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TAPA, Volume 148, Number 1, Spring 2018, pp. 111-138 (Article)

Published by Johns Hopkins University Press
DOI: *https://doi.org/10.1353/apa.2018.0005*

TAPA 148 (2018) 111–138

From Critical Days to Critical Hours: Galenic Refinements of Hippocratic Models *

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SUMMARY: This paper addresses the questions of when, why, and to what degree ancient physicians concerned themselves with temporal precision. Taking *On Critical Days* as a case study, it explores how Galen of Pergamum incorporates hourly timekeeping into his defense and refinement of Hippocratic "critical-day" schemes, designed to help physicians anticipate turning-points in febrile diseases. The paper proposes that Galen, in both his fever case histories and his astronomical explanations for critical days, uses hourly timekeeping to support certain claims about himself, his medical methodology, and the authority of Hippocrates.

IN TODAY'S HOSPITALS, DOCTORS' OFFICES, AND MEDICAL LABORATORIES, time-keeping devices abound.[1] Modern physicians and researchers are deeply

* I am indebted to *TAPA*'s editor and anonymous reviewers for their insightful suggestions, and to Alexander Jones, Paul Keyser, and Glen Cooper for reading and responding to earlier drafts of this paper. I am also grateful for the support and guidance of my dissertation committee members—Christopher Faraone (chair), Elizabeth Asmis, Jonathan Hall, and Alain Bresson—as I developed these arguments. Any errors that remain are, of course, my own.

[1] Much of this article is drawn from the author's doctoral dissertation, Miller 2017. All translations are the author's own unless otherwise stated. There is significant variation in referential style (in both Latin titles and abbreviations). For an overview of these variations see Hankinson 2008a: xix-xxi and 391–404. To avoid confusion, the abbreviations to the Hippocratic Corpus and Galen adhere to *OCD* abbreviations and Latin titles and abbreviations as follow: *Adversus eos, qui de typis scripserunt* (*Ad eos qui typ. scrips.*); *De compositione medicamentorum secundum locos* (*De comp. med. sec. loc.*); *De crisibus* (*De cris.*); *De diebus decretoriis* (*De dieb. decr.*); *De differentiis febrium* (*De diff. febr.*); *De dignoscendis pulsibus* (*De dign. puls*); *De methodo medendi* (*De meth. med.*); *De simplicium medicamentorum temperamentis et facultatibus* (*De simp. med. temp. ac fac.*); *De septimestri partu* (*De sept. part.*); *De usu partium* (*De usu part.*); *In Hippocratis*

interested in the timing and duration of medical events and the rates at which symptoms change over time. They consider this data indispensable for describing and making inferences about patients' conditions. In Greco-Roman antiquity, however, doctors were just starting to explore the ways in which timekeeping could aid their diagnoses and prognoses. Beginning in the late Classical and early Hellenistic periods, sundial and water-clock technology spread throughout the ancient Mediterranean, enabling people to measure time down to the hour (or even, rarely, the half hour).[2] To what extent did physicians incorporate these tools into their medical rhetoric and practice?

To the modern investigator, this question poses a methodological challenge. On the one hand, archaeological, epigraphic, and textual evidence indicates that, in many communities under the Empire, both sundials and water-clocks were available in monumental, domestic, and sometimes portable formats.[3] Thus, it would seem reasonable to assume that the physicians in such communities had access to clocks—whether they were personal (the physicians' own or their patients') or publicly available in bathhouses or town squares. Yet, it is difficult to pinpoint within our textual and archaeological sources any *direct* evidence of doctors using these clocks in the sickroom. For example, a portable sundial discovered in a physician's tomb at Este suggests that the doctor may have wanted to keep time on the go.[4] However, it is impossible to determine whether this physician actually employed the sundial during his medical rounds, or whether he simply used it to manage his personal schedule. It is also possible that the sundial was placed in the grave by a friend or relative, in which case the physician may never have used it at all.[5]

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epidemiarum librum primum commentarii (*In Hp. epid. I comm*); *In Hippocratis Prognosticum commentaria* (*In Hp. prog. comm.*); *De affectionibus Interioribus* (*Int*); *Prognosticon* (*Prog.*); *De Temperamentis libri III* (*Temp*). For English titles see Hankinson 2008a and the *Loeb Classical Library*.

[2] The earliest attestation of a half-hour is Men. Fr. 1015 Kock, late fourth century B.C.E.

[3] The major catalogues are Price 1969, Buchner 1976, Gibbs 1976, Schaldach 1998 and 2006, and Bonnin 2015. For overviews of timekeeping in antiquity, see also Hannah 2009 and Jones 2016.

[4] The tomb was identified as a physician's due to the medical instruments included among the grave goods. "These grave goods comprised surgical and chemical instruments, glass cups, ornaments, a spoon and a little amber statue, in addition to a small sundial that was particularly well preserved" (Arnaldi and Schaldach 1997: 109). The dial is on display at the Museum of Este, near Padua, Italy, and has been dated to the first century C.E.

[5] The imperial-period physician Marcellinus provides evidence that is similarly equivocal. In his work *On the Pulse*, Marcellinus recounts how the renowned Hellenistic physician Herophilus was in the habit of using a small *clepsydra* to measure his patients'

In the face of such interpretative challenges, one must rely on *indirect* evidence of clock-use among physicians, and for this the corpus of the Imperial-period physician Galen of Pergamum stands out as a rich source. While Galen never explicitly says that he has consulted a sundial or water-clock during a patient-visitation, he will often state that a medical event occurred at a numbered hour of the day or night, or that it lasted for a specific number of hours. The distribution of these references is far from uniform.[6] The majority of them appear in his discussions of cyclical phenomena, especially the oscillations between attack ("paroxysm") and remission that characterize periodic fevers. In what follows, I investigate some of these references in an effort to discover how his use of hourly timekeeping allowed Galen to support certain claims about himself, his approach to medicine, and the authority of his intellectual hero, Hippocrates.

The present discussion focuses on Galen's *On Critical Days*, a text in which he seeks to assess and justify Hippocratic "critical-day" schemes (i.e., schemes for anticipating important moments of change in the course of febrile diseases). I begin by suggesting that Galen, in contrast to many of his contemporaries, modeled his fever case histories after those in the *Epidemics* (especially Books I and III). I then examine passages in which Galen offers astronomical and astrological explanations for critical-day patterns. These explanations assume hourly timekeeping technology and demonstrate Galen's commitment to the Hippocratic practice of integrating astronomy into medicine. I argue that, in all these cases, Galen uses the concept of hourly timekeeping to defend Hippocratic doctrine while simultaneously bringing it into greater harmony with Imperial-period ideas and technologies. Furthermore, this becomes a strategy that helps Galen portray himself as Hippocrates' true successor.

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pulse rates (260–7). However, *clepsydrae* do not keep continuous time throughout the day. Thus, while Marcellinus's account tells us something about Herophilus's interest in "egg-timer timing," it sheds no light on the question of how doctors made use of *continuous* timekeeping mechanisms. On the distinction between *clepsydrae* and water-clocks, see Bonnin 2015: 88–98. For more on Marcellinus's understanding of the pulse, see Schöne 1907; on Herophilus, see Von Staden 1989.

[6] Galen seems to have had clear ideas about which medical challenges could and could not be mitigated with the aid of a sundial or water-clock. In all of Galen's detailed discussions of pulse theory, for example, the term ὥρα as "hour" appears in a mere handful of places, usually in contexts unrelated to practical bedside applications (see, e.g., *De dign. puls.* VIII.830.6–10 K). Nowhere, however, does Galen recommend using a clock to time the actual pulse rate of a patient, in the manner of Herophilus, nor does he recommend that doctors check their patients' pulses regularly at particular times of day.

