

CHAPTER 3

THE RELUCTANT WRITERS

No, I don't enjoy writing. I would prefer to just upload the results, upload spreadsheets to come cloud somewhere and that's it; I can get onto the next project. I don't think of the projects I'm doing in terms of paragraphs . . . so having to translate a project into words like this . . . I would prefer not to have to do that.

— Emerging scientist, Cognitive Psychology

Many of the participants in this study revealed positive attitudes about writing (see Chapter 7). There were, however, some scientists—just over 11% of the total sample—many of whom were successful writers, who disliked writing, or who saw writing as largely irrelevant to their science. Two things were striking about this group of reluctant writers. First, they were far more likely to fit Holyoak's definition of the routine expert, writing for a narrow range of journals and peers, and not venturing into more diverse genres. And secondly, most had found a way of compensating for their weaknesses as writers, the most common of which was relying on co-authors.

One participant, a senior scientist in the medical sciences, described her problem as being a perfectionism that made drafting a challenge:

I'm a very good writer. I hate it. I hate it. Well, really, I'm a very good editor and a lousy writer. I have this terrible problem with the tyranny of the blank page. You know, I sit down and look blankly at it. I find it difficult to get started. Which is why I'm a much better editor. Somebody else has started it. There's something there to work on. It's the getting started that I find difficult.

I think the reason I don't like it and prefer somebody else to get started is that because I like it to be right—I'm a bit of a perfectionist. If I'm writing from scratch myself, I waste a lot of time getting it word perfect; just getting it down and going back and editing it. I'm a slow primary writer. I edit my own work as I'm writing. (Senior Scientist, Neonatology)

Her primary solution was to always work with graduate students or post-docs—once she had a draft, she was confident in her role. But she had also

developed a range of approaches to kick-start her writing and bypass her perfectionism, including dictating her work or a technique that she called “the three-hour exam” where she forced herself to prepare for and then write to a goal for an extended, but defined, period.

Those who disliked writing—as opposed to those who simply struggled as writers—tended to demonstrate different beliefs about writing compared with those who actively enjoyed writing. They were more likely to ascribe a narrow function to written language, to see figures and equations as intrinsically more complex and more nuanced than words, to place less emphasis on audience and story, and to define a narrow role for themselves as scientists. They tended to be inward rather than outwardly focused, defining a narrow community with which to engage, which in some instances seemed almost to become invisible during the writing process. “I write for myself, because I am writing for people exactly like me” (Emerging Scientist, Chemistry).

I have included one short and three extended narratives in this chapter which illustrate the range of the attitudes and beliefs of those participants in this study who disliked or struggled with writing. The first is Wendy, a doctoral student who loves to write, has experienced joy and confidence in writing but is struggling to come to terms with unexpected, immobilising criticism. Next, Jane attributes her problems as a writer to her inability to find a writing/research community. Her story of extensive isolation was relatively unusual amongst the people I interviewed (only three interviewees discussed this problem: all were women and all were emerging scientists), and I include it as a comparison to the many other voices in this book that focus so strongly on community. The third narrative tells the story of a highly successful mathematician who revealed a striking struggle to write but who, with a wide range of support from parents, teachers, advisors and co-authors, has become, not the plumber he might have been, but a highly regarded writer in his field. The final narrative comes from a scientist who sees writing as tangential, if not irrelevant, to science. My interaction with him might be described as a clash of ideologies, but he certainly voices an emphatic perspective.

WENDY

Wendy is a mature doctoral student working in an area of women’s health. When I interview her, she’s in the second year of her research, and she’s struggling. She faces numerous obstacles: a lack of funding, no research team around her, and—most problematic of all—an advisor who she perceives to be erratic and volatile. I interviewed her over two sessions—we stopped the first session because she was so distressed about her situation that I switched off the recorder.

What puzzles her most is the critique of her writing: she was a confident writer through school and through her undergraduate and first post graduate degree. She has had a successful career that required her to write about women's health for public audiences—and she's passionate about communicating her work. In this short section of her narrative she links her problems with writing to her philosophy of life. Since this interview she has found a new advisor and successfully defended her dissertation.

MOST OF SCIENCE IS ABOUT PEOPLE

I always think you have to communicate well if you have gone to the trouble of actually doing something. You've got to be able to present that information well for whichever audience it is. So if you are writing for a journal it's presenting it one way, but importantly for me, because I am quite a people person, I like to see that it's translated into readable information for the people it concerns. And most of science is about people.

One of the ladies in my research actually said that me that she had been asked, because she had a particular health condition, all through her life by several major hospitals to participate in research and she never wanted to. She said "I've always hidden, because I think people get used." But for some reason she connected with me, and she said to me at the end that she really enjoyed being part of the study, and she had an understanding that I would take responsibility for communicating the results in a readable or understandable way for lay people. So I took that as quite a challenge and I understood the responsibility involved in that. I think that's important.

