

Fighting with the Heart of a Beast: Galen's Use of the Elephant's Cardiac Anatomy against Cardiocentrists

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IN HIS DISCUSSION of the heart's structure and function, Galen interrupts his narrative to recount an aggressive confrontation with rivals in the streets of Rome over the existence of a bone at the center of the elephantine heart. Throughout this digression, he denounces contemporary physicians alongside medical theorists past and present for their theoretical and empirical inadequacies, especially the claim that the elephant's heart lacked a bone. Galen concludes the episode by triumphantly drawing attention to a massive bone recovered from this elephant's heart, which sits on his desk while he writes, proof to visitors of his medical acumen and his rivals' anatomical failures. Although this bone, the *os cordis*, is found in the hearts of certain ruminants, Galen could not actually have seen what he claims to have. The bone does *not* exist in elephants. What motivated Galen's claim that it does? Why did he turn to the elephant as an *exemplum* for general cardiac structure?

I examine this puzzling episode, described fully in Galen's anatomical treatise, *Anatomical Procedures (AA)*, and alluded to in his more theoretical work, *On the Usefulness of Parts (UP)*.¹ While

¹ *AA* II 619–621; *UP* III 502–503 = I 365.14–366.13 Helmreich. I cite the titles of Galenic works according to the Latin abbreviations in R. J. Hankinson, *The Cambridge Companion to Galen* (Cambridge 2008) 391–397, followed by the Kühn volume and page. Where Kühn's edition has been superseded by a later critical edition, I include a reference to it. Translations are my own unless otherwise indicated.

Galen's accounts of the elephant and its heart bone may appear at first glance to be mere historical curiosities, they should be considered in the context of a fundamental debate in Greco-Roman science and medicine. Cardiac structure and function bore directly on two prominent claims concerning the physical basis for volition in the post-Aristotelian biological tradition. So-called cardiocentrists situated the voluntary faculty (*to hege-monikon*) in the heart, while encephalocentrists such as Galen placed it in the brain. Galen and the doxographical tradition bear witness to the debate from the Classical through the Late Imperial period.² For Galen, affiliation with either camp often entailed further commitments to epistemological positions on the nature of observation, verification, and on the role of empiricism in generalizations about the world.

Therefore, to the extent that philosophical claims about volition depended on one's anatomical claims about the *hegemonikon*, undermining the latter undermined the former. Although some scholars have discussed the performative and political dimensions of Galen's anatomical displays,³ scholarship has not focused on Galen's engagement with rival theorists

² For the debate between cardiocentrism and encephalocentrism see J. Rocca, *Galen On The Brain* (Oxford 2003) 31–47; T. Tieleman, "Galen on the Seat of the Intellect: Anatomical Experiment and Philosophical Tradition," in C. J. Tuplin and T. Rihll (eds.), *Science and Mathematics in Ancient Greek Culture* (Oxford 2002) 254–273; T. Tieleman, *Galen and Chrysippus On the Soul. Argument and Refutation in the De Placitis Books II–III* (Leiden 1996) xix–xx and 38–65; R. J. Hankinson, "Galen on the Foundations of Science," in J. A. López Férrez (ed.), *Galeno: obra, pensamiento e influencia* (Madrid 1991) 15–29; and J. Mansfeld, "Doxography and Dialectic: The *Sitz im Leben* of the 'Placita'," *ANRW* II 36.4 (1990) 3056–3229.

³ See H. von Staden, "Anatomy as Rhetoric: Galen on Dissection and Persuasion," *Journal of the History of Medicine and Allied Sciences* 50 (1995) 48–67, and, more general in scope, "Galen and the 'Second Sophistic,'" in R. Sorabji, *Aristotle and After* (*BICS* Suppl. 68 [1997]) 33–54; M. Gleason, "Shock and Awe: The Performance Dimension of Galen's Anatomy Demonstrations," in C. Gill et al., *Galen and the World of Knowledge* (Cambridge 2009) 85–114.

through his *accounts* of these demonstrations.⁴ Aristotle, in his *History of Animals* (2.15, 506a9–10) and *Parts of Animals* (3.4, 666b17–667a6), had accurately described an elephantine heart without a heart bone, as did his contemporary, Mnesitheus of Athens.⁵ Galen accepts Aristotle's functional analysis of the bone as a structural support in the hearts of some ruminants, even apparently taking this account as the basis for his own. However, his more thoroughgoing teleological commitments require him to argue against Aristotle for the presence of a heart bone in the elephant. I argue that Galen uses the elephant's cardiac structure as a tool for magnification and as a persuasive literary spectacle in a larger skirmish against Stoic and Peripatetic cardiocentrists.

1. The *os cordis*

The heart bone or *os cordis* is a bone found in some mammals, mostly ruminants, between the aorta and atrioventricular openings near the meeting point of the interatrial and interventricular septa. This area is called the fibrous trigone (*trigona fibrosa*). It is formed of tough connective tissues and is part of the fibrous skeleton of the heart, also known as the cardiac skeleton. Galen and Aristotle appear to refer to the fibrous trigone; Galen even describes its tissues: νευροχονδρῶδες σῶμα, χόνδρος, and χονδρῶδες ὀστοῦν (*AA* II 619).⁶ Contemporary terminology maps onto Galen's: fibrocartilage, hyaline carti-

⁴ In a paper on the philosophical commitments underlying Galen's teleological claims, R. J. Hankinson examines Galen's discussion of the elephant's trunk in the so-called Epode (*UP* IV 348–350 = II 438–440 H.): "Galen Explains the Elephant," *Canadian Journal of Philosophy* Suppl. 14 (1988) 135–157. However, Hankinson is mainly interested in how Galen's account of the trunk illuminates his teleology rather than his anatomical method.

⁵ For Mnesitheus, whose treatise on elephantine anatomy is not extant, see J. Bertier, *Mnésithée et Dieuchès* (Leiden 1972).

⁶ I adopt Garofalo's reading νευροχονδρῶδες σῶμα, following the Arabic: I. Garofalo, *Galeno, Procedimenti anatomici* (Milan 1991) II 663 n.59. The Greek is corrupt; the point here stands regardless.

lage, and bone.⁷ To the naked eye the *os cordis* appears as a small bone-like ring segment; in the ox it is only about ten millimeters in length.⁸ The similarities between these ancient and modern accounts of the *os cordis* should give the reader a contemporary perspective on just how much Galen and Aristotle knew about its structure and function. In light of this knowledge, Galen's account of the elephant's heart is striking in its strangeness. A well-known fact about Galen's anatomical method may, however, be illuminating.

Galen based large parts of his anatomical exegesis in *AA* on comparative work with oxen, which do possess an *os cordis*. Julius Rocca argues persuasively that Galen posits at least one other structure theoretically important to his human physiology and psychology by analogy from the ox, namely the retiform plexus (*rete mirabile*).⁹ Given his regular and frequent use of ruminants for anatomical research, Galen would also have been well acquainted with the *os cordis* in oxen and sheep. If his account is based on first-hand evidence, at *AA* II 619–622 what could Galen have seen and how could he have mistaken it for an *os cordis*?¹⁰ Extrapolation from the anatomy of the ox may go

⁷ See G. Gopalakrishnan, W. E. Blevins, and W. G. Van Alstin, "Osteo-cartilaginous Metaplasia in the Right Atrial Myocardium of Healthy Adult Sheep," *Journal of Veterinary Diagnostic Investigation* 19 (2007) 518.

⁸ For a general account and for the length of the *os cordis* see T. James, "Anatomy of the Sinus Node, AV Node and Os Cordis of Beef Heart," *Anatomical Record* 153 (1965) 361–372.

⁹ J. Rocca, *Galen on the Brain* (Leiden 2003), esp. 67–78, 202–208, 249–253.

¹⁰ S. K. Sikes, *The Natural History of the African Elephant* (New York 1971) 218, suggests that Galen may have mistaken a case of advanced arteriosclerosis for the heart bone (cited in V. Nutton, *Ancient Medicine* [New York 2013] 237–238 and n.16). Against this view, Dr. Dennis Schmitt, professor of Agriculture at Missouri State University and Chair of Veterinary Services and Director of Research with the animal stewardship department of Ringling Brothers and Barnum and Bailey Circus, has written to me that there is no likelihood of mistaking any fibrous structure in the elephant's cardiac skeleton for a genuine *os cordis*.

some of the way in explaining Galen's description of the elephantine heart. If the description was derivative, from accounts such as Aristotle's, why deviate from earlier accurate accounts on this point?

