

1. *Assignment*
 - a. Prepare for a wrap-up discussion.
2. *History vs. theory*
 - a. Someone asked about the advisability of organizing an expository paper historically vs. thematically.
 - b. Mathematics almost never develops from the ground up. Mathematicians work on a hard problem, inventing new methods. Those get applied to new areas, refined and generalized, and usually much later some core methods common to several applications crystallize into a new theory of the sort that is explained in monographs and taught in courses. Organizing a paper historically is often infeasible because clean exposition of the early methods requires refinements or generalizations developed only later.
 - c. A vivid example is the study of the groups of symmetries of crystal structures. Crystallography began in France, I think, during the mid-1800s. At that time some group-theoretic methods had been used here and there, but the general idea had not yet appeared. After some false starts, Fedorov was able around 1890 to classify the more than two hundred possible crystal structures. I don't recall to what extent he actually used sophisticated group theory, but it had begun to form a coherent subject by then. His work in Russia, difficult to read, was disseminated slowly. It was reformulated by Schoenflies in Germany about twenty years later, using group theory. Hilbert publicized the study in 1900, posing its generalization to higher dimensions as one of his famous list of problems. Bieberbach pursued that, and a rather hard train of research has followed his. With some detective work, I think, you can conclude that these mathematicians must have known about the seventeen plane and seven linear crystal groups: the wallpaper and frieze groups. But they didn't really describe those simpler cases. Not until the 1920s did their work percolate through Schoenflies and Hilbert to Speiser in Zürich, who influenced Pólya and Niggli there to write for the first time about the wallpaper and frieze groups. Speiser also included those as applications in his group theory text, the first one you'd recognize as organized like your algebra courses. Niggli's niece Edith Müller later pioneered the study of symmetry groups in architectural ornamentation with her 1940s work on the Alhambra in Granada. A modern presentation of this area of mathematics, for example Smith 2000, chapter 8, proceeds in exactly the opposite of the historical order. Any coherent description of the first results on crystals would have to use elementary group theory to provide organization.
3. *Digging for sources*
 - a. We discussed how to locate biographical information, using as an example Trisha Sanford's recent search for information about Ernst Steinitz. The techniques reported here are applicable to other searches as well.

- b. It's easy to use Google to determine his dates and nationality: 1871–1928, German.
- c. Through mathematical sources Trisha had uncovered the published origin of Steinitz' theorem on polytopes, which was her main interest: a German book published in 1934, edited by Hans Rademacher. Our library has it, or else she got it through interlibrary loan. In the preface, Rademacher explained that among the papers Steinitz left after his death (his *Nachlass*) were several notebooks of manuscript for that book. Rademacher edited and published it, providing a detailed account of that process in the preface, as well as a brief biography. I translated the preface for Trisha. The biography was unsatisfyingly brief, and Trisha wanted to know more.
- d. Google led to various websites, all rather meager sources of biographical information, probably just derived from Rademacher's preface. One of those led to the *Dictionary of Scientific Biography*, which is available in our library. Ordinarily that source is tops, with signed articles by researchers familiar with both the culture and the research of the subject. But this article was meager. I thought perhaps its author might have written more elsewhere, but couldn't find anything, and noticed that he had died some decades ago.
- e. Most notable mathematicians are memorialized in obituary articles in the major research journals. Search for those by entering a name such as "Ernst Steinitz" in the title window of a search engine. *MathSciNet* won't provide much about earlier mathematicians, because it only started in 1940, as *Mathematical Reviews*, and doesn't emphasize the social aspects of mathematics. The place to search is the "*Jahrbuch* database," which you can find by googling that phrase. It's the complete digitized version of the *Jahrbuch über die Fortschritte der Mathematik* (Yearbook on Advances in Mathematics), the most important mathematical review journal before *Mathematical Reviews*. It started around 1880.
- f. Nothing at all appeared there. The reason is probably that Steinitz was Jewish, and extreme antisemitism had begun by 1928 to determine what was published in Germany. (It wasn't obvious at the onset of our search that Steinitz was Jewish, but the original googling did reveal that.)
- g. In contrast, *MathSciNet* does lead to information about Van der Waerden; and the *Jahrbuch*, to information about Sylvester. Both of those mathematicians held our interest recently. The *Jahrbuch* is mostly written in German, but the titles of English-language articles remain in English, and you can follow the leads to the articles themselves.
- h. I thought that perhaps Jewish biographical dictionaries might be helpful for Steinitz, but haven't found anything that way yet. For more recent subjects, particularly in the US, reference librarians might show you how to search for obituaries in newspapers and magazines. But that is not feasible to do here and now for a death in 1928 in Germany.
- i. Trisha looked further through the Google reports. She found several red herrings: links to other Steinitz families (including one here in San Fran-

- cisco). But one turned out to be right. A report about Ernst Steinitz is posted on a Steinitz family website by a distant relative of his in Israel.
- j. Simultaneously, I sent an inquiry to two Internet discussion groups on history of mathematics: *Philomathes* and *HOMSIGMAA*. Prof. J. Malkevich responded from New York with a link to that same family website. Through another such lead we found a suggestion of recent biographical work on Steinitz by a German professor H. Gropp. Since Gropp didn't seem to favor English communication, I emailed him in German, asking if more information was available. He sent me a draft of his paper.
 - k. The Steinitz family website included a link to its webmaster, a psychotherapist in Berlin. Trisha sent a similar request to him, and he led her to another professor K. Johnsen, in Kiel, where Steinitz taught last. Johnsen sent her a paper about Steinitz that he had published recently in the Kieler equivalent of the SFSU public relations magazine.
 - l. Both Gropp and Johnsen referred to a Kieler *Staatsexamensarbeit* written about 1960: a paper whose purpose and extent was very like Trisha's project. Indeed, it is listed in the Kiel University Library's online catalog, but our interlibrary loan was unable to request it. Gropp and Johnsen indicated that its author had reported speaking with some relatives of Steinitz. I tried to find that author with an Internet search, but failed.
 - m. Trisha and I sat together about 4–5 hours while I translated those two papers orally into a tape recorder, explaining German academic social organization as I went along. The papers did provide some good biographical information, but only a little about Steinitz' personal life. His widow was murdered by the Nazis, but his son escaped to Israel, and a brother, to Russia and Sweden. Johnsen reported that he had thoroughly searched all possible German sources for Steinitz' *Nachlass*, which Rademacher had used, and found it nowhere. Evidently it was destroyed during the Allied bombing of Kiel in the early 1940s. Perhaps the larger Steinitz family had not been close, and the survivors so preoccupied with post-War affairs that they had lost track of their notable relative. It seems unlikely that any more information will surface about him.
 - n. A remote possibility is investigation of others' *Nachlässe*. Scholars' correspondence is sometimes preserved long after their deaths, and later investigators may find letters from Prof. A to Prof. B that happen to mention Steinitz. That's one reason why we have meetings: to air serendipitous discoveries!