Until last year I may have thought that I was a reasonably good writer. I now think, as a result of what my advisor is telling me, that possibly I am a very poor writer. I'm not sure whether I am misreading or it's my advisor's attitude, but really there's not a huge variation in what I see other people have written and what I see I have written myself. And then what comes back to me, what's fed back to me by my advisor, is that my writing is not good. I can't quite see it because she is saying general terms like, "you have got to learn to critically evaluate." I understand what critical evaluation is and I think I am doing it, but obviously not to the level she wants. And I don't understand how I can see this in somebody else's writing but not in my own. So I have been reading other theses and, while I can see some very well-written ones, I have still got that gap in my own area, so I am thinking I might go and find some help. The worst part of missing something is not knowing what you are missing. If you knew what you were missing, you could aim for a target. This is my biggest hurdle as a writer of science: I can't really get much past my advisor.

When I was at school I always knew I was a reasonable writer. My English teacher loved everything I submitted and that gave me a lot of confidence. It was mainly critical analysis of literature and I really enjoyed it. I remember the feeling of writing and being absolutely emptied out after sitting, perhaps on a Sunday afternoon, writing the assignment and getting so involved in it and how to write it well, and that feeling of being absolutely emptied—it was so wonderful. I was drained physically and probably emotionally, but I had a wonderful feeling of lightness. And I'd submit it and it would come back invariably with A+, and so I did get the English award at the end of the final year, and I have recalled this over these past 18 months when I felt that my writing has come under such close scrutiny. You think, "well, I don't know. I used to write well." I've never had the criticism I've generated in the last 18 months for my writing.

Writing's a process for me, and I just rewrite and rewrite and rewrite. And that's probably got me a little bit into trouble with my lit review because I write a draft that would be where I'm at, and I would be expecting to rewrite it and rewrite it and rewrite it like a series of layers unfolding. This is how I view life; I see life as an unlayering. A peeling back until you get to the essence of something. It's not "oh, I'm this person now, I want to be that person—so I'll do this this and this to get to that point." I don't see life like that. And perhaps that's been unfortunate with science because you are meant to have, according to my advisor, this body of work that's very clear and coherent and explains exactly what you intend to do at the beginning before you go in and do it. And she's probably right in that regard. But I would have written the lit review and thought "oh yes, I'll change that and I'll change that and I'll change that." So that is how I tend to write and think and then change and think. It's great having the computer so you can do that.

Possibly it's a good seven or eight year process to get to grips with scientific writing. I mean I did write science when I did my undergraduate degree, and then I did a post-graduate diploma, and we had a short dissertation to do, and I wrote then and I didn't appear to have any problem with that. When I did my master's I didn't have too much issue with the thesis I wrote but, yes, that all seems to have come a cropper at this level.

In terms of style, there seem to be variations which I am still getting my head around. Like I was reading in somebody's paper, and I have seen it in some theses, about when you have animals that you are using for experiments and they have to be killed. We used to say "the animals were killed," and now they are saying "the animals are being sacrificed." I thought when I first read it that must be the correct term, but I recently read a book which a colleague lent me when she and I were talking about the difficulty with writing, and in this book the author mentioned this word "sacrifice" and he said "they were killed—let's

stop getting pretentious about this.” It’s quite a religious connotation, and when I first read it I had the feeling they were sacrificed like they were on a pyre, and there was incense and a fire going—but no!

And it’s almost like you come up with new words to give more impact. There’s always something new coming out and you’ve got to keep yourself abreast of it, but whether it’s any better or worse than what’s been written before . . . ? I prefer something that’s fairly clean and not too wordy. And I like the statistics to be readable and I am very good at picking up other people’s mistakes in a paper, grammar mistakes or a word missing. Just a typo error always jumps out at me. But apart from that I don’t think I could say very much more about scientific style because my confidence isn’t really great with writing. I feel that I am probably not the best person to be talking about that.

I wrote from the earliest age. I can remember that I could write before I went to school and I used to love writing on projects at elementary school. I think, for all the Catholic schooling that you could disagree with, the one thing those nuns did well was they gave us an exceptional grasp of basic English grammar. And in fact, one of my friends in Australia is also writing a Ph.D. at the moment, she’s a sociologist, and she said something similar when I spoke to her end of last year. You were very conscious that you were taught to write well and it was very disciplined. There was always lots of writing.

For my diploma we had a health communication course, and I think for the other courses I averaged an A- or B+, but that one we all got Cs or B-minuses. We had to write essays about communicating health messages and none of us actually knew what we were to write. The first one we did we had someone teaching the distance course who didn’t communicate to us what was required at that level, or what he was after. We all wrote essays virtually off the top of our head—very creative essays about what we thought about communicating health messages. It came home to me in that course that no one in science was interested in the creative side. They may be interested later on when you have suddenly got to pull it out of a hat and come up with something creative, but at that point in time it was squashed. There was some dissention amongst the ranks because the students thought they’d done pretty well thinking up all these new and novel ways of communicating health messages and expressed them well, and they walked out with B-minuses and Cs because they hadn’t formed the bulk of the assignment or essay around the existing literature.