Despite the importance of the heart to physiological and philosophical debates in the second century CE, Galen's departure from the Peripatetic tradition has not attracted much scholarly attention, even among historians of medicine.¹¹ John Scarborough concludes that some of Galen's anatomical claims about elephants were not based on dissection, citing Galen's detailed description of the elephant's gallbladder (*AA* II 569), another organ that the animal does not possess.¹² In comparing Galen's description of the elephant's gallbladder with Aristotle's and Mnesitheus' accurate accounts, Scarborough suggests that Galen's commitment to biological analogy moved him to deny their claims. Since Scarborough was unaware that the elephant lacks a heart bone, he did not have reason also to question Galen's dissection of the elephantine heart or his vivid first-person narrative. In addition, Scarborough argues, as one might and as Galen did, that Aristotle's joint commitments to teleology and biological analogy led him to believe in the existence of this bone in larger animals. But Aristotle explicitly denies the existence of the bone in all but a few ruminants.¹³

¹¹ Susan Mattern mentions this episode, but only in passing: *The Prince of Medicine: Galen in the Roman Empire* (New York 2013) 151–152. Veterinary scientists have noticed the elephant's lack of *os cordis*: S. Bartlett, in M. Fowler and S. Mikota, *Biology, Medicine, and Surgery of Elephants* (Ames 2006) 318, drawing on S. K. Sikes, "Habitat and Cardiovascular Diseases, Observations Made on Elephants (*Loxodonta africana*) and Other Free-living Animals in East Africa," *Transactions of the Zoological Society of London* 32 (1969) 1–104. See also Sikes, *The Natural History* 123.

¹² J. Scarborough, "Galen's Dissection of the Elephant," *Koeroth* 8.11–12 (1985) 127–130. Scarborough questions Galen's dissection on the grounds that his account of the elephant's trunk is derivative from Aristotle's at *Hist. An.* 2.15, 506a30–b4, and that practical difficulties in the dissection of such a large animal would have been prohibitive (123).

¹³ Scarborough, *Koeroth* 8.11–12 (1985) 124–126. For Aristotle's restriction

Galen's views on teleology and analogy, critical of Aristotle's, together with his polemical stance against cardiocentrists offer some purchase in explaining his departure from the Peripatetic material in these cases.

2. The *agon* over the heart

Galen (*AA* II 619) reduces his rivals' denials of the *os cordis* to observational failure while digressing from his general account of the heart. They compound their error by generalizing from these mistaken observations to the anatomy of other animals. Galen focuses on observational failure since he believes that empirical observation must underpin theoretical medical claims. In the case of minute structures, his criticism hinges on making otherwise unobservable structures apparent by using larger, anatomically analogous subjects as tools for magnification.¹⁴ On this view, structures such as the heart bone should be proportionately more apparent in larger creatures, while the failure to recognize them is proportionately more damning. To illustrate this point, Galen evokes a vivid dispute over the cardiac anatomy of the elephant:

And why do I mention the larger? Indeed, after an elephant was slaughtered recently in Rome many doctors gathered together for its dissection to determine whether the [elephant's] heart possesses one or two apices and two or three ventricles. *And, even before its dissection, I insisted that the structure of its heart would be found to be the same as in all the other animals that breathe air, which became clear when [the heart] was opened. I also easily found the bone in the heart along with my associates when I inserted my fingers.* But those who were

of the heart bone to only a few ruminants see *Part.An.* 3.4, 666b17–21; *Hist. An.* 2.15, 506a9–10.

¹⁴ Cf. *AA* XV 2 (surviving only in Arabic), transl. W. L. H. Duckworth, *Galen on Anatomical Procedures: The Later Books* (Cambridge 1962) 228: "We must then try to learn the conformation of that which is hard to observe in any one type of animal, whichever this may be, in other animals where that can be found and thoroughly investigated, I mean those animals in which such details are in their nature larger and more massive than those which in this [smaller] type are hard to see."

untrained assumed that not even the elephant's heart contains a bone, expecting to find that what was unobservable [to them] in the cases of other animals [would also be unobservable] in the large one. So, I was about to show it to them but I stopped the demonstration when my associates, laughing, begged me not to conduct a demonstration for people whom they saw as insensate on account of their ignorance of the region. *After the heart was removed by Caesar's cooks, I sent one of my associates, trained in these matters, to ask the cooks to let him excise the heart bone. And so it happened, even now it is beside me. It is massive in size and induces in those who see [it] a state of wide-eyed disbelief that a bone so huge eluded these doctors.* So even the biggest structures in animals elude the untrained and it is not at all unbelievable that Aristotle both was mistaken about many other anatomical matters and thought that the heart had three ventricles in large animals, nor ought one to be surprised that as he was untrained in anatomical matters he stumbled regarding the discovery of structures. And it is appropriate to excuse him, since those who have dedicated their entire lives to this pursuit, like Marinus, were apt to make many mistakes. What is one to think would happen to those who pursue it all of a sudden and to those who are convinced by things that they do [not]¹⁵ see at first with the result that they no longer look to try their hands at it a second time?¹⁶

¹⁵ Garofalo (666) expunges οὐκ, with the Arabic translation. I retain the Greek text for contextual reasons. Galen criticizes his rivals precisely for failing to see a structure.

¹⁶ *AA* II 619–621: καὶ τί λέγω τὰ μείζω; μεγίστου γοῦν ἐλέφαντος ἑναγχος ἐν Ῥώμῃ σφαγέντος, ἠθροίσθησαν μὲν ἐπὶ τὴν ἀνατομὴν αὐτοῦ πολλοὶ τῶν ἰατρῶν ἕνεκα τοῦ γνῶναι, πότερον ἔχει δύο κορυφὰς ἢ μίαν ἢ καρδία, καὶ δύο κοιλίας ἢ τρεῖς. ἐγὼ δὲ καὶ πρὸ τῆς ἀνατομῆς αὐτοῦ διετεινόμεν, εὐρεθήσεσθαι τὴν αὐτὴν κατασκευὴν τῆς καρδίας ταῖς ἄλλαις πάσαις τῶν ἐξ ἀέρος ἀναπνεόντων ζώων· ἄπερ ἐφάνη καὶ διαιρεθείσης. εὐρον δὲ ῥαδίως καὶ τὸ κατ' αὐτὴν ὄστον, ἅμα τοῖς ἐταίροις ἐπιβαλὼν τοὺς δακτύλους. οἱ δ' ἀγύμναστοι μὲν, ἐλπίζοντες δὲ εὐρίσκουσιν, ὡς ἐν μεγάλῳ ζῳῳ, τὸ μὴ φαινόμενον ἐπὶ τῶν ἄλλων, ὑπέλαβον οὐδὲ τὴν ἐλέφαντος καρδίαν ἔχειν ὄστον. ἐγὼ δ' ἐμέλλησα μὲν αὐτοῖς δεικνύειν, τῶν δ' ἐταίρων γελόντων ἐφ' οἷς ἐώρων ἀναισθητοὺς ἐκείνους διὰ τὴν ἄγνοιαν τοῦ τόπου, παρακαλεσάντων δὲ μὴ δεικνύειν, ἐπέσχον τὴν δεῖξιν. ἀρθείσης μέντοι τῆς καρδίας ὑπὸ τῶν τοῦ Καίσαρος μαγείρων, ἔπεμψά τινα τῶν γεγυμνασμένων ἐταίρων

Galen pivots from the claim that rival anatomists fail to see minute structures because of their insufficient training to amazement that they even fail to see those structures in larger animals. Galen answers *in medias res*, as though questioned by the reader. He introduces a series of expressions that place the reader in a situational context, largely absent from the otherwise situationally neutral narrative surrounding it. Adverbs locate the reader in a specific space and time: a specific elephant is slaughtered in Rome (ἐν Ῥώμῃ). The bone is retrieved from the kitchens of the emperor's cooks.¹⁷ Galen demurs from a public demonstration at the behest of his *hetairoi*, who pressure him not to debate with clods. Although Galen abstains from a confrontation with his rivals in the streets of Rome, the contest and his victory play out for the reader in the narrative.