GALEN'S *ON CRITICAL DAYS* AND THE HIPPOCRATIC *EPIDEMICS*

Despite the recent upsurge in Galenic studies, the work titled *On Critical Days* has not received much scholarly attention, due perhaps in part to the dearth of critical editions and translations.[7] Nevertheless, it is an important work, in which Galen seeks to test a set of theories advanced by Hippocratic writers for anticipating when the course of a febrile illness might change. Central to these theories is the concept of a "crisis" (κρίσις), a decisive moment at which a fever either dissipates or begins a transition into a new phase (including, but not limited to, death).[8] Some Hippocratic writers had come to recognize through their own bedside experiences that, in illnesses lasting longer than a single day, such turning points tended to recur after a certain number of days. The Hippocratic doctors sought to map these intervals and to come up with schemes that would allow them to anticipate future crises. It was important that ancient physicians predict the outcome of an illness as accurately as possible, so that they might recommend optimal therapies and avoid taking on terminal patients, whose deaths could damage their professional reputation.[9]

The Hippocratic authors of the *Epidemics* display a particular interest in constructing critical-day theories. The *Epidemics* is a collection of useful aphorisms, individual case histories, and "constitutions" (καταστάσεις), i.e., detailed accounts of the seasonal disease patterns produced in different geographic locations. The dating and authorship of each of the *Epidemics*' seven books has been controversial since antiquity.[10] There have been tendencies,

[7] The most recent edition of the original Greek is that published by C. G. Kühn in *Claudii Galeni opera omnia*, vol. 9. Leipzig: Knobloch, 1825 (repr. Hildesheim: Olms, 1965): 769–941. In 2011, G. Cooper published a much-needed critical edition, English translation, and commentary of Hunayn Ibn Ishaq's Arabic translation, penned in the ninth century C.E. (Cooper 2011b). For a critique of this edition, see Langermann 2012. Cooper states that a new edition of the Greek text is forthcoming, but at the time of writing this article, this work was not available for consultation. On the later Alexandrian summaries of Galen's *On Critical Days*, see Bos and Langermann 2015.

[8] Galen often indicates a febrile crisis by using the term καιρός, which includes within its range of meanings the notions of "right time" and "critical or decisive time." On the semantic field of this term, see Sipiora and Baumlin 2002.

[9] E.g., *Ad eos qui typ. scrips.* VII.479.16–480.2 K. Cf. Hippocrates at *Prog.* 1, 2.110–12 L = 2.24 Jouanna.

[10] Among the earliest attested Hippocratic commentators are Bacchius, Heraclides, and Zeuxis, each of whom wrote in the third century B.C.E. Our earliest extant Hippocratic commentary was penned by Apollonius of Citium. On these developments, see Smith 1979: 235–239.

however, in ancient as well as modern scholarship, to group certain of these books together chronologically according to the following scheme: (a) Books I and III, which are dated to ca. 410 B.C.E. and have a more polished, coherent form; (b) Books II, IV, and VI, which have been dated to between 427/6 and 373/2 B.C.E., and are less polished and consistent in their style; and finally, (c) Books V and VII which, already in antiquity, were considered by many to be post-Hippocratic additions to the Corpus.[11] In short, the *Epidemics* was probably pieced together out of a variety of sources, whose authors were located primarily in Northern Greece and wrote, by-and-large, during the late fifth and early fourth centuries B.C.E.[12]

Different configurations of critical days appear throughout the Hippocratic Corpus. The author of *Epidemics* I, for instance, proposes two different schemes, depending on whether a fever's paroxysms arrive on odd or even days.[13] The author of *Aphorisms* IV.36, however, asserts that crises can occur on the third, fifth, seventh, ninth, eleventh, fourteenth, seventeenth, twenty-first, twenty-seventh, and thirty-fourth days.[14] By Galen's time, it seems that the correct sequence and even the utility of critical days were open to debate. In *On Critical Days*, Galen informs us that many doctors of his acquaintance ask, τὸ σημαινόμενον ὑπὸ τοῦ τῆς κρίσεως ὀνόματος ("what is meant by the term *crisis*"), and εἰ δυνατὸν ὑπάρχει τὸ πρᾶγμα ("whether such a thing is even possible," IX.772.11–13 K). Galen aims to resolve this controversy by means of his own scientific method, a system of logical reasoning from self-evident first principles that Galen often terms "demonstration" (ἀπόδειξις).[15] In the first

[11] The dating of Books I and III is based on corroborating inscriptions discovered at Thasos (Langholf 1990: 77). In fact, some scholars now consider them to be two halves of a single work produced by a single author. See, e.g., Álvarez Millán 1999: 22. Wee, however, cautions against conflating the two, noting in particular that "variables of geography, time, and patient were defined and prioritized differently in Books 1 and 3" (2015: 145). Books V and VII constitute two separate collections of case histories, although parallel versions of certain case histories appear in both. The extreme heterogeneity of *Epidemics* VII, along with the dramatic style of its story-telling, suggests that it was constructed from a wide variety of sources and edited to enhance its narrative effect. For more on the generic style of these two books, see Smith 1981.

[12] On the history, dating, and style of the *Epidemics*, see Deichgräber 1971; Smith 1979: 237 and 1981; Langholf 1990: 77–242; Álvarez Millán 1999: 21–27.

[13] I.12, 2.678–82 L = 37.6–39.2 Jouanna.

[14] 4.514–6 L. For other critical day lists within the Hippocratic Corpus and discussion, see Langholf 1990: 78–127. For overviews of critical-day theories, see also Lloyd 1979: 154–68 and Cooper 2011b: 127–28.

[15] Galen seems to have discussed ἀπόδειξις most fully in his 15-book *On Demonstration* (now lost), but the concept appears frequently throughout his corpus. The goal of his

two books, he proceeds to test the Hippocratic systems against the rubric of his own experiences and the observational data aggregated in the *Epidemics* itself.[16] Then, in the third book, Galen reasons through the theoretical underpinnings of his preferred predictive scheme. Galen explains his method thus: ἐπειδὴ πάντα τὰ κατὰ τὴν ἰατρικὴν τέχνην εὑρίσκεταί τε καὶ δοκιμάζεται, τὰ μὲν ἐμπειρίᾳ, τὰ δὲ λόγῳ, τὰ δὲ συναμφοτέρῳ, πειρατέον κἀνταῦθα δι᾽ ἀμφοτέρων ὀργάνων ἐξελέγξαι μὲν τὸ ἡμαρτημένον, ἐπαινέσαι δὲ καὶ προσίεσθαι τὸ κατωρθωμένον ("Since everything to do with the medical art is discovered and tested sometimes through experience, sometimes through reasoning, and sometimes through the two together, one must therefore attempt, by means of both tools, to refute what is erroneous and to commend and accept what is correct," IX.841.9–842.4 K). This paper focuses on two aspects of Galen's approach: first, the temporal structure of the fever case histories that Galen offers as empirical evidence in Books I and II; second, the links that he forges between medical and astronomical periodicities during Book III's theoretical discussion. In both instances, I examine how Galen uses hourly timekeeping to build upon Hippocratic precedents.

TEMPORALITY IN GALEN'S FEVER CASE HISTORIES

Interestingly, recent scholarship on Galen's patient case histories has emphasized the many ways in which they tend to depart from, rather than adhere to, Hippocratic models. Álvarez Millán, for example, has asserted that, when it came to clinical narratives, "Galen did not follow the Hippocratic pattern."[17] In the same vein, Lloyd's contribution to the volume *Galen and the World of Knowledge* is titled "Galen's Un-Hippocratic Case Histories."[18] These scholars' views are based primarily on Galen's work *On Prognosis*, which compiles most of his case histories. Yet, medical historians have often overlooked the various

apodeictic method is to "prove" the validity of a proposition by reasoning logically from agreed-upon axioms that are plain to the senses or obvious to the mind (*Temp.* I 589.17–590.7 K; on first principles in Galenic demonstration, see Barnes 1991: 69–72, 76–77). Galen's ἀπόδειξις owes much to developments in Hellenistic mathematical proofs, Aristotelian and Stoic logic, and contemporary medical debates among Rationalists, Empiricists, and Methodists. On Galen's relationship with logical systems, see Barnes 1991, 1993, and 2003; Morison 2008. On the importance to Galen of empirical testing, see, for example, *De simp. med. temp. ac fac* XI.459.1–462.12 K and discussion at Hankinson 2008b: 169.

[16] Cooper has written extensively on Galen's methodology in *On Critical Days.* See especially Cooper 2004, 2011a, and 2011b.

[17] Álvarez Millán 1999: 32.

