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# A conversation with Elja Arjas (Helsinki, November 2021 and March 2022)

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**Abstract**

Statistics as an independent scientific discipline is relatively young in Finland. Its active history stretches back roughly a century, with the past 50 years signifying a period of growth. Few other academics such as Elja Arjas, now professor emeritus at University of Helsinki, have played a prominent role in establishing statistics in Finland. This conversation tries to illuminate how this came to happen and what was needed to push statistics as a discipline to a firmer ground. We do not have a looking glass at our disposal but will nevertheless also try make some predictions about the future.

**KEYWORDS**

history of statistics, finland

Jukka: Elja (Figure 1), when you look back, what is the most dramatic change that has happened over these 50–60 years in the Finnish academia?

Elja: The most dramatic development, no doubt, was the significant expansion of higher education in the post-war Finland. It involved both secondary and university levels. Many new schools were built, also in small towns and the countryside, and new universities were established in addition to those that already existed in the south of the country, in Helsinki and Turku.

A flood of new students entering the universities had the effect that also many new academic teaching positions had to be created and would thereby in principle be available for ambitious younger people to apply for. Compared to today's situation, the requirements for an academic appointment, in terms of research input, were quite modest. To land on a permanent job, one would usually need to have a PhD, but often not very much more. Even so, filling such positions was a nontrivial matter, particularly in disciplines in which academic tradition in the country was

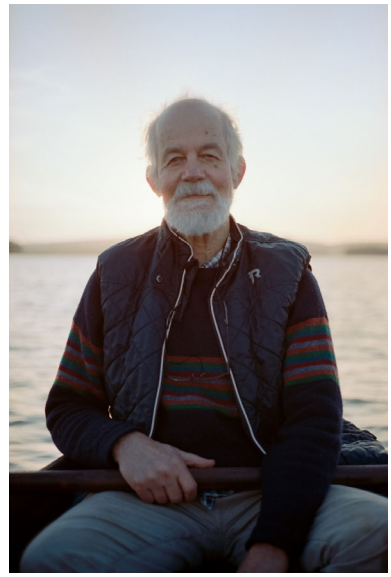

**FIGURE 1** Elja, helmsman of a small boat [Colour figure can be viewed at wileyonlinelibrary.com]

thin, as in statistics, or entirely missing, as in computer science. Moreover, the role of professors was quite different in the 1960s, and young aspiring students did not get supervision in the same way as they do today. Consequently, the number of new PhD's was small. To illustrate this, their names, along with the thesis title, were regularly published in the main newspapers.

Jukka: That is quite incredible, it is probably a world as alien for today's generation of scientists as the analog world of the past is for our children who grew up in a digital world. They are flabbergasted about the need to go to a rental shop to get a video tape so that you could watch a movie of your own choice, and the many other aspects of the analog world which look so incomprehensible and cumbersome today. For me personally, who enjoyed your mentorship after having done PhD in Sweden and moving to Finland, it feels that having front figures and mentors is the essential ingredient which makes scientific progress possible in the first place. However, I would like you to tell a bit more about your past, how you became to be interested in a life within the academia?

Elja: I was born on February 9, 1943, in Tampere, an industrial town nicknamed "Manse," for "Manchester of Finland." World War II was still raging, but of course I have no memory from the wartime itself. I was the middle brother of three boys in our family. I started school in the autumn of 1949, in an era of rebuilding and hope for a better future, where education played a central role in reforming our predominantly agrarian country. I completed my matriculation exam in the spring of 1961, achieving the top grade Laudatur in mathematics, despite that I did not consider myself to particularly shine in that subject. My father had a college degree in engineering, and my elder brother Antti went to study paper technology at the Helsinki University of Technology (TKK, which later became Aalto University). Initially I thought to follow in their footsteps as well, although I could not truly imagine myself as an engineer.

Jukka: Interesting, it seems you needed some time to find out where your true interests would lie.

Elja: For sure. After having debated with myself about possible alternatives, I finally decided to start studying mathematics at the University of Helsinki, but not having a very clear idea about where this would finally lead me. My uncle Ilmo Hela, who was Director of the Finnish Institute of Marine Research, had encouraged me already while I was in school to once become

a scientist. Following him and combining mathematics with geophysics seemed at first an interesting alternative.