In the first italicized passage, Galen reports his expectation of the heart bone's discovery and its discovery through direct observation. The second italicized passage serves no heuristic purpose. It reframes the episode in Galen's present, fostering intimacy with the author and his narrative as well as distance from his rivals. The episode begins with the elephant's

περὶ τὰ τοιαῦτα παρακαλέσοντα τοὺς μαγείρους ἐπιτρέψαι τὸ κατ' αὐτὴν ὄστον ἐξελεῖν· καὶ οὕτως ἐγένετο. καὶ παρ' ἡμῖν ἐστὶ νῦν, οὐ μικρὸν μὲν ὑπάρχον τῷ μεγέθει, θαυμαστὴν δὲ παρέχον ἀπιστίαν τοῖς ὀρώσιν, εἰ τηλικούτου ὄστον ἐλάνθανε τοὺς ἰατρούς. οὕτως ἄρα καὶ τὰ μέγιστα τῶν ἐν τοῖς ζώοις μορίων λανθάνει τοὺς ἀγυμνάστους. καὶ θαυμαστὸν οὐδὲν, ἄλλα τε πολλὰ κατὰ τὰς ἀνατομὰς Ἀριστοτέλη διαμαρτεῖν, καὶ ἠγεῖσθαι, τρεῖς ἔχειν κοιλίας ἐπὶ τῶν μεγάλων ζώων τὴν καρδίαν. ὅτι μὲν οὖν ἀγύμναστος ὢν ἐν ταῖς ἀνατομαῖς ἐσφάλῃ περὶ τὴν τῶν μορίων εὕρεσιν, οὔτε θαυμάζειν χρῆ, καὶ συγγινώσκειν αὐτῷ προσήκει. ὅπου γὰρ οἱ τὸν ὅλον ἑαυτῶν βίον ἀναθέντες τῇ θεωρίᾳ ταύτῃ, καθάπερ ὁ Μαρῖνος, ἡμαρτον πολλὰ, τί χρῆ νομίζειν συμβαίνειν τοῖς ἐξαίφνης μὲν ἐπ' αὐτὴν ἐλθοῦσι, πεισθεῖσι δ' οἷς πρῶτον [οὐκ] εἶδον, ὡς μηκέτι ἐπιχειρήσαι δεύτερον ἰδεῖν;

¹⁷ This Caesar is probably Marcus Aurelius, although Garofalo (665 n.60) identifies him as Commodus. Since *AA* was revised over time and parts were rewritten after a fire at the Temple of Peace in 192 CE burned Galen's library, it is not certain. Marcus Aurelius is a more certain identification if, as he seems to be doing, Galen sets the passage in the period of his life when he reports having conducted most of his public dissections.

slaughter, shortly before (ἔναγχος) the confrontation. Galen shifts from that past event (καὶ οὕτως ἐγένετο) into his present (καὶ παρ' ἡμῖν ἐστὶ νῦν), populated by the visits of passersby, whom the reader is invited to join in marveling at Galen's benighted rivals. The episode ends in Galen's study, far from these rivals in time and place.¹⁸ In the otherwise technical narrative of *AA*, temporal markers and stylized narrative are unusual. Moreover, the bone that Galen describes sitting beside him, massive and awe-inspiring, does *not* exist in the elephant's heart. So, what explanation is there for Galen's vivid claim? Let us consider the first italicized passage in more detail.

Before the dissection, Galen cites the teleological grounds on which he could reliably expect a heart bone in the elephant: structural analogy across kinds arising from the robust goal-directed structure of nature.¹⁹ Only later in the passage does direct observation come into play, and, then, as ancillary evidence. Galen's teleological commitments are one likely explanation for his account of the heart bone, deployed to demonstrate the importance of empirical observation in medical theory.²⁰ According to Galen, his rivals believed that a

¹⁸ Galen's use of νῦν and the subsequent context argue against reading ἐστὶ as an historical present. Cf. his account of the intercostal nerve demonstration in *Praen.*, which ends with the same conceit: καὶ μέχρι γε νῦν, ὃ Ἐπίγενες, οὐδεὶς ἐτόλμησέν ἀντειπεῖν αὐτοῖς ἐτῶν ἐν τῷ μεταξύ γεγονότων πεντεκαίδεκα (XIV 630 = *CMG* V.8.1 100.2–3). As in *AA*, νῦν and the present tense foster a sense of intimacy with the reader, in this case through the reader's surrogate, Epigenes.

¹⁹ *AA* II 621–622. The relevant point is that Galen generalizes from single or relatively small numbers of observations to all animals on the grounds that nature is an ideally organizing principle. On Galen's thoroughgoing teleology see R. J. Hankinson, "Galen and the Best of All Possible Worlds," *CQ* N.S. 39 (1989) 206–227.

²⁰ See *AA* II 618; cf. *Opt. Med.* I 53, a flamboyant general denunciation of medical ignorance: "The sort of thing many athletes are afflicted with—although they desire to become Olympic victors, they do not make an effort to act so as to achieve this—this sort of thing also happens to many doctors. For although they praise Hippocrates and consider him first among all [doctors], to make themselves like him as much as possible they do every-

bone did not exist in the hearts of large animals on the grounds that they did not observe it in smaller ones, an oversight arising from faulty training. Afterwards, a theoretical commitment to structural analogy drove their empirical claims.²¹ At the end of this narrative Galen describes an empirical investigation that he undertook earlier in his career, which first convinced him that a support structure for the cardiac skeleton was theoretically necessary:

For example, I swear by all the gods that I have later seen many things not at all visible to me earlier. And so it is in the case of the heart bone, which I tried to find on my own by cutting the organ into little pieces, since I had not heard from my teachers where [the heart bone] lay or even if it was present in all animals. This way seemed to me to be the most certain for undertaking my investigation. But when I found the roots of the valves attached to it and the sources of the arterial vessels, I was first persuaded that out of necessity nature as an engineer strove toward that end in all animals. Afterwards, I was also persuaded through empirical examination itself, once I tracked down the sources of the aforementioned parts.²²

This passage complicates Galen's claim that observation should

thing but this." Cf. *Opt.Med.* I 53–63; *Protr.* I 1–39; *Lib.Prop.* XIX 9–10; *Ord. Lib.Prop.* XIX 49–54.

²¹ Galen criticizes the views of the *palaioi*, who discussed a heart bone in some large animals (e.g. Aristotle and Mnesitheus), primarily on teleological grounds. Otherwise, he explains their inaccuracies as the natural result of more primitive anatomical knowledge and practice (*AA* II 618).

²² *AA* II 621–622: ἐγὼ γοῦν ἐπόμνυμι τοὺς θεοὺς πάντα, ὡς πολλὰ τῶν ἔμπροσθεν οὐδ' ὄλως ἐωραμένων μοι κατεῖδόν ποθ' ὕστερον. καὶ τοιοῦτ' ἔστι τὸ κατὰ τὴν καρδίαν ὀστοῦν, ὃ μήθ' ὅπου ὑπόκειται, μήτ' εἰ πᾶσι τοῖς ζώοις ἐστί, παρὰ τῶν διδασκάλων ἀκούσας, ἐπεχείρησα μὲν αὐτὸς ἐξευρεῖν, εἰς μικρὰ μόρια κατατέμων τὸ σπλάγχνον· ἀσφαλέστατος γὰρ οὗτος ὁ τρόπος ἐδόκει μοι τῆς ζητήσεως ὑπάρχειν. ἐπεὶ δ' ἅπαξ εὖρον ἀνηρτημένας εἰς αὐτὸ τῶν θ' ὑμένων τὰς ρίζας καὶ τῶν ἀρτηριωδῶν ἀγγείων τὰς ἐκφύσεις, πρῶτον μὲν ἐπέισθην, ὡς ἀναγκαῖόν ἐστιν ἐν ἅπασιν τοῖς ζώοις τὴν τεχνικὴν φύσιν ἐστοχάσθαι τούτου τοῦ σκοποῦ· μετὰ δὲ τοῦτο καὶ δι' αὐτῆς τῆς πείρας ἐπέισθην, ἀκολουθῶν ταῖς πρώταις ἐκφύσεσι τῶν εἰρημένων μορίων.

drive and check theoretical claims. Discovering the bone in the heart of one animal, Galen concludes it must be present in animals generally. The discovery convinced him that nature was necessarily (ἀναγκάϊον) directed toward something like a heart bone as an end in all animals (ἐν ἅπασι τοῖς ζώοις ... ἐστοχάσθαι τούτου τοῦ σκοποῦ). Only later did he confirm its existence by empirical examination (δι' αὐτῆς τῆς πείρας). Galen's reasoning follows straightforwardly only if organs are *so* ideally structured that similar or identical structures are predictable across kinds.

Here and at *AA* II 620, Galen treats hearts as structurally and functionally analogous across air-breathing creatures, which are themselves coextensive with the class of creatures Galen and Aristotle call "blooded" (*ta enaima*).²³ The viscera that are identical across species are *structurally* identical although they need not be *materially* so. For example, Galen remarks, "by however much the kind of animal is unusual in its size, by that degree does the cartilage acquire a bony structure."²⁴ While it may differ compositionally, Galen believes that some sort of anchor or scaffolding is necessary for the valves and vessels leading out from them.²⁵ To this sort of structure he gives or

²³ For Galen, the heart was an organ of respiration dependent on the movement of the thorax for its activity. When he discusses the class of air-breathing creatures, those creatures will have a heart, which is involved in the elaboration of blood. The apparent criteria by which Galen determines which organs will exist across what kinds are similar to Aristotle's. Both differentiate between kinds on the basis of articulation. See P. Manuli and M. Vegetti, *Cuore, sangue e cervello: biologia e antropologia nel pensiero antico* (Milan 1977) 177–182 and foldout. Galen follows Rufus of Ephesus even more closely (cf. *Onom.* 127). For Aristotle's taxonomical principles see G. E. R. Lloyd, *Science, Folklore and Ideology* (Cambridge 1983) 7–57; Lloyd does not mention difference in digits as a taxonomical criterion in Aristotle's corpus but does go into some detail about Aristotle's methods more generally. I am aware of no modern discussion of Rufus' taxonomy.

