BOOK PRESENTATION

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Virtual Edition of Three New Books by Rafael Levi of Hanover Still in Manuscript

I have the privilege and the pleasure to present to the scholarly community the first virtual edition of three books of Rafael Levi of Hanover that have remained until now in manuscript; see http://www.ajdler.com/jjajdler/hanover/. These three manuscripts, each of them unique in the world,[1] have been preserved in the Bodleian Library in Oxford.

Raphael Levi was a celebrated astronomer and mathematician in the Jewish world of the 18th century; he was also considered a distinguished Torah scholar and a natural and divine philosopher. He was the author of two books; the first,[2] ספר תכונת השמים, is a textbook of descriptive astronomy and an introduction to Maimonides' *Hilkhot Kiddush ha-Hodesh*. The second, לוחות העיבור, actually includes two books, both containing astronomical tables with instructions for use, but without explanation or justification. The first[3] follows the new astronomy and the second[4] follows the ancient astronomy according to Maimonides' assumptions.

Hanover's books were known and studied in Jewish society. For instance, we learn from the book *Aliot Eliahu*[5] that the Gaon of Vilna learned astronomy from Hanover's books. However, the interest in astronomy weakened in the rabbinical circles and *yeshivot* of 19th-century Eastern Europe while, at the same time, Jewish studies almost completely disappeared in Germany. Concurrently, the fame and even the name of Rafael Levi were almost forgotten—though not completely, however, as in 1820 an enlarged edition of his לוחות העיבור was issued by Meyer Furth[6] and, at the end of the 19th century, two chapters[7] of ספר תכונת השמים were introduced in the Vilna-Warsaw edition of the *Mishneh Torah* under the title: ביאור פרק י"ט מקידוש החודש מהרה"ג התוכן מו"ר רפאל מק"ק הנובר ז"ל.

1 In fact, it seems that for the second book – ספר חכמת התכונה – a second manuscript exists in Moscow. It could not yet be checked. I thank Eran Raviv for this information.
2 Amsterdam, 1756. It is in fact the printed version of the manuscript of 1734, still extant.
3 Leiden, 1756.
4 Hanover, 1757.
5 *Aliot Eliahu*, edition Levin-Epstein (1954), p. 44.
6 *Sefer Yirat Shamayim* (Dessau, 1820).
7 Chapters 90 and 91 of ספר תכונת השמים.

It was thanks to this work that I discovered Hanover's existence, and tried to learn more about this man, who seemed to have a clear and professional understanding of this hidden subject. When visiting R. E. Guggenheim *z"l* in Paris before my marriage, I discovered the existence of two printed books in the library of the rabbinical seminary, ספר תכונת השמים and לוחות העיבור, which I was permitted to borrow for a short while, against the prevailing rules.

In the introduction to the second part of לוחות העיבור, the author refers to the third part of that book, in which he intends to explain and justify all his calculations. I was in contact with the National Library in Jerusalem, the Bodleian Library in Oxford, and the universities and town libraries of Frankfurt, Berlin, Hamburg, Hanover and Zurich, in search of the manuscript of this third part of לוחות העיבור.

I did not find the manuscript of this third part, but I did find three unpublished manuscripts by Hanover and two of his published manuscripts.[8] The three unpublished manuscripts must have belonged to Heimann Joseph Hayim Michael (1792–1846), the great German bibliophile, before going to the Bodleian Library at Oxford after his death. Indeed they beheld their original system of numbering beginning by *Mich* like Michael.

The deciphering of the manuscripts was the most difficult and tiring part of the work, especially for the eyes. The understanding, the commentary, and the calculations were more rewarding aspects of the study. But the most rewarding part of the work was the discovery of some real jewels: original calculations and discoveries as well as original Talmudic explanations, some of them offering true and definitive understanding, deserving to enter Maimonides' and Talmudic literature.

1. First Book: כללי סוד העיבור והתכונה: Mich 58

This book seems to be a summary of the theory of the Jewish calendar, the ancient astronomical models of the movements of the sun and the moon, and visibility calculations according to Maimonides' methods.

This book is a kind of summary of the subjects that Hanover taught; it presents a form of lecture notes, and it is unlikely that he checked it because there are some errors in the text, the notations, and the drawings.