[18] Lloyd 2009. For an overview of how this genre of medical writing develops over time and across cultures, see Pomata 2014.

case histories embedded within Galen's fever treatises, such as *On Crises, On Critical Days,* and *On the Differences Among Fevers.*[19] While references to hours do not appear in the case histories of *On Prognosis*, hourly timekeeping is an important structuring device in Galen's fever narratives. As I demonstrate, the latter bear a close resemblance to the case histories included within the *Epidemics* (especially Books I and III).[20] Furthermore, Galen's narratives introduce even greater temporal precision.

As Langholf (1990) has pointed out, critical-day schemes serve as the dominant organizing principle in the case histories of *Epidemics* I and III. Some of these case histories are laconic and offer no additional temporal markers beyond the potentially-critical days. Case 10 of *Epidemics* III.2, for example, proceeds as follows, with day-references marked in bold (III 2, 3.60 L = 75.7–76.2 Jouanna):

> Γυναῖκα ἐξ ἀποφθορῆς νηπίου, τῶν περὶ Παντιμίδην, **τῇ πρώτῃ** πῦρ ἔλαβεν· γλῶσσα ἐπίξηρος· διψώδης· ἀσώδης· ἄγρυπνος· κοιλίη ταραχώδης λεπτοῖσι, πολλοῖσιν, ὠμοῖσιν. **Δευτέρῃ**, ἐπεῤῥίγωσεν· πυρετὸς ὀξύς· ἀπὸ κοιλίης πουλλά· οὐχ ὕπνωσεν. **Τρίτῃ**, μείζους οἱ πόνοι. **Τετάρτῃ**, παρέκρουσεν. **Ἑβδόμῃ**, ἀπέθανεν. Κοιλίη διὰ παντὸς ὑγρὴ διαχωρήμασι πολλοῖσι, λεπτοῖσιν, ὠμοῖσιν· οὖρα ὀλίγα, λεπτά. Καῦσος.
>
> A woman from among those around Pantimides, just out of childbirth, was seized **on the first** [**day**] by fever. Tongue very dry. Thirsty. Nauseous. Sleepless. Disturbed bowels, with slender, frequent, undigested [stools]. **On the second** [**day**], much shivering. Acute fever. Much discharge from the bowels. Didn't sleep. **On the third** [**day**], sufferings were greater. **On the fourth** [**day**], she was delirious. **On the seventh** [**day**], she died. Bowels moist throughout, with frequent, slender, undigested stools. Urine small, thin. Causic fever.

We can see here both how the patient's symptoms are grouped according to the day on which they manifested, and how the author has been selective about which days to include in his account.[21]

[19] E.g., *De cris.* IX.680.11–683.2 K; *De dieb. decr.* IX.800.1–802.6 K; *De meth. med.* X. 608.5–615.15 K; *De diff. febr.* VII.351.15–354.13, 355.12–357.17, and 359.9–363.3 K. Hours play an important role in structuring each of these narratives.

[20] These are the only books of the *Epidemics* that Galen consistently attributes to Hippocrates himself. Elsewhere, Galen argues that Books II, IV, and VI were composed by Hippocrates' son Thessalus and that Books V and VII are spurious. This appears in Hunayn Ibn Ishaq's Arabic translation of Galen's commentary on the *Epidemics*: Escorial, MS. 805, fol. 1v (according to Western pagination). For discussion, see Lloyd 2009: 116.

[21] It is unclear whether practice preceded theory in the development of critical-day systems, or vice versa. Many scholars follow Langholf (1990: 115) in supposing that, while

Yet, while critical days create the main framework within *Epidemics* I and III, many case histories also take an interest in the timing of symptoms *within* the day—what I will refer to as "intra-day" timing. Case 3 from *Epidemics* III.17 offers a representative example (III 17, 3.112–6 L = 96.1–97.20 Jouanna). In addition to putting the references to day-units in bold, I have italicized the intra-day time markers and references to temporal durations.

> Ἐν Θάσῳ Πυθίωνα, ὃς κατέκειτο ὑπεράνω τοῦ Ἡρακλείου, ... πυρετὸς ὀξὺς ἔλαβε· ... **Δευτέρῃ**, *περὶ μέσον ἡμέρης* ψῦξις ἀκρέων, τὰ περὶ χεῖρας καὶ κεφαλὴν μᾶλλον· ἄναυδος, ἄφωνος, βραχύπνοος *ἐπὶ χρόνον πουλύν*· ἀνεθερμάνθη· δίψα· νύκτα δι' ἡσυχίης· ἵδρωσε περὶ κεφαλὴν σμικρά. **Τρίτῃ**, ἡμέρην δι' ἡσυχίης· *ὀψὲ δὲ περὶ ἡλίου δυσμὰς* ὑπεψύχθη σμικρά· ...**Ἐν ἀρτίῃσιν** οἱ πόνοι τούτῳ.
>
> In Thasos, Pythion, who was living above the Temple of Heracles, was seized ... by acute fever .... **On the second** [**day**], *around the middle of the day*, a sense of cold in the extremities especially around the hands and head. Speechless, voiceless, short of breath *for a long time*. He heated up again. Thirst. Had a quiet *night*. Sweated a little around the head. **On the third** [**day**], had a quiet *day*. *Late, around sunset*, he became a little chilled .... The sufferings of this man were **on the even days**.

Although this doctor concludes by identifying a critical pattern in the patient's illness (i.e., suffering increased on the even days), he is deeply interested in charting the *whole* temporal progression of the disease. He records his patient's condition not only on the critical even days, but on *all* of the days between the onset of the sickness and the patient's death. Furthermore, this doctor wants to explore the variations in the patient's condition *within* each given day. Thus, his timekeeping is more meticulous than the previous author's. Here, the physician's intra-day time descriptors are approximate and cued primarily by the position of the sun (e.g., περὶ ἡλίου δυσμὰς). He occasionally alludes to symptom durations, but does not record them with any specificity (e.g., ἐπὶ χρόνον πουλύν). Hours make no appearance in this account, nor do we see any intra-day time markers that are derived from social, rather than celestial, cycles.

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critical-day theories may have found their *inspiration* in actual experience, it is likely that many physicians simply placed their trust in a specific critical-day system, and only visited patients at times that the system anticipated would be decisive. For physicians, such a practice could help self-advertising, as patients were bound to be impressed by doctors who would appear ready to perform at precisely the right moment.

By the time we get to the "later" books of the *Epidemics*, however, the situation has changed. On the one hand, we begin to see some socially-based time markers, derived primarily from cycles of activity in the agora. Case 92 in *Epidemics* VII, for instance, describes sweats that come τρίτῃ δὲ, ἀγορῆς πληθούσης ("on the third [day], when the agora fills," VII 92, 5.448 L = 104.9–10 Jouanna),[22] and Case 62 in *Epidemics* V informs us that the patient ἔθανε πρὶν ἀγορὴν λυθῆναι, ἅμ' ἡμέρῃ πληγείς ("died before the opening of the agora, coincident with daybreak," V 62, 5.242 L = 28.8–9 Jouanna). *Epidemics* IV may even contain an isolated reference to a numbered hour: τρίτην ὥρην ἴσως ὠδυνήθη ὕστερον ("He felt the same amount of pain later in the third hour," IV 12, 5.150 L).[23] Yet, as Álvarez Millán has suggested, the authors of these later case histories seem less interested in temporal patterns, and increasingly prioritize self-advertisement and dramatic narrative.[24]

There are many ways in which Galen's fever case histories can be said to imitate the temporal patterns and principles found in *Epidemics* I and III. A representative case history occurs in the first book of *On Critical Days*. In this instance, Galen presents a clinical narrative that he marks as hypothetical, but which he recounts with such specificity that a reader might be inclined to assume Galen had experienced one or more similar cases in real life. He begins in the following manner (IX.800.1–9 K):

> ἔστω δή τις τοιοῦτος ἡμῖν ἄῤῥωστος ἐξ ὑποθέσεως εἰς σαφήνειαν τῆς διδασκαλίας προκείμενος, τῇ δεκάτῃ τῆς ἡμέρας ὥρᾳ πυρέττειν ὀξέως ἀρξάμενος ... αὐτοὶ τὴν δευτέραν ἡμέραν, ἢ εἴ τιν' ἀρχὴν ἑτέραν ἐν αὐτῇ ποιεῖται παροξυσμὸς ἕτερος, αἰσθητὴν καὶ σαφῆ παραφυλάξομεν· εἶθ' οὕτω καὶ τὴν τρίτην, ἵν' εἴτε διὰ τρίτης, εἴτε καὶ καθ' ἑκάστην ἡμέραν οἱ

[22] Cf. *Epid*. V.88.3, 5.252 L (= 40.8 Jouanna) and VII.25, 5.394 L (= 66.23 Jouanna). The Liddell-Scott-Jones lexicon lists comparanda from other well-known literary sources, including Herodotus (2.173, 4.181, 7.223), Xenophon (*Mem*. 1.1.10; *An*. 1.8.1 and 2.1.7), and Plato (*Grg*. 469d).