Jukka: What topic within mathematics piqued your interest the most and why?

Elja: The most exciting topic of my mathematics studies turned out to be probability theory. It was lectured in a course by Professor Gustav Elfving. Incidentally, as the occupant of the of the "Swedish Chair of Mathematics," he gave all his lectures in Swedish.[1]

However, after getting a master's degree, in 1965, I felt that I had a problem in how to continue. There was no active research group in the Mathematics Department in probability that I could have joined, and no one to suggest a possible topic for a PhD thesis in that field. So, instead of pursuing on to graduate studies, I went to the TKK Mathematics Department, working there in the position of "laboratory engineer." (I had also received a job offer from the newly established Computer Lab of Nokia Electronics. I have sometimes wondered where the choice of this counterfactual alternative would have led me in later life.)

My work at TKK involved mainly administrative duties, and therefore wasn't really what I had been hoping for. All this time I was trying to find a suitable research topic on which I could start. In order to prepare, I read on my own books like the long-awaited Volume 2 of William Feller's monograph (Feller, 1966), and journal papers that I could find in the library. This search for a suitable research topic continued until I was able to head abroad in 1970.

Jukka: How did you arrive at the idea of going abroad to do research for a PhD?

Elja: As I recall, this idea was suggested to me by both Elfving and Professor Olli Lokki, my boss at the TKK Mathematics Department. I wrote a letter to Professor Joseph Gani, asking whether he would be willing to have me as a visitor in his Department of Probability and Statistics at Sheffield University, a hotspot of Applied Probability at the time. The Department was a creation of Gani, who was also the founding Editor of the profiling Applied Probability journals. Elfving and Gani knew each other from the time of their concurrent visit to the Stanford University Statistics Department. My letter addressed to Gani in Sheffield had been forwarded to him to America. He replied immediately, and in a hand-written letter "warmly welcomed any student of Gustav Elfving."

Jukka: How did your visit to Sheffield unfold?

Elja: The beginning, in November, wasn't that easy. The small attic apartment I rented had some resemblance, I should think, to Rodolfo's place in a classic *La Bohème* scene. Snow on the skylight started to melt if you fed enough coins to the gas burner in one corner. Fortunately, by Christmas, I found much better accommodations, then sharing an apartment with Lauri Saretsalo, another Finn working toward a similar goal as I.

More importantly, however, the research environment in Sheffield turned out to be just as lively, active and welcoming as I had dreamed it might be. We had weekly seminars, often given by international guest speakers and, in addition, the department gave us train tickets to travel to Manchester or London to listen and take part in more. There were many people approximately of the same age as I, quite a few from Australia and India, who were already past their PhD and working as lecturers or in temporary visiting positions. The crucial thing, from my perspective, was that I saw what it was like to do research, as an academic, on a full-time basis. This was a transformative experience for me who had not seen anything like it before.

Jukka: What turned out to be the pivotal idea that turned your Sheffield visit into a real mathematical research expedition?

Elja: Soon I figured out that some key ideas in Feller's book, on random walks, could be extended in rather simple ways to the situation in which the increments of the walk would be conditionally independent, given the states of an "underlying" Markov chain. So, I drafted by hand,

on a foolscap pad, a provisional manuscript along such lines and gave it to Gani. He returned it to me after a couple of days, having read it in train on his way to Manchester, and said "This is good stuff, go ahead."

That was really all I needed. During the winter in Sheffield, I wrote three manuscripts, and submitted the first two to the Applied Probability journals. A fair assessment of these papers is that their level of originality was modest at best. But then again, PhD should be viewed as a journeyman's first credentials, not as life's achievement, in contrast with the common view prevailing in the Finnish academia back then.

Jukka: Did you have an actual supervisor for your PhD thesis?

Elja: While there wasn't anyone in Sheffield who would have been an actual supervisor of my thesis, Gani obviously had an important supportive role. Even more important, in retrospect, were some of the contacts that were established during this time. Of particular significance was getting to know Terry Speed, with whom I wrote five joint papers during the next subsequent years. I returned to Sheffield a few times later, always enjoying the hospitality of Terry and Sally in their home. A short account of this period is contained in Arjas (2012).

Jukka: When you look back at the applied probability research from that era, is there anything that strikes a difference to the contemporary research within the field?