8 A manuscript of each of the published books. I also found a manuscript of Rabbi Yom Tov Lipman Heller Wallerstein and a manuscript of Rabbi Joseph Solomon Delmedigo, both on *Hilkhot Kiddush ha-Hodesh*. Recently, engineer Eran Raviv showed me that the catalog of manuscripts of the Hebrew University now gives the complete list of Hanover's extant manuscripts.

We have no precise data about the date of the composition. However, the use in his calculations of the time around Tishri 1729 could lead one to assume that this book was composed around this period.

Among the various subjects considered, two deserve special attention.

1. Early visibility of the new moon one day before the Neomenia

In the present book, we find the following text (p. 9) about the extremely rare eventuality of seeing the new moon on the evening preceding the day of the *keviyah*, thus before the Neomenia:[9]

וכן אפשר בחדשים הקודמים בזה המשל שיהיה יום הראייה קודם ליום הקביעה כמו שכתב הרב הראב"ע אמור אבל בדרך אחר אי אפשר שיום הראייה יהיה קודם ליום הקביעה יום אחד והוא פלא כי צריך להיות מולד אמצעי בתשרי ב- ג ט ר"ד וצריך להיות שנה פשוטה, וגם צריך להיות הקיבוץ מוקדם לאמצעי כדי שיהיה ריוח בין רגע קיבוץ עד עת הראייה יתר מן כ"ד שעות וצריך שיהי רוחב הירח צפוני חמש מעלות ודבר זה שיהיו כל התנאים הממהרים הראייה ביחד הוא פלא גדול ואפשר שלא המצא תמצא בחמש מאות שנים וכבר יגעתי א"ע ומצאתי תאמין שחקרתי וחפשתי בחיפוש אחר חיפוש משנת 4000 עד שנת 5000 ליצירה ולא מצאתי רק במשל אחד בשנת 4683[10] שהיה מולד אמצעי בתשרי ג. ט. תמ"א ונדחה לחמישי ונראה הירח בליל ד' והיה יום הראייה ביום ד' יום אחד מוקדם ליום הקביעה.

This outcome is truly exceptional. Hanover managed this using a rather primitive lunar theory and Maimonides' theory of the new crescent's visibility. All his calculations were manual. However, he succeeded in finding the only case in a 1000-year period when the moon was visible on the last day of the preceding month.

2. The postponements in the Jewish calendar

At the beginning of our book, כללי סוד העיבור והתכונה, the author explains and justifies the postponement rules of the Jewish calendar by a fundamental and general rule. He presents without irrefutable proof a general principle of the Jewish calendar: the first day of any Jewish month may not fall before the day of the true conjunction. He writes:[11]

9 I quoted already this text in *Hilkhot Kiddush ha-Hodesh al-pi ha-Rambam*, p. 225.

10 This corresponds to Tishri 922 C.E. This exceptional case is known in the Jewish literature surrounding the dispute between Sa'adiah Gaon and Ben Meir. The discovery of this exceptional case by Hanover through manual calculations is amazing. Later, Hanover found a second case—as he noted at the end of his *Tekhunat ha-Shamayim ha-Arokh*, p. 137, where a similar phenomenon happened in Tishri 5275.

11 Beginning of the book, p. 11.

דע בזמן שאין שם סנהדרין בא"י או סמוכים, אין רשות לקבוע החדשים והמועדות על פי הראייה. וראוי להיות יום הקביעה מכל החדשים או ביום קיבוץ האמיתי או ביום אחר קיבוץ אמיתי, אבל לא קודם לו כמו בעיבור השנה צריך להיות פסח או ביום תקופת ניסן האמיתי או לאחריו אבל לו קודם יום תקופה אמיתי.

Hanover also mentioned this principle a few times in his other book in manuscript, תכונת השמים הארוך.

He considered this principle as the fundamental rule explaining and justifying all the postponements of the Jewish calendar. However, I have shown that this rule is not absolute and that there were at least 24 exceptions in the history of the Jewish calendar – always at the beginning of the month of Shevat in leap years.[12]

2. Second Book: חכמת התכונה: Mich 498

We present here a second book still in manuscript in the Bodleian Library under No. 2063 in A. Neubauer's Catalogue of Hebrew manuscripts in the Bodleian Library, Oxford (1886–1908). The manuscript includes 45 folios: one folio is the title page, followed by 24 folios, i.e. 48 pages, which are devoted to the text of the manuscript. The last 20 folios correspond to 20 figures illustrating the main text.