[23] τρίτην mss. and edd.; αὐτὴν Smith. One other reference to numbered hours appears in the Hippocratic Corpus, at *Int.* 27, 7.238 L. For discussion of the fever theory implied in *Epidemics* V and VII, see Smith 1981.

[24] Álvarez Millán 1999: 24–27. Some later physicians abandoned critical-day theories all together. One such was Asclepiades, whom later Methodists claimed to be the founder of their school (Smith 1979: 228). Pearcy makes the interesting observation that when Aelius Aristides contrasts divine and human medicine (*Or.* 61–68), he presents the god Asclepius's medicine as "perplexing, fey, and ambiguous," while the medicine of the human doctors is "chronological, rational, [and] particularized" (1992: 606–09). However, Aristides does not use hours in this passage.

> παροξυσμοὶ γίνονται, γινώσκωμεν· ἔτι δὲ τούτου μᾶλλον, εἴτ' ἐν ταῖς ἀρτίαις, εἴτ' ἐν ταῖς περιτταῖς ἡμέραις παροξύνεται σφοδρότερον.
>
> Let some such patient be set before us, as an example for the clarity of our teaching, a patient who began to experience fever acutely in the tenth hour of the day. ... We ourselves, during the second day, will closely observe whether, on that day, another paroxysm makes another beginning, which is perceptible and clear. Then we will do the same on the third day, in order that we might know whether the paroxysms occur every third day or every day and, furthermore, whether the paroxysms are more robust on the odd or even days.

It is clear that Galen's narrative is structured according to a critical-day format. But in specifying the precise hour at which this hypothetical fever comes on, Galen signals that his temporal framework may deviate somewhat from the Hippocratic. As the case history progresses, it maintains this extra level of temporal precision (IX.800.11–16 K):

> διὰ τρίτης δ' οἱ παροξυσμοί· καὶ τῇ τρίτῃ μὲν τῶν ἡμερῶν ἑνδεκάτης ὥρας, τῇ πέμπτῃ δὲ νυκτὸς ὥρας πρώτης παροξυνέσθω, τῇ δὲ ἑβδόμῃ νυκτὸς ὥρας τρίτης· ἀεὶ γὰρ ὑποκείσθω δυοῖν ὥραιν ὑστερίζειν τὸν παροξυσμὸν, ὥστε καὶ τῆς ἐννάτης νυκτὸς ὥρᾳ πέμπτῃ παροξυνθήσεται καὶ τῆς ἑνδεκάτης ἑβδόμῃ.
>
> [Let] the paroxysms come every third day. And let there be a paroxysm in the eleventh hour of the third day, and another on the fifth day in the first hour of the night, and another on the seventh day in the third hour of the night. For let us always assume that the paroxysm comes two hours later, with the result that there will be a paroxysm on the ninth day during the fifth hour of the night, as well as on the eleventh day during the seventh hour.

Galen's temporal map of this imagined illness is plainly at a higher resolution than those of the Hippocratic writers. Galen organizes his account according to a scheme that indicates not only the critical *days* upon which a paroxysm occurred, but also what one might call the "critical *hour*" within each day. He asserts that, ideally, such precision will help the physician μὴ μόνον ἡμέραν ἔχειν εἰπεῖν βεβαίως ἐνίοτε, ἀλλὰ καὶ τὴν ὥραν αὐτὴν ἐν ᾗ κριθῆναί τινα τῶν νοσούντων, ἢ ἀποθανεῖν ἀναγκαῖον ("to be able to say at times, with certainty, not only the day but also *the very hour* in which one of his patients will experience a crisis—or must die," IX.831.7–9 K, emphasis added).[25]

[25] Cf. *De cris.* IX.674.16–675.4 K: ἐνταῦθα χρὴ προσέχειν τὸν νοῦν ταῖς ὥραις τῶν παροξυσμῶν, ἵνα προγνῷς τι περὶ τῆς τρίτης ἡμέρας. εἰ μὲν γὰρ ὁ τῆς τριταίας εἰ τύχοι περὶ τὴν πρώτην ὥραν μέλλει γίνεσθαι, περὶ δὲ τὴν ἑνδεκάτην ὁ τῆς ἀμφημερινῆς, οὕτω μὲν ἑκατέρων ἔσονται σαφεῖς αἱ ἀρχαὶ ("At this point, one must pay attention to the hours of the paroxysms, in order that one might predict something about the third day. For if,

Unfortunately, due to the paucity of extant medical writings by Galen's contemporaries, it is difficult to say how unique Galen was in privileging hourly schemes within his clinical narratives.[26] The best available source for comparison is a collection of case histories, preserved only in Arabic, that claims to reproduce faithfully texts written by "Rufus of Ephesus and other ancient and recent doctors."[27] Ullmann, who edited the compilation and provided a German translation, has argued on the basis of syntax, diction, and the case histories' internal references to one another that the Arabic texts not only mask authentic Greek originals, but also can be attributed, as a collection, to Rufus or to members of his school.[28] Ullmann's second claim has since been contested,[29] but the former is still accepted widely. Thus, with due caution, let us examine a few case histories from this collection to see how their temporal structures compare with those we have already seen in Galen's *On Critical Days* and in the Hippocratic *Epidemics*.

Of the twenty-one case histories included in this compilation,[30] only one has fever as its focus. Ullmann's Case 5, addressing a "Quartan Fever with Melancholic Symptoms," reads:

> Another man lay for a long time with quartan fever. He was thereby an ascetic; he suppressed his appetites and fasted for a long time. Thence impairment overtook his thoughts, and he developed bad ideas about himself. When I saw the sign of coction in his urine, and when, at the evacuation, black bile came out of him, I could hope that he would get better, since the humor had come out cooked. However, that was not at the beginning, but he lacked coction, until he was <…> Then I made his body moist and reestablished his vigor. Then he recovered without having had a noteworthy evacuation. I have cured many patients of this disease by bringing their temperament into balance, without evacuation.[31]

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by chance, the paroxysm of the tertian is going to occur around the first hour, and the paroxysm of the daily fever around the eleventh, the beginnings of each will be clear." See also, *De cris.* IX.749.8–10 K.

[26] We have reason to believe that the Pneumaticists made use of hours in constructing their own fever theories, but since none of their writings have been preserved, we do not know whether they also wrote case histories and employed a "critical-hour" framework in the process. On this topic, see Miller forthcoming.

[27] The manuscript, at the Bodleian Library, Oxford, is MS. Hunt. 461, fols. 38b-50a.

[28] Ullmann 1978: 16.

[29] See, e.g., Mattern 2008: 33. Álvarez Millán 1999, however, accepts both claims.

[30] Ullmann suggests that the extant group is only the beginning of a more extensive compilation (1978: 16).