²⁴ *AA* II 619: ὅσῳ γ' ἂν ᾗ τὸ τοῦ ζώου γένος ἀξιολογώτερον τῷ μεγέθει, τοσούτῳ πλέον ὀστώδους οὐσίας ὁ χόνδρος ἐπικέκτηται.

²⁵ Cf. *UP* III 501–503 = I 365.14–366.13 H., quoted 717 below.

accepts the name, “the bone in the heart” (τὸ κατὰ τὴν καρδίαν ὀστοῦν), which is only in some cases descriptive, as I will elaborate below. The graduated density of the *os cordis* cannot be separated from his commitment to the presence of a structural support at the base of the valves. Since larger structures require larger supports, nature “as an engineer” (τὴν τεχνικὴν φύσιν) strives to supply a support whose hardness is adequate to the structural demands of the creature’s heart. This teleological commitment along with his observation of the bone in some smaller ruminants likely prompted Galen to suppose that the elephant possesses an *os cordis*.²⁶ Mostly, the episode tracks Aristotle’s account of the heart in so-called blooded animals in *Part.An.* 3.4, 665b10–667b14, which mentions the presence of a bone in the hearts of some oxen and horses while denying it in other animals that Aristotle reports having observed.²⁷

3. Galen’s engagement with Aristotle

Aristotle figures prominently in Galen’s account of the heart in *AA* and *UP*. The physicians against whom Galen is arguing at *AA* II 620 are gathered in the street to examine the number of apices and chambers of the heart. He explicitly associates these questions with Aristotle, whose views he repudiates (618, 621).²⁸ Here Galen introduces his account of the heart bone, whose existence in certain animals is denied by Aristotle and his Roman rivals. Aristotle believed that the chambers of the heart (κοιλίαι) differ in number from one to three, in keeping

²⁶ When Galen mentions the heart bone here and elsewhere, it is important to keep in mind his comments immediately after those above. He simply uses the phrase “the bone in the heart” here as a name rather than as a description. In the case of the elephant he means the phrase descriptively, as a bone: “the valves, which I said are called tricuspid, and the base of the arterial vessels (aorta) are attached to a structure, in every case [a] hard [structure] but not hard to the same degree in all animals” (619).

²⁷ See *Part.An.* 3.4, 666b18–19; *Hist.An.* 2.15, 506a9–10.

²⁸ Aristotle’s claims about the apices and chambers of the heart are in *Part.An.* 3.4, 666b1–35; *Hist.An.* 1.17, 496a4–27, and 3.3, 513a27–b1.

with body size.²⁹ Aristotle's claim is difficult to explain observationally. κοιλία (originally 'hollows'), commonly translated as 'ventricles', meant 'chambers'. The translation 'ventricles' reflects the modern identification of the κοιλία with two of the four chambers of the heart. It obscures a common ancient Greek notion that the heart possessed only two chambers. If Aristotle meant κοιλία to describe what later anatomists took to be the right and left ventricles, it is unclear how he might have envisioned a third ventricle. It is difficult to untangle the knot by supposing a taxonomical difference involving the atria, which in antiquity were rarely seen as distinct *chambers* of the heart but as the expanded terminal points of the venae cavae and the pulmonary vein.³⁰ Aristotle's view on the three κοιλία of the heart in large animals is a springboard for Galen to criticize him and contemporary physicians for their observational and methodological failures. It introduces Galen's discussion of the heart bone at *AA* II 618 and the anecdote on the slaughtered elephant at 620.³¹ His discussion of the number of the heart's ventricles then closes his general discussion of cardiac anatomy, of the elephant episode, and finally of his criticism of the physicians who share Aristotle's views.

Even if he criticizes Aristotle for his willingness to deny the heart bone's existence in some larger animals, Galen is more

²⁹ *Part.An.* 3.4, 666b22–35. On the chambers of the heart in Aristotle see C. R. W. Harris' overview, *The Heart and Vascular System in Ancient Greek Medicine* (Oxford 1973) 121–133. There is no consensus on a solution to this puzzle. Suggestions range from supposing that Aristotle was simply mistaken or was motivated by a need for a single source (ἀρχή) of blood and volition, to attempts to locate what his third chamber may have been.

³⁰ See e.g. Harris, *The Heart* 98. The account is dated but comprehensive.

³¹ C. Singer, *Galen on Anatomical Procedures* (Oxford 1956) 251 n.155, believes that Galen's reference is to the number of vessels in the heart. I agree, *contra* Singer, with Garofalo (663 n.53) and references, who takes the dispute to be over the number of chambers in the heart rather than coronary vessels: "Galeno allude al numero di ventricoli non ai vasi come pensa Singer." The context both before and after this passage involves Aristotle's claim about the three cardiac chambers.

sympathetic to Aristotle's functional explanation of it. Aristotle argues that some structure will serve as a cardiac support. However, he is committed to this structure being a bone in only some cases:

[the heart] of all [animals], even the ones that we have examined, is boneless, except for horses and a certain kind of ox. And, on account of their size, these possess a bone [in their heart] for support (ἐρείσματος χάριν), just as also whole bodies do.³²

Galen takes issue with Aristotle on the explanatory force of animal size. He reads Aristotle as saying that animal or perhaps organ size determines the density of the support structure. On this reading, Aristotle's observations are at odds with his theoretical claims. The text admits of another reading: size may explain the presence of a heart bone while not demanding it. In other words, for all animals, if an animal possesses a denser supportive structure, the animal or its organ must be larger. Aristotle need not hold the converse. However, this interpretation merely defers questions about the inconsistent presence of the heart bone among animals, especially of the same species.

Galen's retrojection of his terminology onto Aristotle muddies the water further. For Galen, 'bone' (ὄστον) merely indicates the cardiac support, whatever its composition: "likewise, the bone in the heart, which [some] think exists in large animals and not even in all of those, does exist in all the rest although it is not precisely a bone in all of them but cartilage" (*AA* II 618). It is more straightforward to take Aristotle's 'bone' as descriptive, referring to an actual bone in the heart, and Galen's use as stipulative, referring to its structural scaffolding. On the descriptive interpretation, Aristotle's view is consistent with Galen's; a structural support may exist in the hearts of all blooded animals but is only a bone in some cases. Aristotle probably would not deny that some functionally identical sup-

³² *Part.An.* 3.4, 666b17–21: ἔστι δ' ἀνόστεος πάντων ὅσα καὶ ἡμεῖς τεθεάμεθα, πλὴν τῶν ἵππων καὶ γένους τινὸς βοῶν· τούτοις δὲ διὰ τὸ μέγεθος οἶον ἐρείσματος χάριν ὄστον ὑπεστί, καθάπερ καὶ τοῖς ὅλοις σώμασιν.

portive structure should be found in the hearts of all blooded animals. For example, he describes what must be the *chordae tendineae*, which aid in the operation of the tricuspid valves.³³ He treats these νεῦρα as structural supports, analogous to the body's skeleton:

The heart has a number of tendons (νεύρων), and this is reasonable as the motive impulses (κινήσεις) proceed through [its] contracting and relaxing. Consequently, it needs this sort of service (τοιαύτης ὑπηρεσίας) and strength. And the heart, just as I said also earlier, is a sort of animal in those that have it.³⁴

The word ὑπηρεσία normally refers to the groups of rowers, who power a trireme. The image is lost in the translation but is informative here. The bank of rowers strains to aid the heart in contraction and then relaxation. They require some sort of brace to aid them in their efforts. Aristotle does not explicitly conclude that all hearts, by virtue of possessing νεῦρα, require an underlying structural support. But his argument on the function of the νεῦρα in the heart makes a support functionally necessary.