The present book does not revolutionize our understanding of Maimonides' *Hilkhot Kiddush ha-Hodesh*, but it does allow us to understand fully Hanover's methods of calculation of the moon's visibility according to the conception of the ancient astronomy (the astronomy of Ptolemy). In this field, Hanover was fortunate to be on the bridge between the ancients and the moderns. His education gave him full understanding of the ancient astronomical models, without the dull study of ancient books. His profound mathematical knowledge, including the new notions of calculus learned under Leibnitz, gave him the necessary tools to be the first to perform a complete study of the visibility of the new moon, and determine true conjunctions and *tekufot*. We have no precise data about the date of the composition. However, the use in his calculations of the time around 1725 would lead us to assume a date of composition around that period. It could be then the oldest of all his books. Hanover was convinced that mastery of the subject required the ability to perform the complete practical calculations of the phenomenon under analysis. The present book was a practical instruction manual supporting his oral teaching. For this reason, it is very similar to the spirit of his לוחות העיבור. Both are practical books explaining the *how* and not the *why*.

12 I hope to publish a paper on this topic.

Another book intended to answer this last question was frequently included as a reference in the present manuscript and in the introduction to לוחות העיבור. Unfortunately, it could not be found.

Probably because of the author's high requirements, our book would never be edited—just like this third part of לוחות העיבור.[13] In his לוחות העיבור, the author presented easy-to-use and improved tables. In the present manuscript, he performs all the complete and detailed calculations "as a professional astronomer would do them." This of course is of the highest importance in our efforts to understand his methods of calculation. We can now imagine what this book would have been like. When we compare Hanover's methods of calculation with those of E. Baneth in Maimuni's *Neumondberechnung* (1898, 1899, 1902 and 1903), we are struck by the similarity and even the identical characteristics of the methods. The only difference is in the scholarly aspects of Baneth's work and study of the ancient texts. This explains the interest of Hanover's manuscript in the history of the study of Maimonides' *Hilkhot Kiddush ha-Hodesh*.

If our assumption that the present manuscript was written in about 1725 is correct—thus still during the life of Newton and only 38 years after the edition of the *Principia*, only seven years after the death of Flamsteed and 53 years after the publication of *De Inaequalitate Dierum Solarium*—then we may well assume that the old astronomy of Ptolemy was still being taught in the European universities, and that it was exactly the astronomical model described in his book. The parameters of this model are very similar to those of al-Battani (slightly different from those of Ptolemy), but include some new parameters that were unknown to the ancients.[14] These permit us to calculate the distance of the earth from the moon, 1238,[15] and from the sun, 273633, giving a ratio of 221, different from the modern value. Indeed, the parallax of the moon is, on average, 57' (this figure was already known by Ptolemy) and, according to modern astronomy, the parallax of the sun is 8.794"; this gives a ratio of 388.9.

Hanover mastered spherical astronomy and all its concepts. He attached great importance to the concept of the equation of time. Hanover adopted the new theory

13 Perhaps both books were in fact the same book.

14 The distance between the center of the earth and the center of the deferent is fixed at 9730; the radius of the earth is fixed at 20.47. Hanover never gave any indication about the meaning of these figures. This method of working is similar to that of the ancients: the figures must be considered as relative data. However, as soon as the radius of the earth is fixed to 20.47, we can deduce that the unit used by Hanover is, in modern units of length, 311 km.