Elja: Perhaps the most essential difference is that data were not brought along to the models in those days. Today data occupy a more central role in modeling of phenomena involving randomness. This provides an important source of inspiration and, of course, a big challenge too.

Jukka: Can you tell a bit about how your academic life evolved after PhD?

Elja: With the three published articles born out of the Sheffield visit, combined with a summary, I finally defended my doctoral thesis in April 1972. Then I spent a year as a post-doc at C.O.R. E. in Leuven, Belgium. On returning to Helsinki, I was teaching, in the role of an acting associate professor, courses in matrix calculus and probability at the Mathematics Department in Helsinki.

A pivotal point, in 1975, was the appointment to a new Chair in Applied Mathematics and Statistics at University of Oulu. This nudged me onto the process of progressively transforming myself from a mathematician to a statistician, which nevertheless took many years. Some memories from the first years in Oulu are encountered in Arjas (2015). During this time, I kept the habit of commuting between my new base in Oulu and the old one in Helsinki, running in the latter a biweekly probability seminar.

A development that turned out to play an important role for the future of probability research in Finland was Richard Tweedie accepting in 1976 an invitation to act as the official examiner for Esa Nummelin's PhD thesis "*On the α-properties and quasi-stationary distributions of semi-Markov processes*". We got lucky as Richard agreed to stay around for a bit longer, lecturing in a summer school we had arranged near Helsinki—as I recall—a total of 20 h within a week, telling an eager audience about his latest research.

This was followed by days of intensive research collaboration later during that same summer, in a cottage I had rented near Oulu, where Esa, Pekka Tuominen, and I were taking turns in working with Richard. This intensive "research kitchen" experience led to several joint articles between us and Richard. Perhaps, one might say, a culmination of the work that was started then was Esa's paper (Nummelin, 1978), proving a central ergodicity result of general state space Markov chains, by employing the so-called splitting technique. Little could we foresee that such a result would become, a decade later, one of the corner stones for justifying the use of Monte Carlo estimates in MCMC when applied for Bayesian computations.

**FIGURE 2** Summer school 1976, Elja with Richard Tweedie while visiting *Ainola*, Jean Sibelius' home museum (left); Esa Nummelin being offered some refreshment during Tweedie's lecture (right) (*Source*: Erkki Mikkola).

The importance of Richard's visit was more profound in the sense that our hectic summer activity sparked off the series The Finnish Summer School on Probability and Statistics. The following year, in 1977, there were two guest speakers, Jim Pitman and Cindy Greenwood. (*Some pictures from 1976 and 1977, taken by Erkki Mikkola, are shown herewith* Figures 2 and 3.) For my own later work the most important influences from these early Summer Schools came from the lectures, by Pierre Brémaud (1978) and Jean Jacod (1980), on the martingale approach to point processes.

This tradition of Summer Schools continues after 45 years of its initiation and is now carried on by Dario Gasbarra. They have been a forum for young Finnish probabilists and statisticians to hear about the latest developments in their fields directly from the leading characters across the world. This serves as an example of the importance of personal scientific networks for building scholarly activity, which enables aspiring young scientists to get inspiration and training by international experts even in a research environment lacking the rich tradition and resources of the top universities.

Jukka: What aspect of academic life was the most fun part?

Elja: Here the answer is obvious: It was the opportunity to work with many talented young graduate students, then acting in the roles of teacher, co-author and mentor. In many cases, the fact that my students worked with research problems rooted in applied sciences across different disciplines gave them the opportunity to assume, later in their careers, expert roles within these same disciplines. For me, it gave opportunities to learn something from different fields of study, such as genetics, infectious disease epidemiology, fisheries research, or insurance, in which I had no previous knowledge. And the influence does not end there. As is appropriate for an 80-year-old, my academic pedigree now has some members three generations down. This is a source of pure delight!

Jukka: What else can a good supervisor do?

Elja: An important aspect is the ability to develop skills for looking at a scientific problem from different angles and choosing the one that appears most fruitful for finding a working solution.