[31] Author's English translation of Ullmann's German translation of the Arabic translation of the (lost) Greek. See Ullman's German translation (1978:74): "(1) Ein anderer

There are no time markers in this passage whatsoever, not even a consideration of critical days. This physician is concerned less with the temporal cycles of the quartan fever than with the patient's dietary regimen and humoral balance. The majority of the other case histories in the collection share this focus, though some reveal slightly more interest in the timing of a patient's symptoms.[32]

As in the *Epidemics*, the most common temporal indicators in these case histories are approximate and pegged to solar rhythms. Ullmann's Case 1, for instance, describes a patient who "experienced a fever in the evening and melancholia the next morning, in which, however, he did not persist for long" (12). References to numbered hours do occur, but they are rare and diffuse. I have counted only seven, extracted from four different case histories.[33] Only in Case 21, an account of angina, are hours used as an organizing principle, and this only for the brief section of the case history in which the physician records the frequency with which he lets the patient's blood (10–12). In this instance, hours are used to describe the behavior patterns of the physician, not of the disease.[34]

Mann litt lange am Quartanfieber. Er war dabei ein Asket, tötete seine Begierden und fastete lange. (2) Da ereilte sein Denken eine Schädigung, und er machte sich über sich selbst schlechte Gedanken. (3) Als ich nun das Zeichen der Kochung in seinem Urin sah und als bei der Abführung aus ihm ein schwarzgalliger Saft herauskam, konnte ich hoffen, daß er geheilt werde, denn der Saft kam gekocht heraus. Das war aber nicht zu Anfang, sondern er ermangelte der Kochung, bis er <...> war. (4) Da machte ich seinen Körper feucht und stellte seine Kraft wieder her. Da genas er, ohne eine Entleerung nötig gehabt zu haben. (5) Viele an dieser Krankheit Leidende habe ich dadurch geheilt, daß ich das Temperament ins Gleichgewicht brachte, ohne Entleerung."

[32] For further discussion of Rufus's case histories, see Swain 2008. On Rufus's approach to medicine generally, see Thomssen 1994.

[33] Ullmann Cases 14.9, 15.9, 18.6, and 21.7 and 10–12.

[34] This relative disinterest in the temporal cycles of disease seems to persist into the Islamic period. Álvarez Millán, for example, has shown that the case histories of the tenth-century physician Abū Bakr Muhammad ibn Zakariyā al-Rāzi (which were collected posthumously by his students in two volumes: the *Kitāb al-Tajārib* and the *Kitāb al-Hāwī*) are not structured according to any critical temporal system (1999: 33–42). Álvarez Millán has also demonstrated that the case histories of Avicenna (Ibn Sīnā), whose *Canon of Medicine* (*al-Qānūn fi l-ṭibb*) was considered an essential medical textbook through the 18th century, do not seem to have been based on personal experience and hardly employ temporal markers at all (2010: 209–213). It seems that the models most commonly used by Islamic writers of case histories were Rufus's collection, the Hippocratic *Epidemics*, and Galen's *On Prognosis* (as opposed to his fever case histories).

If these Arabic case histories are indeed translations of Greek originals composed under the Empire (whether or not they should be attributed to Rufus himself), they illustrate that, around Galen's time, case histories could take many forms. Although critical-day doctrines seem to have circulated widely, these were not always used to structure case histories, even those concerned with fevers.[35] In fact, the Arabic examples suggest that case histories need not have discussed the temporal patterns of fevers at all, much less at Galen's level of horological precision. Thus, in imitating the temporal structures of early Hippocratic case histories, but adapting them to emphasize the role of what I am calling critical hours, it becomes clear that Galen made a deliberate choice, one available to his contemporaries but not always adopted. I suggest that Galen's decision was based, at least partially, on his desire to present himself as Hippocrates' intellectual descendent. By recalling the systems of critical days that pervade *Epidemics* I and III, Galen establishes continuity between those systems and his own temporal framework for analyzing fevers, complete with its emphasis on critical hours.

By adjusting the critical-days concept to allow for developments in timekeeping that had occurred between the Classical and Imperial periods, Galen also defends Hippocrates against the charge of being out-dated.[36] While Galen's contemporaries acknowledged Hippocrates as a founding father of the art of medicine, many contested the claim that he should still be considered the ultimate medical authority. So-called "Dogmatist" or "Rationalist" physicians, for example, tended to champion the Hellenistic doctors Erasistratus and Herophilus. The Methodists, so loathed by Galen, looked to Thessalus of Tralles, while many Pneumaticists followed in the footsteps of Agathinus and Athenaeus.[37] Thus, physicians like Galen, who advocated for Hippocrates'

[35] This is suggested by *De dieb. decr.* IX.934–6 K, for example, where Galen addresses alternative explanations for critical-day periods.

[36] Tieleman observes, "[Galen] tends to stress his independence from his contemporaries, while representing himself as conversing directly with the classical authors. ... And of course he understands the great past thinkers much better than their self-styled followers do" (1996: xxii). Tieleman goes on to discuss how Galen updates Hippocratic anatomy and physiology to account for Hellenistic developments and his own discoveries (xxix). See also Dillon 1977: 289 and Mansfeld 1991: 137n78.

[37] The extant writings of Methodist physicians have been collected by Tecusan 2007. On the distinctions between ancient medical sects, and on their most prominent adherents, see, e.g., Smith 1979: 198–215 (specifically on the rivalry between Empiricist and Dogmatist sects), Gourevitch 1999, Nutton 1992 and 2013.

medical supremacy, were under constant pressure to demonstrate the coherence, sagacity, and continued relevance of the Hippocratic texts.

Critics of Hippocrates often pointed out that these texts were riddled with inconsistencies, ambiguities, and generalities.[38] Many of his supporters, however, saw in these qualities the opportunity to exercise exegetical license.[39] Galen, for instance, regularly inserts his own ideas into a Hippocratic work by explaining what the author "really meant" by a word or phrase,[40] or reading back into the text concepts and terms that were not there originally.[41] These tactics allowed Galen to claim for his own theories the full weight of Hippocratic tradition and authority, while simultaneously defending Hippocrates against the accusation that he was inconsistent or outmoded. In what follows, we will see more explicit examples of how Galen uses these revisionist techniques to read hourly timekeeping and Imperial-period astronomical knowledge back into Hippocratic critical-day theories.

HOURS AND ASTRONOMY I: THE PERIOD OF THE MOON

Let us turn now to the third book of *On Critical Days*, where Galen transitions from his more "empirical" discussion of how and when febrile crises manifest in the sickroom to a more "rational" meditation on how the cycles of human biology relate to the cycles of the heavenly spheres. I propose that Galen's interest in such cycles was motivated, at least in part, by a desire to

[38] The "Hippocratic Corpus" as we have it today is actually a compilation of texts by a variety of authors. These men wrote from different geographical locations, at different times within the late Classical and early Hellenistic periods, and their theories of medicine differ from one another to varying degrees. On the medical theories articulated or implied in the Hippocratic Corpus, see Langholf 1990. For a broader perspective on how its authors participated in contemporary intellectual trends, see Jouanna 1999.

[39] For examples, see Smith 1979: 175–76; Lloyd 1988; Von Staden 2002: 114–16; Yeo 2005; Flemming 2007: 343–46; Van der Eijk 2012: 33–34.

[40] For discussion of this phenomenon, see, e.g., Manuli 1983 and Asper 2013. Manuli calls this practice "l'integrazione del significato" (472).

[41] Holmes 2012, for example, has argued that Galen assimilated the Stoic concept of sympathy (συμπάθεια) into his own theory about the interconnectivity of anatomical systems. In his liberal commentary on *Epidemics* II, Galen reads this concept back into the Hippocratic text, despite the fact that the term συμπάθεια does not appear there. Manetti 2003 has observed that Galen also reads certain stylistic qualities back into the Hippocratic Corpus. By being selective about which texts and passages he cites, Galen can claim that Hippocrates' style is clear, concise, and properly Greek, and thus should be a model to the loquacious, long-winded physicians of Galen's day.

adhere to the Hippocratic dictum that good doctors incorporate astronomical principles into their theories of medicine.