15 Again this number is relative.

of Flamsteed, although it was not much older than that of Newton. The great difference in Hanover's attitude with regard to these two theories is that Newton's theory was a revolutionary theory that had to be completed and perfected until it could assert itself; it was like a theory of relativity appearing in an ancient landscape. By contrast, the concept of the equation of time was an ancient concept familiar to Ptolemy and al-Battani, which was misunderstood and disputed in the 16th and 17th centuries. Flamsteed proposed a new and definitive presentation of the concept, and Hanover immediately adopted it. Apparently, Hanover did not know the works of the ancients, Ptolemy and al-Battani, in the text, and he gives the impression that he was probably not aware of their understanding of the *equation of the days*. He was, however, a well-read, cultured and curious man who, as we learn from another of his manuscripts, the third one, visited what he called "the library of the Gaon of Prague" (Hanover did not elaborate. In fact he was referring to R. David Oppenheim [1664–1736], a great bibliophile and the Chief Rabbi of Bohemia. Because of censorship problems, his library was in Hanover during his lifetime. It would later become the nucleus of the Bodleian Library.[16]) He even visited the Royal Library in Paris. This led to an anachronistic situation: Hanover, on the one hand, developed in this book a model based on ancient astronomy, but, on the other hand, adopted the new theory of Flamsteed's equation of time. In fact, this was probably the general scientific position at that time: Flamsteed had conceived his equation of time before Newton's new theory, when he was still using the model of the ancients, despite all its weak points. Flamsteed's theory asserted itself in the scientific community far before the Newtonian astronomy. However, Hanover's anachronistic attitude remains incomprehensible. Indeed, the almanacs of this period, the first half of the 18th century, and notably the famous *Connoissance des Temps* published the table of the equation of time according to Flamsteed's new theory, and the table of the equation of the clocks according to the ancient conception that preceded Flamsteed. Hanover thus could certainly not have been unaware of the fact that the ancients calibrated their mean time differently, and it remains a conundrum why he did not raise this issue and how he could propose that the epoch[17] of Maimonides was at 6h 20m p.m. modern mean time. This

16 In 1829 the University of Oxford purchased for the Bodleian Library the whole collection that had formerly belonged to R. David Oppenheim. Later in 1848 it bought the collection of the Hamburg bibliophile Heimann Joseph Michael.

17 The *epoch* is the reference moment for which all the radices or astronomical reference data are given.

statement is in fact an absurdity, as Maimonides could not even have imagined our modern mean time.

Raphael Levi had the reputation of being an extraordinarily skilled calculator. We discover in the present book that he used logarithmic tables of the numbers, sine and tangent, with seven exact decimals, permitting very precise calculations. We know also that he championed the use of logarithms in commercial and banking calculations (see his book in German on the subject: *Vorbericht vom Gebrauch der neuerfundenen logarithmische Wechsel-Tabellen... verfertiget und Hrsg von Raphael Levi* [Hannover, 1747]).

In the field of trigonometry, he used the word בקע for the sine and נוגע for the tangent. He did not use the cosine or the cotangent and would use, instead, the sine or the tangent of the complement. He used mainly the sine-formula and the derived tangent-formula in the plane triangles; similarly, he used mainly the sine-formula in the spherical triangles and the different formulas of the spherical rectangular triangles. Normally, the formulas of trigonometry are correct not only in absolute value but also in sign. However, Hanover seems not to rely on the knowledge of his pupils, and feels obliged to explain at length, on each occasion, the rules of sign for each operation. This is rather disturbing for the modern reader, who prefers a general formula.

In the field of spherical astronomy, we note that Hanover mastered the subject and knew the formulas of transformation between the horizontal, equatorial, and ecliptic coordinates based on the fundamental formula of spherical trigonometry. He did not know the sidereal time $Ts = \alpha + H$ but used the correlated oblique setting $\alpha + \Delta$ and the oblique rising $\alpha - \Delta$, with $H = 90° + \Delta$. Again, these formulas are valid in size and signs, but Hanover felt obliged to detail at length. Similarly, Hanover did not use the azimuth Az, but used the quantity $w = Az - 90°$, representing the distance from the middle western point W or from the middle eastern point E.

Hanover, as a pupil of Leibnitz, mastered calculus and introduced the notion of differential calculation, more exactly finite differential calculation, into the ancient astronomical model. Indeed, the calculation of two true positions of a body for two consecutive mean longitudes of l_b and $l_b + 1°$ allows calculating the true displacement of the celestial body when its mean displacement is 1°. This allows calculating the true celerity of the celestial body with regard to its mean celerity. Hanover made use of this feature to improve the calculation, according to the ancient model of astronomy, of the true conjunctions, the true oppositions, the eclipses and the *tekufot* with a precision that was never previously achieved. Hanover clearly claimed the originality of this procedure. It is certain that in the field of Jewish astronomy, this

was a justified claim. It is, however, likely that this procedure was used in parallel, and probably before him, by professional astronomers of the most advanced countries of Europe.