Galen's description of these views as *problemata* sets the episode in a formal agonistic context: "many doctors gathered together for its dissection to determine whether the [elephant's] heart possesses one or two apices and two or three ventricles" (620). Given the questions posed for debate and the positions implicitly taken by the gathered rivals, they should be identified as including Peripatetics and probably Stoics. Galen often links the two groups in his anatomical demonstrations on the

³³ Although it is unlikely that Aristotle had this function in mind. The tricuspid had not yet been identified as such. Depending on how one reads Galen's comments at *PHP* V 548–550 = *CMG* V.4.1.2 396, this discovery is credited to Erasistratus in the third century BCE or to later Erasistrateans. See Harris, *The Heart* 197–198, and H. von Staden, "Experiment and Experience in Hellenistic Medicine," *BICS* 22 (1975) 183–184.

³⁴ *Part.An.* 3.4, 666b13–17: ἔχει δὲ καὶ νεύρων πλῆθος ἡ καρδία, καὶ τοῦτ' εὐλόγως· ἀπὸ ταύτης γὰρ αἱ κινήσεις, περαίνονται δὲ διὰ τοῦ ἔλκειν καὶ ἀνιέναι· δεῖ οὖν τοιαύτης ὑπηρεσίας καὶ ἰσχύος, ἡ δὲ καρδία, καθάπερ εἵπομεν καὶ πρότερον, οἶον ζῷόν τι πέφυκεν ἐν τοῖς ἔχουσιν.

heart.³⁵ *On Prognosis* contains a particularly striking example of this guilt by association. As part of his suite of proofs against cardiocentrists, Galen demonstrates the function of the recurrent laryngeal nerve and intercostal muscles in voice production.³⁶ He refers to this encounter as his *agon* against Stoics and Peripatetics.³⁷ To the extent that he can undercut Aristotle's views on these *problemata*, he undercuts Aristotle's views on the heart generally, including the heart's role in volition. By extension, Galen attacks contemporary cardiocentrists, whose views he treats as derivative from Aristotle's.³⁸

While Galen explicitly mentions Aristotle in his discussion of cardiac ventricles, it requires further argument to claim that he targets Aristotle and his cardiocentrism specifically in his arguments for the heart bone. In the digression on the elephant, he intimates that Aristotle is the source of his rivals' mistaken views, including the heart's bone and its ventricles: "Aristotle both was mistaken about many other anatomical matters and thought that the heart had three ventricles in large animals" (621). Aristotle's texts bear this connection out. Throughout *Part.An.* 3.4, especially at 666b14–35, Aristotle discusses the elephant's heart bone, the ventricles, and the apices of the heart. He also mentions the heart bone in passing in *Hist.An.* and *Gen.An.*³⁹ Setting aside these passages, which do little more than

³⁵ Cf. *PHP* V 276, 278, 587–588 = *CMG* V.4.1.2 160, 162, 428–430.

³⁶ *Praen.* XIV 624–630 = *CMG* V.8.1 94–100.

³⁷ *Praen.* XIV 626 = *CMG* V.8.1 94.25–26: κατὰ τὸν πρὸς τοὺς Στωϊκούς τε καὶ Περιπατητικοὺς ἀγῶνα.

³⁸ For a related example of Galen's indirect attacks cf. H. von Staden's "surrogate targets": "Teleology and Mechanism: Aristotelian Biology and Early Hellenistic Medicine," in W. Kullman and S. Föllinger (eds.), *Aristotelische Biologie* (Stuttgart 1997) 183–208, at 197–199.

³⁹ *Hist.An.* 2.15; *Gen.An.* 5.7, 787b15–19: "that the heart of oxen is so by nature is clear since there is a bone in some of them; and bones seek out the nature of sinews" (δηλοῖ δὲ τοιαύτη τὴν φύσιν οὐσα ἢ καρδία τῶν βοῶν τῷ καὶ ὀστοῦν ἐγγίνεσθαι ἐν ἐνιαίᾳ αὐτῶν· τὰ δ' ὀστᾶ ζητεῖ τὴν τοῦ νεύρου φύσιν.)

locate a heart bone in oxen, horses, and bulls, let us consider Aristotle's fuller account in *Part.An.* After discussing the material composition and one of the primary functions of the heart, as a source and central vessel for blood in the body (3.4, 665b10–21), he engages with thinkers who believe that the brain is the source of blood vessels (665b28–33), an etiolated encephalocentric position. For him, the centrality and primacy of the heart make an implicit case for cardiocentrism.⁴⁰ But Aristotle claims that the human heart is off-center while it is centered in other animals.⁴¹ The human heart is indeed off-center, complicating Aristotle's argument from position. This account is interesting in its own right, but for present purposes it suffices to note an emerging pattern in which Aristotle's reports of cardiac anatomy are consistent with empirical observation and problematic for his general theoretical claims.

Galen's discussion of the double apex and chambers of the heart in larger animals at *AA* II 624–625, the *problemata* he establishes as context for the elephant episode, and his references in *AA* and *UP* to Aristotle's views on the heart bone are evidence that Galen had this section of *Part.An.* in mind while constructing his own accounts of the heart bone. His reference to material in *Part.An.* 3.4, here and elsewhere (e.g. *At.Bil.* V 147 = *CMG* V.4.1.1 93), also makes a very strong case that this section was a point of engagement for him against Aristotle's account of the heart. That Galen engages with Aristotle on the heart is not surprising; he spends a great deal of time inveighing against cardiocentrists. These connections, however, make

⁴⁰ Galen focuses on Aristotle's arguments from position in *PHP* ch. 2 (V 228–229 = *CMG* V.4.1.2 116.34–118.21). Cf. Tieleman, *Galen and Chrysippus* 39–42. Furthermore, Galen's digression at *AA* II 624 echoes Aristotle's account in *Hist.An.* 2.17, 507a2 ff. Both discuss the apex of the fish heart in the immediate context of their discussions on hearts.

⁴¹ *Resp.* 478b3; *Hist.An.* 2.17, 506b32–507a10. By comparison, Galen's accounts of the position of the heart differ in *UP* and *AA*. In *UP* he claims that the human heart lies in the center of the chest and in *AA* that the right ventricle is off-center. Galen's changing views on the subject or the unusual editorial process both texts underwent may explain the discrepancy.

the case that Galen's *os cordis* episode is not only a corrective of Aristotle's views on cardiac structure and function but also collaterally undermines his cardiocentrism.

4. Galen's robust teleology

Aristotle describes the heart as structurally analogous to a living body.⁴² Consequently, one might expect there to be a supportive structure in the heart that performs the same function as the skeleton does for a body:

Flesh surrounds the bones, fastened by thin and fibrous sinews. The skeleton is for the sake of [the flesh]. For just in the way that sculptors who are sculpting an animal out of clay or some other wet substance set up some sort of solid body as a support and then mold around it, in the same way nature builds an animal out of flesh.⁴³

Like Galen, Aristotle believes that every heart will be reinforced by some functionally analogous structure and that when a bone is present, it is so in virtue of animal size. While this functional account explains the presence of a heart bone in large animals, it does not address the bone's presence in only some members of a species, as in the ox, and its complete absence in some larger animals like the elephant. One might expect that functionally useful structures would exist in every member of a kind if they exist in any member of it. Aristotle offers no explanation; his silence leaves the door open for Galen to question whether he had seen the consequences of his theoretical commitments.

One avenue for response involves the degree to which teleological structure pervades the natural world. Although

⁴² Cf. *Part.An.* 3.4, 666a19–24.

⁴³ *Part.An.* 2.9, 654b27–32: *περὶ δὲ τὰ ὀστᾶ αἱ σάρκες περιπεφύκασι, προσειλημμένοι λεπτοῖς καὶ ἰνώδεσι δεσμοῖς, ὧν ἕνεκεν τὸ τῶν ὀστέων ἐστὶ γένος. ὡσπερ γὰρ οἱ πλάττοντες ἐκ πηλοῦ ζῶον ἢ τινοῦ ἄλλης ὑγρᾶς συστάσεως ὑφίστασι τῶν στερεῶν τι σωματίων, εἴθ' οὕτω περιπλάττουσι, τὸν αὐτὸν τρόπον ἢ φύσις δεδημιούργηκεν ἐκ τῶν σαρκῶν τὸ ζῶον.* Cf. Galen *AA* II 218–219, which repeats this metaphor.