Galen often asserts that astronomical knowledge is a critical component of medicine, and he traces this view directly back to Hippocrates.[42] In *The Best Doctor is also a Philosopher*, for example, Galen criticizes other physicians who praise and seek to assimilate themselves to Hippocrates while, at the same time, refusing to take the renowned physician's advice about integrating geometry and astronomy into their medical studies: ὁ μὲν γὰρ οὐ σμικρὰν μοῖραν εἰς ἰατρικὴν φησι συμβάλλεσθαι τὴν ἀστρονομίαν καὶ δηλονότι τὴν ταύτης ἡγουμένην ἐξ ἀνάγκης γεωμετρίαν· οἱ δ' οὐ μόνον αὐτοὶ μετέρχονται τούτων οὐδέ|τερον ἀλλὰ καὶ τοῖς μετιοῦσι μέμφονται ("For [Hippocrates] says that astronomy contributes no small part to medicine, and it is clear that geometry is, by necessity, antecedent to this. Yet they themselves (i.e., other doctors) not only take no part in any of these things, but even censure those who do," 284.9–13 Boudon-Millot = I.53.5–54.2 K). Galen, on the other hand, is eager to avoid this mistake. He has chosen to heed Hippocrates' advice and to follow him in his interdisciplinary scientific pursuits. For if, as Galen cautions in *On the Method of Curing Diseases*, physicians ignore astronomy (and related disciplines, like geometry), ἕτοιμον ἤδη προσιέναι παντὶ γενησομένῳ ῥᾳδίως ἰατρῷ ("it will soon be permitted to everyone to become a doctor easily," X.5.8–9 K). Galen claims to have learned from Hippocrates that what distinguishes a true doctor from a lay-healer is not simply the doctor's cache of medical experiences, but also his grounding in mathematical arts like astronomy.

In Book III of *On Critical Days*, Galen draws upon his mathematical and astronomical knowledge in order to explain and defend the theoretical bases of Hippocratic critical-day models. He concludes, on the basis of his examinations in Books I and II, that there are two kinds of critical-day periods: a primary cycle of one week, and a secondary cycle of four days.[43] Galen's data, however, present him with some problems. First, he would like the primary cycle to be divisible into secondary-cycle units, but the number of days in a week, seven, is not neatly divisible by four. In Book II, Galen sidesteps this problem by recourse to creative numbering.[44] If one divides the seven-day

[42] On Galen's relationships with astronomy and its practitioners, see Toomer 1985 and Strohmaier 1997.

[43] IX.900.5–901.8 K. He also acknowledges the possibility of less-decisive crises occurring on days that do not correspond to either cycle.

[44] For discussion of this strategy, see Cooper 2004: 48–9 and 2011b: 448.

week in half, he points out, the midpoint of the week will fall on the fourth day. If you then count this day twice—both as the last day of the first four-day period and as the first day of the second four-day period—you will wind up with a seven-day primary period that is indeed divisible into two four-day periods.[45] Galen adopts a similar strategy to resolve a second conundrum; his empirical testing has indicated that the clearest and most decisive crises occur on the seventh, fourteenth, and *twentieth* day—not on the seventh, fourteenth, and twenty-first.[46] This is all right, Galen explains, because the second and third weeks can be said to "overlap," so that one day is shared between them.[47] Greeks were familiar with the practice of inclusive counting, and this may have made Galen's argument seem rhetorically plausible to his readers, though it is clearly mathematically unsound.

In Book III, however, Galen offers a different explanation for critical-day patterns, one that is more mathematically rigorous and appeals to astronomical principles. He may have been motivated to alter his approach in response to a change in intended audience. Galen tells us that Books I and II were written for medical students, whose astronomical knowledge could perhaps not be assumed.[48] He composed Book III, on the other hand, for a small group of professional colleagues demanding a technical account of why critical days exist.[49] To this group, Galen explains that the critical days result from the changing position of the moon and the waxing and waning of its influence over earthly matters during the course of a month. Cooper and others have analyzed this argument in detail.[50] I will offer only a brief outline here, paying particular attention to Galen's use of hours.

Galen's argument in Book III stems from the observation (already articulated in the Hippocratic writings) that changes in environmental conditions and human health correlate with changes in solar and lunar "seasons."[51] Just as the Sun passes through four seasons in the course of a year (each approximately three months long), the Moon passes through four "seasons," or phases, in the course of a month (each approximately seven days long). Galen sees that each step in the primary sequence of critical days corresponds to one lunar phase of approximately seven days, and that each step in the secondary

[45] IX.845.16–846.6 K.

[46] On the significance of the twentieth day, see, e.g., IX.851.11–853.6 K.

[47] IX.850.16–851.11 K.

[48] IX.789.17–790.10 K.

[49] IX.934.1–9 K. See also Cooper 2011b: 61.

[50] See especially Cooper 2011b: 61–76 and Langermann's 2012 critique.

[51] IX.908.4–12 K.

sequence corresponds to one half-phase (approximately 3.5 days, which Galen elsewhere rounds up to four). Thus, he concludes that critical-day patterns must be tied to the motion and influence of the Moon.

But how does this help to explain the primary-sequence progression from seven to fourteen to *twenty* days, rather than twenty-one? The key, Galen asserts, is that, while in common parlance people often say that a year is three hundred sixty-five days or a month thirty, these are only rough approximations; neither solar nor lunar periods can be expressed accurately in whole days. In support of this fact, he cites not only Hippocrates,[52] but also the Hellenistic astronomer Hipparchus.[53] Therefore, Galen continues, in order to anticipate when a febrile paroxysm will actually occur, one must use a more precise value for the length of an average "medical week." To calculate this, one must first discover the more precise length of an average month and then divide that value by four.[54]

Galen proceeds to calculate as follows. First, he makes a distinction between *synodic* and *sidereal* months; the former represent the time the moon takes to return to its starting phase, the latter the time it takes to return to a certain position in the zodiac.[55] Because one year is approximately 365 ¼ days long, Galen calculates that each synodic month is, on average, approximately 29 ½ days long, while the average sidereal month lasts only a little over twenty-seven days.[56] Galen subtracts three days from the average synodic month (yielding 26 ½) to reflect the period when the Moon is not visible in the sky, and its influences are therefore negligible. Then, because he has reasoned that both synodic and sidereal months must be influential for determining clinical crises, Galen averages their two lengths to arrive at 26 11/12 days.[57] Finally, he

[52] IX.928.16–929.3 K. Galen is here quoting *Prog.* 20, 2.170 L = 58.9–59.2 Jouanna. On fever theories in the Hippocratic Corpus, see Sticker (1928–1930).

[53] IX.907.14–16 K. Hipparchus's name occurs six other times in the Galenic corpus: *De dieb. decr.* IX.907.16 K; *In Hp. epid. I comm.* XVIIa.23.13 K; *In Hp. prog. comm.* XVIIIb.240.14 K; *De meth. med.* X.12.10 K; *De comp. med. sec. loc.* XIII.353.14 K; *De sept. part.* line 19 Schöne; *De usu part.* IV.359.11 K. In this last instance, Galen locates Hipparchus in the same intellectual stratum as Plato, Aristotle, and Archimedes.

[54] On Galen's process of defining "medical" weeks and months, see Garofolo 2003: 52–3 and Cooper 2004: 53–5, 2011a: 129, 2011b: 75.

[55] IX.907.8–908.1 K.

[56] The discussion that follows can be found at IX. 930.15–933.4 K.

[57] He asserts that the synodic month influences the general atmosphere, while the sidereal month influences the particular changes affecting an individual.

divides that number into fourths to produce an average "medical week" of 6 35/48 days. Three such weeks comes to 20 9/48 days, which is closer to twenty days than twenty-one. In this way, the dilemma of the seven-fourteen-twenty progression is resolved.