In the present book, Hanover introduced an original criterion of visibility of the new moon. He affirmed that the new lunar crescent is visible if the central angle of the lightened moon d is 5°, corresponding to the illuminated fraction k of the disk of the moon $k = (1 + \cos E) / 2 = \cos^2 E/2 = 0.019$ with $E = 180° - d$.

We note, however, that he made a mistake of judgment and considered that the angle of the illuminated part of the moon depends on the apparent altitude of the moon. In reality, it depends on the geocentric elongation E between moon and sun (arc of light of the ancients). We note also that this criterion would contradict the observations of Danjon. According to the latter, the new crescent is not visible as long as the angle d is less than 7° (see Danjon, *Astronomie Générale* [Paris, 1958 and 1986], p. 348).

Furthermore, when we examine the modern criteria of visibility, that of Fotheringham and the Indian criterion, giving Δh in function of ΔAz, the difference of altitude between moon and sun in function of their difference of azimuth, we must ascertain that the elongation between sun and moon is not a constant, and depends on the relative values of Δh and ΔAz. Therefore, it does not seem that the fixed value of angle E can offer a good criterion of visibility. Of course, Hanover could not have known all these new elements and his idea was certainly original.

His language is very clear and precise, and, in this respect, it is much clearer than that of the ancient Jewish astronomers and the modern Jewish astronomers of his time. One point, however, is disturbing: like the Jewish rabbinical authors of that time, he did not pay attention to the gender of the words and cheerfully mixed masculine gender and feminine gender of a word, even in one sentence.

In any case, the present book allows the revival of the methods of calculation and the way of thinking of a great personality of the Jewish nation at the end of the old regime. He succeeded in receiving the respect not only of his fellow Jews, but also of his non-Jewish contemporaries, as indicated on his epitaph.

3. Third Book: תכונת השמים הארוך[18]: Mich 603

The manuscript includes 66 folios. The first 26 folios are devoted to an explanation of astronomy necessary to understand the treatise of *Hilkhot Kiddush ha-Hodesh*.

18 This is my denomination, in order to distinguish this book from the book edited in 1756 in Amsterdam.

This text is very similar to the printed book, and probably constitutes a parallel version of this book. It begins on page 1a and ends on page 26b. This first part was not reproduced in the present edition.

The second part of the manuscript is a complete commentary on Maimonides' *Hilkhot Kiddush ha-Hodesh*; it begins on page 27a and continues until page 49b.

A third part of the manuscript, from folio 50a until 55b, includes commentaries on selected passages from the Mishnah and the Talmud connected to astronomical or mathematical aspects.

A fourth part of the manuscript, from page 56a until the end of page 66b, is devoted to astronomical calculations, mainly examples of visibility calculations and a list of *moladot* of the different months of the years from 4108 until 4207.

The first part of the manuscript is identical or at least very similar to the printed edition of *Sefer Tekhunot ha-Shamayim*. This situation prevails until chapter 59. From chapter 60 onward, we find noticeable differences between the printed text and the manuscript. The comparison is made difficult because we observe in the manuscript a double numbering. An ancient numbering, very similar to that of the printed edition, was struck out and replaced by a new numbering. In the following table, we give an equivalence table between the ancient and the new numbering of the manuscript and the numbering of the printed book. It appears that the great majority of the chapters of the manuscript can be found in the printed book. The printed book includes, at the end, chapters that are not found in the manuscript. When we compare the same chapters in the printed and manuscript versions, we observe that the identity is not complete; words or expressions may differ but the content is the same. In the first part of the manuscript, we find reference to the date of Tishri 1729. However the redaction of the book extended over many decades.

The present manuscript is probably an autograph. This assumption is based on the following elements: re-numbering of chapters, texts erased, additional notes, reference marks, irregular and shaky writing, and additional remarks written many years after the main texts. These do not correspond to a text recopied by a pupil, like the other existing manuscripts.

Hanover had a rich vocabulary, biblical and Talmudic Hebrew, and Aramaic. However, one aspect of this manuscript is problematic—the grammar and syntax of Hanover's Hebrew. It was probably a failing common to the rabbinical authors of that time, but it is striking and disturbing. There is a systematic carelessness of the gender agreement of the substantives, adjectives, and related verbs. It is hard to believe, but we often come up against an almost systematic contradiction of the grammatical rules.