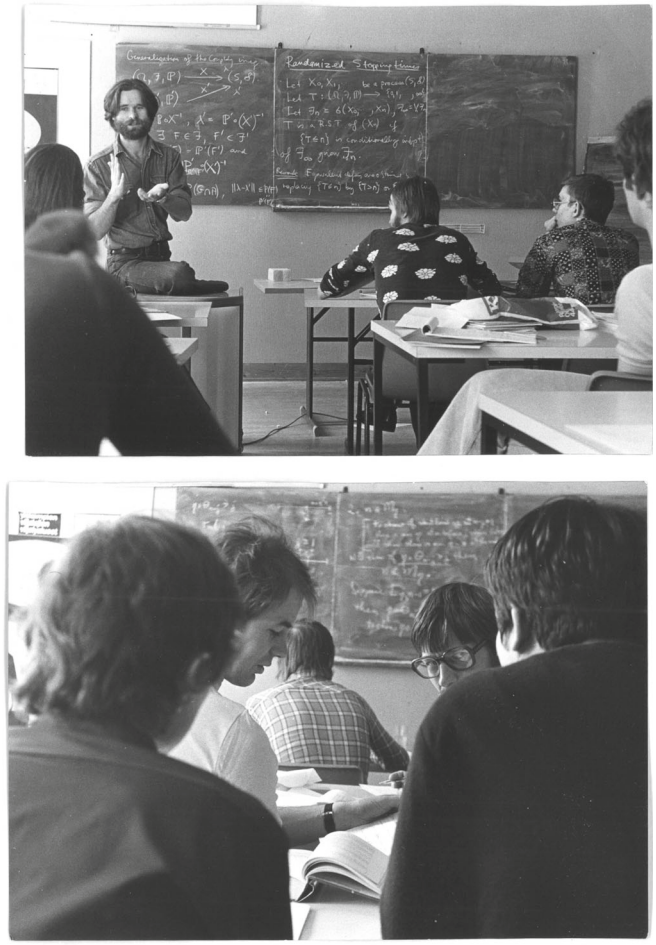


**FIGURE 3** Summer school 1977, Jim Pitman explaining the idea of randomized stopping times, with Seppo Niemi and Pentti Haara in the front row (top); Elja discussing the contents of the lectures with Pekka Tuominen (bottom) (*Source*: Erkki Mikkola).

This applies to teaching as well, since by presenting multiple views on statistics instead of a dogmatic approach with one and only one truth, one helps the students from being trapped in a single narrow perspective.

A good example is how we teach the basic principles of probability and statistical modeling, where most often the starting point is an assumption of independently and identically distributed (i.i.d) random variables following some distribution, whose mathematical form, as it were, descends on us from heaven. Often an intuitive alternative would be to formulate the phenomenon using a dynamic model, such that the observations are viewed as forming a realization of a stochastic process.

Jukka: I definitely agree here!

Jukka: I remember that the "Nordic dimension" has been an integral part of your research life.

Elja: Very much so. And, in that, the *Scandinavian Journal of Statistics* (*SJS*) has played an important role. In many ways, I have thought of *SJS* as "our statistics journal". I served as *SJS* Editor for the years 1991–1994.

My impression is that an important motivation for starting a new journal, in 1974, was a general feeling that the research that was done in statistics in Scandinavia at the time was not rightly appreciated in the predominantly Anglo-American world of scientific publishing. As an indication of such views, on the second cover page of *SJS* there was the text: "The Scandinavian Journal of Statistics is an international journal, which supports research in the Nordic countries but welcomes contributions from all countries.". As Editor, I removed the "support" part from this sentence because I felt that it might give an impression, however unjustified, of preferential treatment in reviewing submissions from the Nordic countries. For this same reason, I discontinued the practice of including, at the end of each issue, a special section called "Brief information on current unpublished research in Scandinavia" (Arjas, 1992). Here, "unpublished" meant de facto "not peer reviewed". Concurrent with this, the publisher of *SJS* was changed from Stockholm-based Almqvist and Wiksell into Blackwell, as we thought that the journal would thereby gain additional visibility internationally.

Returning to the "Nordic dimension," in the 1980s and 1990s I enjoyed frequent communication, for example, with Per Kragh Andersen, Ørnulf Borgan, Richard Gill and Niels Keiding, whose seminal book (Andersen et al., 1993) has been called "the Bible of survival analysis." Even after my retirement, the Nordic dimension has continued to play an important role for me. In 2013–2019 I worked part-time at the Department of Biostatistics at the University of Oslo.