Here, Galen expresses his calculations as a combination of integers and unit-fractions.[58] Elsewhere in his corpus, however, Galen chooses to translate these day-fractions into hours and fractions of hours. The relevant passage occurs in *On Seven-Month Children*, which Galen composed in response to the Hippocratic texts *On the Seven-Month Child* and *On the Eight-Month Child*.[59] *On Seven-Month Children* has come down to us both in a fragmentary Greek version and in a complete Arabic translation by Hunayn Ibn Ishaq.[60] In this text, Galen participates in a lively medical debate, ongoing since the time of Hippocrates, over the appropriate length of human fetal gestation.[61] Galen observes that at the heart of this debate lies a dispute over the definition of a month, so he explains to his readers how trained astronomers measure its length. Preserved among the Greek fragments of *On Seven-Month Children* is the following passage (19–38 Schöne):

> ἄλλο τι μόριον Ἵππαρχος ἀπέδειξε τῆς ὅλης ἡμέρας εἰς τριακοστὸν τὸν καὶ εἰκοστὸν καὶ δισμυριεπτακισχιλιοστὸν ἄλλο τέ τι πρὸς τούτῳ πάλιν σμικρόν, οὗ περιττὸν εἰς τὰ παρόντα μεμνῆσθαι. τὸ γάρ τοι προκείμενον ἤδη πέρας ἔχει, κατὰ μὲν τὸ δεύτερον τῶν Ἐπιδημιῶν ... "Οἱ δ' ἑπτάμηνοι, φησίν, γίνονται ἐκ τῶν ἑκατὸν ἡμερῶν καὶ ὀγδοήκοντα καὶ δύο καὶ προσεόντος μορίου." ἑπταμήνους ἤτοι παιδία ἢ τόκους, τὸ δ' ἐπὶ ταῖς ἑκατὸν ὀγδοήκοντα δύο ἡμέραις μόριον τὰς πεντεκαίδεκα ὥρας λέγει μετά τινος, ὡς ἔμπροσθεν ἔφην, μορίου σμικροῦ, ὃ καὶ αὐτὸ μιᾶς ὥρας ἐστὶν εἰκοστὸν τέταρτον ἔγγιστα. δῆλον γὰρ ὅτι τὰς ἰσημερίνας ὥρας λέγομεν ἐν πᾶσι τοῖς τοιούτοις,

[58] IX.932.13–933.1 K. The ancient Greeks and Romans, like the Egyptians, expressed the remainder of a quotient as the sum of a series of "unit fractions," which had the number one as numerator. On fractions in ancient Greece and Egypt, see Knorr 1982.

[59] The relationship between these two texts is controversial. *On the Eight-Month Child* appears in a different sequence in manuscripts M and V. As Potter, editor and translator of the Loeb Classical Library edition, explains, "V presents the whole of chs. 10–13 and 1–9 in succession under the title *Eight Months' Child*, and then another short spurious text under the title *Seven Months' Child*. ... To avoid the unnecessary confusion a departure from Littré's chapter numbering would entail, I have kept his and M's order of the text, but adopted Joly's and V's title *Eight Months' Child* for the whole work" (73–4).

[60] The incomplete Greek text is based on the Greek codex Laurentianus LXXIV 3 (L), fol. 104r-105v and Laurentianus Gr. LXXIV 2 (l). The complete Arabic translation appears in Codex 3725 of the Library of the Aya Sofia in Istanbul (fol. 127b-134b). See Walzer 1935.

[61] Mention of this debate also occurs at, e.g., Plin. *HN* 7.4 and Gell. *NA* III. 10 and 16.

ὧν ἐστι καὶ τὸ νυχθήμερον ὀνομαζόμενον ὑπὸ τῶν ἀστρονομικῶν εἴκοσι καὶ τεττάρων ὡς ἁπάντων αὐτῶν ἴσων ὄντων, ἐπειδὴ τὸ παραλλάττον ἐλάχιστόν ἐστι, ὥς τινας νομίζειν ὅλως αὐτὸ μηδ' εἶναι.

Hipparchus demonstrated that, of a whole day, one thirtieth and one twentieth and one twenty-seven-thousandth are added, and another small fraction again in addition to this, which it is superfluous to mention at present.[62] For the point is that [the month] has the aforementioned boundary, according to the second book of the *Epidemics*. ... [*Galen quotes the Hippocratic* On the Eight-Month Child]: "The seven-monthers," [Hippocrates] says, "are born after one hundred eighty-two days and an additional fraction." With regard to seven-month infants or children, he means that the portion added to the one hundred eighty-two days is fifteen hours, with, as I said before, some small fraction close to one twenty-fourth of an hour. It is clear that we are talking about equinoctial hours in all these cases, a twenty-four-hour span of which is called the "night-and-day" by astronomers as if all of the hours were equal, since their deviation is very slight, with the result that some think it should be entirely ignored.[63]

Galen's central aim, in *On Seven-Month Children*, is to vindicate Hippocrates from accusations of self-contradiction. In two texts, *On the Seven-Month Child* and *On the Eight-Month Child,* Hippocrates correctly states that the length of an average synodic month is 29 1/2 days. In two other texts, however, *On Nourishment* and *Epidemics* II, Hippocrates gives a less precise month-length of thirty days. To resolve this apparent contradiction, and to demonstrate that Hippocrates was not, in fact, in error, Galen argues that *On Nourishment* and *Epidemics* II were written early in Hippocrates' career, whereas *On the Seven-Month Child* and *On the Eight-Month Child* were composed later, after Hippocrates had learned the more precise value. To support this interpretation, Galen even cites the same passage from *Prognostic* that he cites in *On Critical Days*, about the lengths of solar and lunar periods being immeasurable in whole days.[64]

It is notable, however, that no Hippocratic writer expresses the length of an average month with precision down to the hour. While the author of *Epidemics II* states that "seven-monthers ... are born after one hundred eighty-two days

[62] For an explanation of this calculation and its relationship to Hipparchus's data, see Neugebauer 1983.

[63] For the corresponding passage in Hunayn's Arabic, see 126–137, pp. 339–340 Walzer (German translation at pp. 349–350).

[64] 114–124, p. 347 Walzer. The text in the Greek differs somewhat from the Arabic and can be found at 21–27, p. 354 Walzer.

and an additional fraction," it is Galen himself who redefines that fraction as fifteen hours and one twenty-fourth. Galen explicitly reads this figure into the subtext of *On the Eight-Month Child* when he asserts, "[Hippocrates] *means that* the portion added to the one hundred eighty-two days is fifteen hours" (emphasis added). Galen thereby attributes to the Hippocratic author the same concern with temporal precision that he himself shares, despite the fact that the word ὥρα, in the sense of "hour," only appears in the Hippocratic corpus on a handful of occasions.[65] It seems that, while at least some of the Hippocratic writers had exposure to hourly timekeeping, they elected not to use hours in their calculations (or, as we have seen, in structuring their case histories). This contribution is wholly Galen's, and it serves him in a variety of ways: it helps to exonerate Hippocrates from charges of error and contradiction, to strengthen the link between Hippocrates and Galen, and to highlight Galen's own astronomical proficiency.

HOURS AND ASTRONOMY II: THE PERIODS OF PLANETS

Returning to Book III of *On Critical Days*, it is worthwhile to consider one other passage where hourly timekeeping, though not mentioned explicitly, is fundamental to Galen's argument. Here, Galen seeks to explain, by recourse to contemporary astrological theory, how it is that the Moon's quarterly position can affect human health.[66] He refers to a form of astrology handed down πρὸς τῶν Αἰγυπτίων ἀστρονόμων ("by the Egyptian astronomers," IX.911.15–16 K) dedicated to determining whether an event or undertaking will be auspicious. According to these unnamed astronomers, a day is auspicious if the Moon, on that day, is in an astrologically-significant aspect (e.g., quartile, trine, etc.) with τοὺς εὐκράτους ... τῶν πλανητῶν, οὓς δὴ καὶ ἀγαθοποιοὺς ὀνομάζουσιν ("the well-disposed planets, which they call benefic," IX.911.18–912.1 K), based on its position at the time of the person's birth. If, on the other hand, the Moon is in astrological aspect with τοὺς δυσκράτους ("ill-disposed" or "malefic planets," IX.912.2 K), the day is inauspicious. By extension, if, on a critical day, the Moon is in quartile with a malefic planet, it is likely that the patient will experience a crisis that is severe and even fatal. If, however, it is in quartile with a benefic planet, the patient's condition will likely improve.

[65] *Epid.* IV 12, 5.150 L and *Int.* 27, 7.238 L. The earliest example of their popular (as opposed to technical) use is in Callim. Fr. 550 Pfeiffer. See Langholf 1973 and Hannah 2009: 73–75.

[66] The full passage can be found at IX.911.14–913.10 K. I am indebted to Alexander Jones (pers. comm.) for his assistance with the following translation and discussion.

