin's solution rests on a distinction between allowing species like *Homo sapiens* or *Lepas anatifera* to exist, while denying that there is an essential species category *per se* possessing explanatory power, although distinguishing between species on the basis that if one knows that a taxon belongs to a species category you can explain various features of that taxon, is somewhat circuitous [61].

In 1856 Darwin acknowledged to Hooker that he thought the species concept to be indefinable because there was no natural essence to be discovered that could enable a theoretical definition of it.[9] In 1859 he concluded *Origin of Species* in this striking fashion:

> …we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect but we shall at least be freed from a vain search for the undiscovered and **undiscoverable essence of the term species** [3]. (Stress ours).

Equally Darwin seems to have believed that it was useful to accept the conventional way naturalists identified particular taxa as 'species'. As he wrote in a draft of *Origins*:

> In the following pages I mean by species those collections of individuals which have commonly been so designated by naturalists [3].

Likewise he advised that:

> …in determining whether a form should be ranked as a species or a variety, the opinion of naturalists having sound judgment and wide experience seem the only guide to follow [3].

Darwin's reference to species does not signify that he believed species occurred in nature [8,60]. Rather, needing to convince other naturalists of his account of evolutionary selection, it seems that he may simply have opted for the conventional discursive practice of other naturalists… when Darwin used the word 'species' we contend that he was merely referring to those taxa that biologists call species rather than to a natural category [8]. The point that many have overlooked or ignored is that Darwin's theory of evolution precisely advocates for and requires the dissolution of any essentialist understanding or conceptualization of the species category. For modern science sustains a consensus about the biological species concept which allows taxa to exist within an evolutionary framework, and that in this case Darwin was premature in trying to dispose of the species concept [35]. Darwin's problem was that he was not around in the late 20th century to enjoy the benefits of contemporary science! Indeed, in the mid 19th century, there was no contemporary scientific consensus about the Biological Species Concept [8]. If anything, the diversity of attempts to ground the species concept has increased even more, for there are now at least 24 species concepts proposed by mainstream biologists—and this does not include palaeontologists [6]. It seems that modern biology and palaeobiology is yet to supersede Darwin's seminal point:

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[9] Darwin put the problem clearly to Hooker:

> It is really laughable to see what different ideas are prominent in various naturalists' minds, when they speak of 'species'; in some resemblance is everything and descent of little weight—in some, resemblance seems to go for nothing and Creation the reigning idea-in some sterility and unfailing test, with others it is not worth a farthing.

Darwin to Hooker, 24 Dec. 1856 [7].

> When the views entertained in this volume on the origin of species, or when analogous views are generally admitted, we can dimly foresee that there will be a considerable revolution in natural history. Systematists will be able to pursue their labours as at present; **but they will not be incessantly haunted by the shadowy doubt whether this or that form be in essence a species** [3]. (Stress ours).

These remarks help to contextualize White's advocacy for a theoretical turn to a 'critical historical consciousness' and to engage the 'history of historiography' through close attention to the role played by the vocabulary of categories available to, and used both by historical actors and by later historians [37]. As we argue here, paying attention to what is now called the 'myth of the barnacle-goose' raises important and interesting questions about how to write the history of science—in particular how we account for the way 'science' itself evolves classificatory schemes as well as clarifying the role played by categories in the work of observation and classification. How is a history of science to be written which addresses both the problem of the species category in light of the empiricist claim that medieval eyewitness observations made by people like Gerald of Wales? And how should we view the claim made in 1661 by Sir Robert Moray, who described a bird-like creature that he said he had personally observed within the shell of an acorn barnacle? Finally the case of the barnacle-goose challenges us to ask why it is not helpful to continue to believe that Darwin confronted a persistent tradition of species essentialism arching back over two millennia.

This is nicely encapsulated by Richards:

> What confronted Darwin then, was not a property essentialism but a multiplicity of species concepts based on similarity, fertility, sterility, geographic location and geologic placement, and descent [2].

The case of the barnacle-goose—something we would now conventionally enough condemn as superstitious nonsense and/or as thoroughly unscientific, recalls to mind the strangeness of the ways we make sense of our world. Darwin, who thought the mutability of species not at all strange, was prepared to dissolve the putative stability and determinacy of the species category altogether. He undertook this in terms that seemingly anticipate contemporary cognitive scientists who understand that all categories (like 'species') are inherently indeterminate and should be retained only when serving some pragmatic sense-making function. This reminds us of the shift in the intellectual culture of 20th century philosophy and the humanities conventionally attributed to Wittgenstein, who drew attention to the larger problem of using any 'category' in a non-arbitrary way. In Wittgenstein's discussion of the category *game*, he opened up the problem of language use itself, which he argued was resolved by treating all language use as a 'language game' [62].

As cognitive psychologists have shown, we should be mindful that there is an essentially pragmatic and arbitrary character to any category like 'species' whenever we use language (or discourse) to represent the world, even when or especially when we are engaged in observing this world.

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