Aristotle's teleological commitments incline him to the view that organs should be usefully structured, his teleology admits of occasional structures that exist for no proximate reason but are the consequence of goal-directed processes, such as the gall-bladder. Aristotle calls these "by-products" (τὰ περιττώματα), often translated "residues." In some rare cases, his teleology even allows structures to exist to the detriment of their possessor, as in the much-discussed case of deer antlers.⁴⁴ These phenomena are partly explained by two Aristotelian views: nature is goal-directed but materially constrained, and nature in the sub-lunar realm may operate "for the most part," ὡς ἐπὶ τὸ πολὺ. These features of Aristotle's teleology could account for his silence on the *os cordis*. While he explained that the heart bone exists in some animals for support, in keeping with their size, this explanation only commits him to the weaker claim that an animal possessing a heart bone will be large; it does not follow that being large is a sufficient condition for the presence of a heart bone. Hence its absence in some oxen. This weaker claim is consistent with Aristotle's view that functional structures exist for a benefit but not all of them are necessary (e.g. kidneys, which filter urine but are not necessary on the grounds that the bladder can do their work). Galen reads Aristotle as asserting an equivalence: if a creature has a heart bone, it will be large *and* if a creature is large, it will have a heart bone. This reading is reasonable but may be distorted by the lens of Galen's more robust teleology. For Galen, the teleological organization of the world is more thoroughgoing. As much as possible, every structure in the world exists for some purpose and there is a strict economy of structures to accomplish that purpose, what Jim Hankinson refers to as Galen's Principle of Creative Economy.⁴⁵ In *UP* Galen writes:

⁴⁴ Antlers are discussed at *Part.An.* 2.16, 659a19, 3.2, 663a8–12, and 4.7, 694a20. On account of their weight, they can be more a hindrance than a help.

⁴⁵ Hankinson, *Canadian Journal of Philosophy* Suppl. 14 (1988) 151–155.

But it would be better said as follows: Nature has attached the ends of ligaments to cartilage or to cartilaginous bone. She was not about to overlook the ligaments in the heart, given that the membranes at the openings of the vessels are of this type, nor the tunic of the arteries, which is similar to a ligament in the nature of its material. Rather, she also attached the ends of all these to this cartilaginous bone, as I have shown in my *Anatomical Procedures*. In large animals the bone is cartilaginous, in very small animals it is a neurocartilaginous structure. And so every heart has some hard structure in the same place, which is present in all animals for the same purpose. And the fact that larger [hearts] *require* this sort of structure is not at all strange, for a large heart possesses a harder structure, suitable as an attachment for the ends of ligaments and as a foundation for the whole heart.⁴⁶

Galen's more thoroughgoing teleological views commit him to the stronger equivalence claim mentioned earlier: if a creature has a heart bone, it will be large *and* if a creature is large, it will have a heart bone. Aristotle's account is consistent with the former claim but his teleology does not commit him to the latter: he claims only that not every large heart contains a bone. He remains silent on whether they must possess some other foundational support *materially* analogous to it, since he primarily discusses *functional* analogy. Aristotle's silence is rel-

⁴⁶ UP III 502–503 = I 365.22–366.13 H.: κάλλιον δ' ἂν ἦδε λέγοιτο. πανταχοῦ τῶν συνδέσμων τὰς ἀρχὰς ἢ φύσις ἢ εἰς χόνδρον ἢ εἰς ὄστον ἀνάπτει χονδρῶδες. οὐκ οὐκ οὐδὲ τῶν κατὰ τὴν καρδίαν συνδέσμων, ἐκ τούτου γὰρ τοῦ γένους εἰσὶν οἱ ἐπὶ τοῖς στόμασι τῶν ἀγγείων ὑμένες, ἀλλ' οὐδὲ τοῦ χιτῶνος τῶν ἀρτηριῶν, ὁμοίου συνδέσμου τὴν τοῦ σώματος οὐσίαν ὄντος, ἤμελλεν ἀμελήσειν, ἀλλὰ καὶ τούτων ἀπάντων εἰς τουτὶ τὸ χονδρῶδες ὄστον ἀνήψε τὰς ἀρχὰς, ὡς ἐν ταῖς Ἀνατομικαῖς ἐγχειρήσεσιν ἐδείκνυμεν. ἐν μὲν οὖν τοῖς μεγάλοις ζῴοις ὄστον ἐστὶ χονδρῶδες, ἐν δὲ τοῖς πάνυ μικροῖς νευροχονδρῶδες τι σῶμα. πάντα δ' οὖν ἔχει καρδία κατὰ τὸν αὐτὸν τόπον οὐσίαν τινὰ σκληρὰν ἕνεκα τῶν αὐτῶν χρειῶν ἐν ἅπασι τοῖς ζῴοις γεγεννημένην. τὸ δὲ τὰς μείζονας σκληροτέρας δεηθῆναι τῆς τοιαύτης οὐσίας οὐδὲν θαυμαστόν· εἷς τε γὰρ τὸ τὰς ἀρχὰς τῶν συνδέσμων ἀσφαλέστερον ἀνήφθαι καὶ εἰς τὴν ἔδραν ὅλης τῆς καρδίας ἐπιτηδειότερόν ἐστι τῇ μεγάλῃ τὸ σκληρότερον.

evant because Galen appears not just to fault him for believing that the elephant has no heart bone but also for a failure to cleave to his own teleological commitments, as Galen interprets them.⁴⁷ Explicitly, Galen faults Aristotle for his claims about cardiac anatomy. Implicitly, he takes Aristotle to task for a lapse in his adherence to robust teleology. While Aristotle shares Galen's commitment to functional and therefore, to a certain degree, structural analogy across animal kinds, this shared commitment does not move him to commit to the stronger claims that result from Galen's teleological commitments. Rather, empirical evidence seems to drive Aristotle's account of the elephant's heart. Had it been theoretically driven, his anatomy of the heart bone would have more closely resembled Galen's.

Galen can infer a heart bone in the elephant on teleological grounds alone. Since the bones in oxen and horses, which Aristotle observed, establish a baseline for the density of the support structure in animals of this size, larger animals should also have a heart bone in Galen's descriptive sense. Galen's comments at *AA* II 620 and 622 suggest that he made just this inference. His teachers of anatomy were unsure of the bone's existence and he himself was unable to find it at first. He expected it, however, and on finding an instance of it, extrapolated it to other animals. This argument is fleshed out in *UP*:

And since there is also found a certain bone at the top of the heart in large animals, it would also be reasonable not to overlook its function. And perhaps the function mentioned by Aristotle is right. He said that it was a sort of support and a foundation for the heart and for that reason is found in the large animals. For clearly it would be reasonable that a large heart

⁴⁷ On Galen's exploitation of other authors' silences as tacit denials see von Staden, in *Aristotelische Biologie* 196: "This [referring to Erasistratus] is similar to other instances in which Galen infers an elaborate negation or negative theory—here 'in vain the spleen, in vain the omentum, in vain the renal arteries, in vain numberless other things'—from an author's silence or putative silence on a given point."

hanging in a large chest would also *require* this sort of part.⁴⁸

It is not enough for Galen that animal size *explains* the presence of a heart bone. It *requires* the presence of the heart bone in order to be explanatory. Aristotle's account was right insofar as it proceeded from the notion that the heart's structure entails certain functional supports, but for Galen the heart's function also entails *that particular* structure.

5. The polemical dimension of Galen's anatomical prose

This discussion has centered on theoretical reasons for Galen's account of the heart, which diverges in slight but significant ways from Aristotle's account by describing a non-existent structure, whose absence Aristotle and Mnesitheus detailed. Not only does the elephantine heart lack a heart bone, but also there is also no obvious fibrous structure in a normal heart that could be mistaken for one. It is just possible that Galen saw a pathological structure that he mistook for an *os cordis*. Sylvia Sikes, a veterinary scientist, conjectured that he was describing a case of advanced coronary sclerosis.⁴⁹ But this seems unlikely. Sikes overlooks his claim that the bone is mas-

⁴⁸ *UP* III 501–503 = I 365.14–366.13 H.: ἐπεὶ δὲ καὶ ὀστοῦν εὕρεται τι κατὰ τὴν κεφαλὴν τῆς καρδίας ἐν τοῖς μεγάλοις ζώοις, εὐλογον ἂν εἴη καὶ τὴν ἐκείνου χρεῖαν μὴ παρελθεῖν. ἔστι μὲν οὖν ἴσως καὶ ἡ ὑπ' Ἀριστοτέλους εἰρημένη λόγον ἔχουσα. στήριγμα γάρ τι καὶ οἶον ἔδραν εἶναι φησι τῆς καρδίας αὐτὸ καὶ διὰ τοῦτ' ἐν τοῖς μεγάλοις ζώοις εὕρεσκεσθαι. δῆλον γάρ, ὡς ἐν μεγάλῳ θώρακι μεγάλην καρδίαν αἰωρουμένην εὐλογον ἦν δῆπου καὶ τοιοῦτου τινὸς δεηθῆναι μορίου.