Since the Moon can move from one zodiacal sign to another at any time of day or night, the astrological character of a day can change from one hour to the next.[67] Thus, it was important for ancient astrologers to be able to track the movements of celestial bodies over time with as much accuracy and precision as possible—ideally, down to the hour or fraction of an hour.[68] The technology for tracking and modeling celestial cycles improved dramatically between Hippocrates' day and Galen's. The late Classical and early Hellenistic periods, when the Hippocratic writers were active, constituted an important transitional time for Greek astronomy. It was already recognized in the Archaic period that close observation of celestial movements could enable one to make predictions about related, personally-relevant matters. Farmers and merchants were better off if they could anticipate the likelihood of rain or high winds, and if they knew when the period of daylight would be longer or shorter. Since both the weather and the length of daylight correlate with the time of year, farmers and merchants discovered that they could get a handle on these factors by pegging their own enterprises to recurring celestial events. The poet Hesiod offers our earliest literary testimony of what seems like a Farmer's Almanac in *Works and Days*.[69]

By the end of the Classical period, however, new technologies and new data enabled Greeks to develop predictive models of greater complexity. One such tool was the *parapegma* (from παραπήγνυμι, "to fix beside"), which coordinated the risings and settings of fixed stars with weather predictions for given dates.[70] Another was the practice of astronomical table-making.[71]

[67] This is evident, for example, in *P.Oxy.* 65.4483 (194 C.E.), where the author recommends that his addressee meet a friend while the moon is in Sagittarius, which he claims will be from the fourth hour on Thoth 12 until the seventh hour on Thoth 14.

[68] On the extent to which ancient Greek scientists concerned themselves with precise measurement, see Lloyd 1987: 215–84.

[69] Hesiod recommends, for instance, that his lay-about brother Perses gather the grapes from his vines Εὖτ' ἂν δ' Ὠρίων καὶ Σείριος ἐς μέσον ἔλθῃ/ οὐρανόν, Ἀρκτοῦρον δὲ ἴδῃ ῥοδοδάκτυλος Ἠώς ("whenever Orion and Sirius reach mid-heaven and rosy-fingered Dawn sees Arcturus," *Op.* 609–10).

[70] *Parapegmata* came in a variety of forms, both literary and inscriptional. Inscriptional varieties use a hole-and-peg system to keep track of the date, and it is from this practice of "fixing" the peg in each successive hole that the term *parapegma* derives. For an in-depth history of Greek and Roman *parapegmata*, see Lehoux 2007, where he notes that the Greek *parapegmata* of the Hellenistic period show a greater interest in astrometeorology than do the Latin *parapegmata* of the Roman period (14 and 24). See also Lehoux 2005 and Hannah 2009: 53–54.

[71] On the history of mathematical table-making, see Campbell-Kelly 2003.

Babylonian priests, eager to predict the occurrences of celestial omens, such as lunar and solar eclipses, had maintained meticulous records of astral, planetary, and lunar positions with which they could calculate impending syzygies.[72] At some point during the Hellenistic period,[73] these tables made it into the hands of Greek astronomers, providing them with raw data and models[74] for organizing their own records and observations in the future.[75]

As sundials and water-clocks become more widely available over the Hellenistic and Imperial periods, a variety of tables begin to appear in the papyrological sources that recorded the hour of a celestial event's occurrence alongside other factors.[76] Ephemerides, for example, list the daily positions of celestial bodies, and often include the hour of zodiac sign-entry as well as the longitude and time of particular syzygies.[77] Sign-almanacs from the third century C.E. onward also tend to include a column for the seasonal hour of sign-entry.[78] Thus, by Galen's day, astronomers were in the habit of recording the exact hours at which periodic events occurred, and then using

[72] I use the term "syzygy" here in the astrological sense of "alignment," not in the modern astronomical sense of three celestial bodies that appear in a line.

[73] We do not know precisely when or how this Babylonian data was transmitted to the Greek world, but we do know that Hipparchus, who was active in the second century B.C.E., had access to Babylonian lunar eclipse reports that ranged from the mid-eighth century B.C.E. to at least the early fourth century B.C.E. (see Neugebauer 1975: 309 and 590; Jones 1991: 443). On Greek adaptations of Babylonian astronomy, see Jones 1996.

[74] Lehoux has pointed out that the producers of *parapegmata* often preferred to collate data from preexisting models rather than make new observations of their own (2007: 69). The Babylonian system was also based primarily on mathematics, not observation (see Neugebauer 1975: 363–8).

[75] These developments in astronomical data organization also contributed toward the invention of more complex predictive devices, like the so-called Antikythera Mechanism, which was salvaged from an ancient shipwreck off the coast of Antikythera and dated to ca. 100 B.C.E. The Antikythera Mechanism (National Archaeological Museum of Athens, Inv. 15087) is a geared, computational device that allows the user to input a date and determine where that date falls within a number of calendrical cycles (both astronomical and political) and the positions of the celestial bodies at that time. On the mechanism and its functions, see, e.g., Freeth et al. 2008, Carman et al. 2012, Freeth and Jones 2012, Lin and Yan 2016, as well as Jones 2012 and 2017.

[76] See especially Jones 1999 and 2009.

[77] Some *ephemerides* were used for catarchic astrology (e.g., Jones 1999 no. 4180), as evidenced by the fact that they evaluate each day as "good" or "bad" for certain kinds of endeavors. Our extant *ephemerides* date from the first century B.C.E. to the late fifth century C.E. The most extensive collection and commentary to date is Jones 1999.

[78] E.g., Jones 1999 nos. 4192 and 4194–4196a.

that observational data (whether their own or someone else's) to construct mathematical models for anticipating future events. In turn, catarchic and horoscopic astrologers, whose trades became wildly popular under the Roman Empire, often attempted to impress their clients by drawing upon the latest developments in astronomical table-making, time-keeping, and celestial trigonometry.[79]

Galen appeals to such developments in order to provide a more nuanced explanation of why Hippocratic critical-day theories work. Since these astronomical and astrological trends, in full force during Galen's time, were only just beginning to take off during the period of the Hippocratic writers, it seems likely that these writers did not share the same degree of exposure to or interest in this mode of interpretation. Many of the Hippocratic works certainly display an appreciation for astronomy.[80] The *Epidemics*, for example, contains many references to seasonal astronomical events, such as equinoxes, solstices, and the rising and setting of stars and constellations.[81] The author(s) of *Epidemics* I and III, whose case histories were examined above, could even be said to have mapped the progression of diseases over time for predictive purposes in a manner analogous to the astronomer tracking the movements of celestial bodies. Galen, however, seems to read back into these texts a capacity for and familiarity with hourly timekeeping (and its astronomical and astrological applications) which was not appropriate for the late Classical and early Hellenistic eras. In so doing, Galen appears once again to present himself as a follower and refiner of Hippocratic doctrine.

CONCLUSION

This paper investigated the role of hourly timekeeping in Galen's *On Critical Days*. Galen introduced greater temporal precision into clinical narratives that are otherwise modeled on Hippocratic critical-day structures. Galen's account of the theory behind critical days, and the astronomical and astrological arguments he musters, implies the use of hourly timekeeping technology. Engaging with hourly timekeeping in these ways enabled Galen not only to

[79] For Greek and Roman horoscope collections, see, e.g., Vettius Valens, Ptolemy's *Tetrabiblos*, and the astronomical papyri compiled by Neugebauer and Van Hoesen 1987 and Jones 1999: 371–450. On the data-processing and marketing strategies of ancient astrologers, see Barton 1994: 27–94. On their tools, see Evans 2004.

[80] See, e.g., Hipp. *Aer.* 2. 2.14 L (= 189.4–6 Jouanna); *Vict.* II.25, 6.470 L. On Hippocratic engagement with meteorological medicine, see Liewert 2015.

[81] Many such references can be found in *Airs Waters Places* and *On Nourishment*. For discussion, see Phillips 1983.

weigh in on the debate surrounding the utility of critical-day systems, but also to support a network of interrelated claims. One of these claims is that the genuine Hippocratic writings are internally consistent and contain within them the seeds of important medical advancements (including the use of hourly timekeeping). Another is that Galen's own medical theories represent truthful and logical extensions of Hippocratic doctrine. The refinements that Galen introduces (such as precision down to the hour) simply bring Hippocratic teachings into closer alignment with contemporary developments and technologies. Ultimately, Galen claims that he, like Hippocrates before him, practices a form of medicine which is grounded in demonstrative method, and which incorporates data and strategies from mathematical arts like astronomy. Thus, Galen seems to have considered hourly timekeeping to be both a practical and a rhetorical tool for promoting himself, his scientific method, and his professional hero, Hippocrates.

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