Jukka: How did you become a Bayesian statistician?

Elja: It is a long story … It did not happen overnight, of course. It wasn't a sudden revelation, suddenly "seeing the light," as some people might say, more likely with some scorn.

One thing was that I had a probability background, so I was accustomed to thinking in terms of probabilities and had reasonable mathematical fluency to deal with them. But there had never been, not even when I was working in the applied probability domain, any real question in my mind of where such probabilities would come from, and even less on their ontology. It was obvious that the classical probability concept, as presented in introductory books and based on symmetry, would not be sufficient for most serious applications. However, I suppose that, at least implicitly, people like myself were relying on the Popperian idea of physical propensity, which would then manifest itself in stable relative frequencies in repeated experiments under similar circumstances if such were performed. Like many others, I had been accustomed to start a paper with the phrase "Let $(\Omega, \mathscr{F}, \mathrm{P})$ be a probability space…," without paying any attention to how $p$ should be interpreted. It was thought to be enough, for a mathematician, that $p$ would obey the Kolmogorov axioms. Even numerical evaluation of probabilities was not of interest.

I believe that an important reason for why I stated to think in Bayesian terms came from the work in reliability with Ilkka Norros. There, it was natural to think that the faults in a system (machine, device, …), such as failures of its components, were not necessarily observed immediately at the time they occurred. Instead, a system failure would be observed when some critical configuration of components had failed. Another possibility would be that component failures would be found in a technical inspection when the functioning of the system had been stopped for pre-planned maintenance. In both types of situations, one can distinguish between two layers of development, an underlying component level process that may not be observed directly, and another, being in some way dependent on this underlying process, consisting of observed measurements and thereby giving rise to empirical data. This comes close to the idea employed in Hidden Markov Models. The natural question to ask is then an inverse one: "What can I say about the underlying process, given the data I now have?" Also: "How do these probabilities change when more data, in the form of new observations, become available?"

Jukka: What was the crucial insight that led to the Bayesian mindset in this context?

Elja: Motivated by the reliability problems, Ilkka Norros, Pentti Haara and I, in Arjas et al. (1992), were led to considering dynamic problem formulations, where both the underlying variables and the data were considered over time and were then modeled in terms of corresponding marked point processes. In the consequent filtering formulas that we got, probabilities concerning the latent process would be updated by applying Bayes' formula as more data were observed.

The crucial thing here was that all these probabilities would be conditional, depend on data. They would not be viewed as entities with an objective existence in the physical world but, rather, as epistemic degrees of belief in the truth of a statement made about the underlying state of the system at the considered time, given the available evidence. Many years later, in Arjas (2016), I came back to this topic in a commentary.

With this insight, also words such as *random* got a new meaning: it was not important, ultimately, that the value of a quantity varied in some way, supposedly over time; important was whether its value would be known or not. With this understanding, the characterization "fixed but unknown" given in many statistics textbooks for the model parameters then immediately implied that, in these semantics, they are random variables.

Jukka: What do you consider as the pivotal piece of knowledge that was still lacking in those days?

Elja: Perhaps the most important single event on my path toward becoming "a practicing Bayesian" was when I learned, in a lecture by Amy Racine-Poon, about the possibility of applying Markov chain Monte Carlo (MCMC) for performing numerical computations for Bayesian inference. I had thought that, in a context such as the above filtering problems, numerical computations could be done only by discretizing the time parameter and then applying Bayes' formula stepwise, in a recursive fashion. Therefore, it was a big relief to learn that MCMC could be applied "in one go" for all data. The methods would still be algorithmic and approximate, but sampling would in the standard case be in the parameter space, not in the original sample space. In my own work, the word "Bayesian" appeared for the first time in the title of a paper in Arjas and Gasbarra (1994), where we tried out possibilities of using a Gibbs sampler in the context of a nonparametric hazard model for survival data.

With this, I felt that I had found a better understanding on how to work as a statistician. In addition, in 1992, I was fortunate to get an appointment to a 5-year research position, with the title of Academy Professor, funded by the Academy of Finland, which enabled me to concentrate on research on a full-time basis. This new arrangement not only involved more opportunities for supporting graduate students but made me independent of geographical coordinates. Thus, in 1995 and after 20 years in Oulu, I moved to Helsinki.