The reading of this manuscript brings us much information about Hanover's education. It appears that Hanover received a thorough Jewish education before becoming a mathematician. He certainly learned *Tanakh* and had a good and probably outstanding Talmudic knowledge. His general education was vast and erudite. Of course, he mentioned only those Talmudic treatises connected to the examined topic. However, on one occasion, when examining a passage in B. Shabbat, he discussed the significance of the word זוגיא, which means "even" and "pair" (a pair of), and he was able to enumerate five references.[19]

We note that Hanover was aware of and quoted recently edited books. He visited the library of the Gaon of Prague, R. David Oppenheim, housed in Hanover, quoted from the manuscript of R. Yom Tov Heller (Tosefot Yom Tov), and had access to a manuscript of *Hilkhot Kiddush ha-Hodesh* of the Rambam. He quoted also from a book that he found in what I assume was the Royal Library of Paris.[20]

Books mentioned in this manuscript:

* Bible and Scriptures (*Tanakh*) with commentaries of Rashi, Ibn Ezra, Ralbag and Abarbanel
* Mishnah with commentaries of R. Ovadia of Bertinoro and Tosefot Yom Tov
* B. Talmud with commentaries of Rashi, Tosefot and Ha-Maor ha-Katan on Rosh ha-Shanah
* Rambam with commentaries of ha-Rav ha-Magid, Kesef Mishneh, Lehem Mishneh and Hagahot Maimoniot, Hassagot ha-Rabad and Remah
* *Hilkhot Kiddush ha-Hodesh* with the additional commentaries of R. Ovadia the Mefaresh, R. Levi ben Haviv, Levush, Hagahot ha-Levush, R. Jonathan of Ruzani the Mehaber
* *Shulhan Arukh* with Magen Avraham
* *Sefer Elim* (1629)
* Hon Ashir on the Mishnah (1731)
* Hoshev Mahshavot (1732)
* Yosiphon (1529)
* *Mirkevet ha-Mishneh* (Frankfort on the Oder: 1751)
* *Seder Olam*
* *Netzah Israel* (1741)
* *Tzurat ha-Aretz* (1720)

19 I checked that these references are not mentioned in *Sefer ha-Arukh*.

20 Today, the National Library of Paris.

* *Likutei ha-Or* (Ha-Maor ha-Gadol ve ha-Katan) (1667)
* *Ateret Rosh* (1766)
* *Luhot ha-Ibbur* (1756)
* *Kuzari ha-Sheni* (1714)
* *Pnei Joshuah* Vol. 1 (1752)
* *Ta'avah le-Einayim* (1687)
* *Yessod Olam* (1777). Because of the late edition of this book it must be assumed that Hanover had access to another source, probably a manuscript from the library of R. David Oppenheim.
* *Yeshuah be-Israel* (1720)
* Manuscript of Tosefot Yom Tov on *Hilkhot Kiddush ha-Hodesh*

Some of these books had been edited only shortly before.

Personalities mentioned in the manuscript:

* R. Abraham of Basel (personality in correspondence with Hanover)
* ha-Torani Meir Metz (personality in correspondence with Hanover)
* R. Isaac Israeli
* R. Gedalia Eskeles
* R. Zerahia ha-Levi
* R. Emanuel Hay Ricci
* The Gaon of Prague (R. David Oppenheim)
* Mehorar Shimshon (a contemporary)
* Ha-Kalir
* R. Sa'adiah Gaon

The edition of the present manuscript, in its present imperfect condition, teaches us a lot about many of Hanover's original understandings and exegesis of Talmudic and Maimonides' quotations. Some of these Talmudic quotations are still incorrectly understood, and the solutions proposed by Hanover will certainly be welcomed. Many of his explanations are original and genuine and some of them, I think, reach the status of "the true understanding of the quotation."[21]

In our book, Hanover examines Talmudic texts related to astronomic or calendric problems. We note that his approach is on occasion "pilpulic;" this was likely the mark of his education and social circle. But most remarkable is his vivacity, originality and imagination, which allow him to propose new exegesis on different issues, different than Rashi and Tosafot, to complex classical problems. In certain

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cases, his exegesis could well be the definitive and absolute solution. The following Table of Contents gives an idea of the extent of the subjects treated.

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