⁴⁹ Sikes, *The Natural History* 218: "Galen (AD 130–200) described an *os cordis*, or 'bone of the heart', in an elephant heart he examined at autopsy. As is usual (even today) in such circumstances, he was so crowded during his dissection by spectators and fellow 'scientists' that he decided to curtail the autopsy. As was customary the heart was taken to the palace kitchen to be served up for the royal dinner that evening. By a judicious alliance with the palace cooks, he managed to re-examine the heart in less disturbed circumstances and reported finding this 'bone'. It seems most probable, however, that what he really found, making allowance for his harassment during the autopsy, was pathological and was actually a case of advanced coronary sclerosis."

sive.⁵⁰ Its size belies identifying it with arterial plaque, which is limited by the size of the arteries in which it is found.⁵¹ Its material composition is also a stumbling block for this identification. It is clear that Galen did not see an *os cordis*, but his account of the necropsy suggests perhaps also that he never went looking for it. Galen had powerful theoretical and polemical motives for describing an *os cordis*, made of bone, in the elephant's heart. Moreover, there are stylistic, textual, and anatomical reasons to suppose that this is not simply a case of *Verformungstendenzen*, seeing what one wants to see, but that Galen is actually describing the heart of an ox.

First, the anecdotal structure and language of the necropsy episode is marked differently from Galen's general anatomical narrative, which prompts one to question what role that narrative plays in a treatise often considered to be merely technical.⁵² There are also textual reasons to suspect that Galen based his elephantine anatomy in *AA* on the ox. In *AA* and *UP*, Galen claims that the structure of the heart across kinds is identical. His argument takes the same form in both texts: for any animal *a*, where *a* is larger than the largest animal or smaller than the smallest, the structure of its heart will be the same. However, candidates for the largest and smallest animals in each text differ. In *AA*, he introduces the elephantine heart to present structures that are so minute in smaller animals as to be hidden (ἄδηλα), for direct observation in an enlarged context. He cites the elephant and the lark as the extreme ends of

⁵⁰ *AA* II 620: οὐ μικρὸν μὲν ὑπάρχον τῷ μεγέθει, θαυμαστὴν δὲ παρέχον ἀπιστίαν τοῖς ὀρώσιν, εἰ τηλικούτων ὀστοῦν ἐλάνθανε τοὺς ἰατρούς.

⁵¹ See n.10 above. Danielle Gourevitch cites French veterinary scientists who also were not able to find a structure that could be mistaken for an *os cordis*: "Un éléphant peut en cacher un autre, ou comment sauter du coq à l'âne peut mettre la puce à l'oreille," in A. Debruet et al. (eds.), *Docente natura: mélanges de médecine ancienne et médiévale offerts à Guy Sabbah* (Saint-Etienne 2001) 157–176, at 159.

⁵² This notion of technical writing is of course anachronistic. Greco-Roman work on technical subjects did not adhere to the generic norms typical of contemporary technical work.

size in a hypothetical:

For it is necessary that you know well that *even if there were some air-breathing animal bigger than an elephant or smaller than the crested lark*, the structure of its heart would be similar to theirs; and it is not better to say similar but rather the same in form.⁵³

In contrast, he writes in *UP*:

The largest horse has precisely the same cardiac structure as the smallest sparrow, even if you should dissect a mouse or an ox and *even if, of animals, there were yet some other either smaller than a mouse or larger than an ox*, the number of its ventricles would be equal and the rest of the structure of the heart would be the same.⁵⁴

At most points, the account of cardiac structure in *UP* mirrors *AA*. The heart bone and ventricles are both mentioned; so is their issue of scaling size. But Galen's exemplars for massive and minute animals differ revealingly, the elephant and lark in *AA* and the ox and mouse in *UP*. Although Galen does not mention the elephant in conjunction with the heart in *UP*, parallels between the two texts argue either that his two cardiac accounts are the same, albeit differing in length, or that they influenced one another during the complicated editing history of their texts.⁵⁵ Galen's general account of the heart, which

⁵³ *AA* II 624: εὖ γὰρ εἰδέναι χρή σε, κἄν ἐλέφαντος ἢ τι μεῖζον, ἢ κορυδοῦ μικρότερον, ἐξ ἀέρος ἀναπνέον, ὁμοίαν αὐτοῖς εἶναι τὴν κατασκευὴν τῆς καρδίας· ἄμεινον δ' οὐχ ὁμοίαν, ἀλλὰ τὴν αὐτὴν κατ' εἶδος εἰπεῖν.

⁵⁴ *UP* III 442–443 = I 323.3–9 H.: τὴν αὐτὴν γὰρ ἀκριβῶς ἔχει κατασκευὴν καρδίας ἵππος ὁ μέγιστος ἐλαχίστω στρουθῷ, κἄν εἰ μὴν ἀνατέμοις κἄν εἰ βοῦν κἄν εἴ τι τῶν ἄλλων ζῴων ἢ μικρότερον ἔτι μὲν ἢ μεῖζον βοός, ἅπασιν αὐτοῖς ὅ τ' ἀριθμὸς ἴσος ὁ τῶν κοιλιῶν ἢ τ' ἄλλη κατασκευὴ τῆς καρδίας ἢ αὐτή.

⁵⁵ Galen rewrote parts of each treatise. Both texts refer to one another and it is not always clear to which version of a text Galen is referring. For present purposes, this complication means only that arguments about relative chronology between episodes in each text and, therefore, about the influence of one text on the other are not straightforward. It is clear, however, that the two texts are closely related, tracking one another in the order of anatomical exposition and in many episodes, such as the heart bone, com-

better describes the auricles of an ox than of human beings or elephants, and his known use of oxen in anatomical discussions argue that his account of the heart is based on the cardiac structure of the ox. His use of the elephant and ox as examples of the largest imaginable animal in two intimately linked texts is further textual evidence that the elephantine heart in this hypothetical claim about viscera across animal kinds in *AA* is an extrapolation from oxen, made for polemical purposes, rather than an account of actual autopsy. Galen has simply substituted the elephant in *AA* for the ox in *UP*.

Finally, from an anatomical point of view, Siegel concludes that Galen dissected *only* the hearts of oxen, on the grounds that his description of the atria matches the auricles of oxen but not the atria of humans or apes.⁵⁶ Galen's use of the ox as an exemplar does not, of course, preclude his knowledge of other animals. However, Siegel's observation that Galen's account of the auricles describes an ox heart rather than a primate heart furthers the view that Galen modeled the elephantine heart on the ox's, whose heart was the largest familiar to him. Harris argues against Siegel in his discussion of Galen's changing views on the position of the human heart. Although he dismisses Siegel's claim that Galen worked exclusively with the ox, Harris' own analysis surmises that Galen's cardiac anatomy was comparative not autoptic.⁵⁷

pressing or expanding the same account. E.g. at *UP* III 500–503 (= I 364.5–366.13 H.) Galen mentions *AA* II 618–622. At the start of Book 7 (*AA* II 590) he says that he has detailed the theoretical (i.e. teleological) background of the structure of the respiratory organs in *UP* Books 6–7. In Book 6 (*UP* III 439 = I 320.17–22 H.) he alludes to the method of dissection he recommends at *AA* II 626–632.

⁵⁶ R. E. Siegel, *Galen's System of Physiology and Medicine* (Basel/New York 1968) 34: "Only in the ox heart, which Galen exclusively studied, both venae cavae appear to terminate in the right atrioventricular valve without forming an atrium. Since Galen never stated that he dissected a human heart, we should not consider his description of the relation between auricle, venae cavae, and right ventricle as erroneous, as we so often read."

⁵⁷ Harris, *The Heart* 269–270, citing Daremberg's extensive note to his

There are parallels for Galen postulating structures in human beings without having seen them. In order to explain neural physiology, he mistakenly posits a retiform plexus (*rete mirabile*) in human beings by analogy from the ox, which does possess this structure. Galen's comments regarding the subjects of his dissections and Rocca's work on the brain show that Galen made analogical claims about humans specifically from the anatomy of oxen, sheep, and goats, all of which possess an *os cordis*. The ox was easily available in Rome: "ox brains suitably stripped of most of the parts of the cranium are commonly sold in big cities."⁵⁸ As the largest anatomical subject widely available it was also a useful tool for the magnification of analogous structures in smaller animals. In addition, it was a common subject of his anatomical investigations, common in ritual sacrifices and cooking, and one of the few animals dissected by him that contain an *os cordis*.

Galen's general description of the heart began with a reference to Aristotle's belief that the hearts of larger animals possess more κοιλία than those of smaller animals. This critique is flanked by language that emphasizes the importance of direct observation and its results, which to Galen are manifestly obvious:

It is better to examine (ἐπισκέπτεσθαι) these things, as I said earlier, once the heart has been removed from the animal, even more so in the case of a large animal. For [things] obtain similarly for all animals and there is no difference among them on account of size as Aristotle supposes (οἶεται). The sight (ἡ θέα) is more fully visible (σαφεστέρα) in large hearts.⁵⁹

translation of *UP*: C. Daremberg, *Oeuvres anatomiques, physiologiques et médicales de Galien I* (Paris 1845) 383–384.