Jukka: Can you tell more about what the methods like MCMC allowed you to do in terms of statistical modeling?

Elja: Let me start by moving quite far back in time. In my first job at TKK, in the late 1960s, I had done some computer programming, in an era when ticker tape and punch cards were the tools of choice. Working with them and the clumsy mainframe computer interface lacking interactivity was extremely frustrating. You would learn about errors in the code only after submitting the work to a queue maintained by the computing center operators and then waiting for the results to appear in a day or two. The arrival of PCs and better programming languages in a sense liberated us statisticians from the early 1990s onward. Later, when open-source software, such as R, and sharing of code packages became a commonplace, the next generation of scientists could truly stand on the shoulders of earlier scientists and continue the development of new methods at an increasing pace. (With some regret, at hindsight, I need to say that over the years I lost the ability

to keep up with such developments myself, in the form of actual coding. My excuse for this has been that all my graduate students have been true computer wizards, and a closer involvement in coding would most likely only have slowed them down in what they knew so much better.)

But, to answer your question, a good example of applying MCMC to solve modeling problems was the work I did with Kari Auranen on models of transmission and immunological characteristics of bacterial pathogens (Auranen et al., 1999, 2000). In such applications it is typical to have unobserved variables whose values evolve over time in a manner that is amenable to dynamic modeling, aided by epidemiological understanding, about latent carriage and infectious disease. Here Bayesian thinking and MCMC as the inference tool are natural choices, since there is a need to augment the observed process with a latent process and use sampling to marginalize over the system variables that are not of primary interest. Should one use only, for example, an optimization approach, this would lead to overly confident statements about the parameters of interest.

Jukka: Can you share some of your thoughts about the future of statistics?

Elja: This is a tough one! And, honestly, I don't think it is a good idea to put much weight on predictions made by an octogenarian pensioner. But here is something …

In 2010, at the 23rd NordStat Conference that was held in Voss, Norway, I was invited to give a special "SJS Lecture," the first one in that series, on a topic of my own choice. Given such a wonderful opportunity, I chose the title "On future directions in statistical methodologies - some speculations". A paper (Arjas, 2011) with that same title appeared in *SJS* the following year.

Although I did not believe in the prediction that was made long ago by de Finetti and Lindley, that the statistical world would be Bayesian in 2020—now, by hindsight, a counterfactual event—I do believe that the Bayesian ideas are becoming more and more widely accepted in the future. This does not mean that statisticians and practitioners who have spent their professional life relying on frequentist methods would make a U-turn. Instead, and more realistically, statistical data analyses are increasingly made by people from various backgrounds, with an open mind and without inherited methodological prejudices. They will simply take advantage of the far greater flexibility in formulating (often, hierarchical) Bayesian models, and the consequent improved realism in the description of the studied phenomena they provide.

A particular area, though, where I have had some interest recently (Arjas & Gasbarra, 2022) and where I would very much hope to see a radical change is the design and analysis of clinical trials, which are currently still dominated by rules based on a fixed $\alpha$-level to bound the error rate of false positives under a hypothesized null. This becomes very clumsy in trials for comparing multiple treatments in the same trial, and even more so when considering dynamic treatment regimes with the aim of finding successful individualized treatment strategies. A clinical trial is a decision problem where the way in which the data will be analyzed needs to be specified in advance, as part of the design. Consistent with the conditionality principle, Bayesian decision rules based on posterior probabilities, and optimally also involving a prespecified utility function, would then appear to offer the natural means for rational decision-making. And, if I may say so, not only then but always.

Jukka: Thank you Elja and happy 80th birthday!

Supporting information. Additional information for this article is available online including the following two articles: "Arjas, E. (2012): Probability." and "Arjas, E. (2015): When we were very young: Some recollections from Hannu Oja's first years of academic life."

## ENDNOTE

[1] Finland is officially bilingual, with approximately 5% of its current population registered with Swedish as their mother tongue. For example, at the University of Helsinki several curricula can be studied with lectures held in Swedish. Throughout the history of Finland, language issues have had a prominent role in creating the national and cultural identity of the country. This holds true also for Elja's family background.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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