⁵⁸ *AA* II 708: ἔτοιμοι δὲ τοῦπίπαν ἐν ταῖς μεγάλας πόλεσιν ἐγκέφαλοι βόειοι πιπράσκονται τῶν πλείστων τοῦ κρανίου μερῶν γυμνοί.

⁵⁹ *AA* II 618: ἄπερ, ὡς ἔφην, ἄμεινον ἐξηρημένης τοῦ ζώου τῆς καρδίας ἐπισκέπτεσθαι, καὶ μᾶλλον ἐπὶ μεγάλου ζώου· πᾶσι μὲν γὰρ ὡσαύτως ὑπάρχει, μηδεμίᾳς διὰ μέγεθος ἐν αὐτοῖς γιγνομένης διαφορᾶς, ὡς Ἀριστοτέλης οἶεται. σαφεστέρα δ' ἡ θέα κατὰ τὰς μεγάλας ἐστὶ καρδίας. It is not

Galen contrasts what Aristotle erroneously supposes with visual experience, which is clearer for purposes of direct examination. This sort of language is common in Galen, who frequently tells the reader that his claims are not only manifest to reason but also often manifest visually to those who possess the right sort of training and disposition.⁶⁰

Galen's emphasis on visual language is hardly surprising given the role that perception, along with reason, plays in his epistemology as a guarantor of truth and a control on truth claims.⁶¹ He requires that premises be manifest (ἐναργής) either to sensation or to reason. This demand is reflected in his pervasive use of verbs of perception. Unlike his opponents, he claims that his own observations are clearly perceptible. Galen's language presents a picture to the reader of how vision and sensation underwrite epistemic medical claims. While Aristotle's and his rivals' theoretical claims are a consequence of misperception or even of a failure to investigate empirically at all, Galen's claims follow from facts that can be clearly presented to an eyewitness, facts manifest to reason and sensation. This contrast underscores the overall trajectory of Galen's digression on the *os cordis*. Galen presents the case of the heart bone as an example of how epistemic anatomical claims should take their warrant from careful empirical observation, observations which by Galen's lights Aristotle failed to make, at least properly. By holding up Aristotle's account of the cardiac chambers, the number of apices, and structures such as the *os cordis* to observational criticism, Galen undercuts one of his *bêtes noires*, Peripatetic and Stoic cardiocentrism.⁶² How can one be

always clear what structures should be identical across kinds for Galen. Gross structural features (e.g. the number of cardiac chambers, the number of organs, the types of organs) must remain the same among animals analogous to human beings.

⁶⁰ See n.20 above.

⁶¹ See e.g. *Opt.Doc.* I 48–49; *Temp.* I 590; *PHP V* 722–723 = *CMG V.4.1.2* 540–542; *MM X* 36–37; *HNH XV* 152.

⁶² This debate occupies Galen throughout his corpus. He devotes most of

confident, after all, in Peripatetic claims about the sovereign role of the heart if their observations about its basic anatomy are demonstrably false?

6. Conclusions

Throughout *AA* Galen engages the reader conversationally, phrasing detailed procedural instructions in the second person. Time, place, and context are mostly absent, however. The heart bone anecdote breaks sharply with this pattern, situating the reader in time (ἔναγχος, νῦν) and place (ἐν Ῥώμῃ). A performative context takes shape as interlocutors are introduced. Galen pits himself against these rivals in an exotic agonistic medical display. He figures himself as character as well as narrator, taking pains to reiterate a frequent criticism of rival physicians. These armchair physicians (λογίατροι) generalize recklessly about medical and anatomical matters,⁶³ since their claims are not founded on and checked by empirical examination (πεῖρα).⁶⁴ For Galen, the structure of the elephant's

PHP to a defense of encephalocentrism, as he retrojects it onto Plato and Hippocrates, against the cardiocentrism of the Stoics and Peripatetics. For his recurrent laryngeal nerve experiment, which is intended to show that the brain rather than the heart is the source of volition, see *Praen.* XIV 625–630 = *CMG* V.8.1 94–100; *UP* III 570–585 = I 414–415 H.; IV 278–281 = II 386–389 H.; *AA* XI 101–109, 131–134, 255–269; cf. *AA* II 661–690 for the related experiment involving the destruction or ligation of the intercostal nerves. J. J. Walsh, “Galen’s Discovery and Promulgation of the Function of the Recurrent Laryngeal Nerve,” *Annals of Medical History* 81 (1926) 176–184, on the recurrent laryngeal nerve, is in this limited respect useful.

⁶³ The vivid word λογίατρος is attested only six times in the Greek corpus. All six are in Galen (*Lib.Prop.* XIX 15, *MM* X 582, *Purg.Med.Fac.* XI 339, *HNH* XV 159, and twice in *Hipp.Prog.* XIII.B 258). However, it is doubtful that Galen coined the word. The abstract, λογιατρεία, is attested in Philo of Alexandria (*De congressu eruditionis gratia* 53), in the context of Roman medical charlatans.

⁶⁴ On πεῖρα see von Staden, *BICS* 22 (1975) 178–199. The word has a wider semantic scope than “experiment.” Although often translated “test,” “trial,” or “experiment,” these can suggest a misleading degree of standardization and rigor. For its breadth see *LSJ* s.v. I.1–2.

heart proves this criticism true and proves that nature is thoroughly organized, a fact which passes his rivals by. The anecdote's unfolding events demonstrate Galen's complaints to the reader. Lack of training results in avoidable observational failure. Galen and his associates easily find the heart bone with their fingers; his rivals gape blindly. Galen's belief that the elephant would possess a heart bone before it was examined predicts this failure and underscores the training that made it avoidable. Atypically, Galen's *hetairoi* cannot persuade him to compete publicly with his rivals. His demonstration of the heart's structure and his victory are for the reader alone. After the heart is taken away to Caesar's cooks, the heart bone is laid out on a table, now available for all to see, found both through Galen's philosophical training and his observational skill. As a coda to the anecdote, Galen exclaims that passersby looking on the bone as he writes his account, "even now" are mystified that anyone could have been so blind as to have missed this immense but, as it turns out, non-existent structure.

If taken merely as a case study in dissection, Galen's account of the heart bone is difficult to explain. The heart bone does not exist in elephants. Galen had every reason to be familiar with the structure so as not to have mistaken another structure for it easily. However, there are compelling theoretical reasons for Galen to have expected the bone in larger mammals. These theoretical reasons and most probably his experience with oxen, which do possess a heart bone, motivate him to extrapolate it to elephants. Galen does not just extrapolate, however; he claims to have seen, recovered, and still possess the bone long after its recovery. These observations argue against Galen mistaking some other structure for the heart bone. Rather, I think that Galen has invented or at least distorted events, justified by analogical and teleological beliefs.

I read this episode as an example of how Galen uses invention in an anatomical context to develop his philosophical and medical arguments. However, this is not to claim that his account is fraudulent rather than being merely mistaken. I reject this dichotomy. The modern technical treatise has no exact generic ancient equivalent. Typical features of contemporary

technical literature (e.g., economy of speech, standardness of style, and avoidance of anecdotal evidence or personal commentary) are not typical of ancient medical treatises. Certainly they are not features of the Galenic corpus, even in procedural descriptions.⁶⁵ These differences caution one against summarily evaluating Galen's anatomical narrative through contemporary frames of reference, especially regarding fidelity to events throughout the treatise. Galen may well have considered his account to be true, in that it was faithful to its aim: describing the structure and function of major organs in teleological terms, of whose truth he was unassailably convinced. But his inaccurate anatomical conclusions and their explanations illuminate the role that his teleological beliefs can play in empirical claims, and the central role of the heart in his engagement with other theorists.⁶⁶

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⁶⁵ See H. von Staden, "Author and Authority, Celsus and the Construction of a Scientific Self," in M. E. Vázquez Buján (ed.), *Tradición e innovación de la medicina latina* (Santiago de Compostela 1994) 103–117; H. Hine, "Subjectivity and Objectivity in Latin Scientific and Technical Literature," in L. Taub and A. Doody (eds.), *Authorial Voices in Greco-Roman Technical Writing* (Trier 2009) 13–30; V. Nutton, "Galen's Authorial Voice," in *Authorial Voices* 53–62.

⁶⁶ I thank Lesley Dean-Jones and Jim Hankinson for their helpful comments and support on this paper, which revises a section from a dissertation supervised by them at the University of Texas at Austin. I also thank Marquis Berrey, the anonymous reviewer(s) of this paper, and the editors of the journal for criticisms and suggestions on an earlier draft. The mistakes that remain are mine alone.