So that was a bit of a wakeup call. And I often think, where does the creativity go when it’s squashed at an early stage? If you spend years like that we can lose that creativity—but how you incorporate it is another thing.

For my master’s, I spent two years part time writing a dissertation. That process was interesting; I didn’t find it too onerous. I enjoyed what I did. I enjoyed

interviewing the women and relating it to what had been said in the literature. It was an area my advisor, K, didn't know very much about.

Yes, she was my advisor then too. There were obviously some issues there with communication all the way through because I was using grounded theory and she was not familiar with it; she did give me some instructions that I had to follow because I said "well I'm not going to do any quantitative analysis" because with grounded theory you are not meant to. But she told me I had to go out there and get some quantitative data and do the analysis and put it in the thesis. When the thesis came back, I had very favourable comments on what I'd done but both reviewers were grounded theory experts and they said "why is the quantitative material in there? It shouldn't be in there."

My colleague J and I talk about a course in scientific writing; not involving huge amounts of assignments if you are already writing a thesis, but so you can see why something's considered good writing and why something's considered not so good. You would think at this level that you would have that understanding anyway, but when you get feedback and you are not quite sure what the problem is it's hard to go and find help and hard to find where you can analyse what you are doing wrong. But I've this week been over to the learning centre and discovered that they do offer a one-on-one, perhaps an hour a week, with the writing specialist—I wasn't aware of that. And you write something, and then they take some of your writing to critique it.

I wonder how many science writers they have over there because I find when they do run the post-graduate courses here for Ph.D.s or post-graduate students, they tend to be led by people who have written in the arts disciplines. I remember one I went to and a few of us science writers were talking about having to write and produce a paper. Those sessions we had didn't really throw that much more light on it because the people weren't aware of where we were at.

If and when I finish this thesis I often think I'll write poetry. I'm a little bit of a closet poet. I love poetry. I love the way it's only a few words to say something and you leave it to the reader to interpret it. I find it very soothing, and I find that poems I learnt as a child have stayed with me all over the years. It's fall right now, and I'm riding to work and I'm looking around thinking, yes "seasons of mist. . . ." It's just so beautiful and it's amazing how you can learn a poem and it will stay with you for the whole of your life. Now how many things like that happen?

All the words come back in various guises. I mean, I wouldn't have thought of that probably for years but it's always there, like it's been planted, it's a seed. And I think writing can be planted as a seed and then can come out and mature in later life—it's a real blessing.

JANE

Jane's quiet voice described to me the darker side of science's social context: what happens when you're not part of a team? When people you expected to collaborate with leave? When your doctoral advisor doesn't communicate? Jane attributes her lack of confidence as a writer to her social context. Her story was startlingly different to that of most of the people I interviewed, and I'm still puzzled by the causes of her unwanted solitude. Was it because she's a woman? Because she's working in a particular discipline (community ecology, macroecology)? Or was it just a matter of chance? But it is also, I think, worth noting the support she did acquire along the way. It's clear from Jane's story that doing science alone is a difficult task. But is Jane's real problem "a fear of the blank page"?

I THINK I'M A BIT SCARED OF WRITING

I came to this university to collaborate with people that I had worked with before, but they'd moved on, and I didn't end up forming good, strong collaborations with anyone here. In the last year or so I've started some collaboration with people here and so I probably will end up writing with people I work with. But over the last six years or so, I've been doing most of my work by myself or with people from overseas, and so that's how I ended up doing a lot of my writing alone.

I almost always come up with my own ideas for research, which again is how I end up doing it by myself. I'll have an idea, and sometimes I'll go and ask people if they want to be involved, and often people will say yes. But they don't really mean it, because everybody's doing way too many things.

I got a grant and I collected some data and added it to some historical data. I ended up writing it up with a guy in the UK. It started when I came here and I was talking to a guy here, and he knew of a data set we could use to test some of the hypotheses that were out in the literature. So I wrote the grant and did a lot of reading and writing at that time.

That was the first big grant I'd ever written, and I had quite a bit of help from two people who were actually on the grant, neither of whom ended up helping with the project at the end of the day. I haven't published with them because they just ended up not really being interested. Once I'd got the money then I wrote a number of smaller grants and got additional money. I didn't really do any writing for a long time—a number of years I guess—while I was collecting and analysing the data. The writing I did do was like progress reports for funding bodies.

I don't tend to write while I'm collecting data. But while I was doing data collection, I was writing up things from stuff I'd done before. I tend to write stuff up after I've collected and analysed, because it takes quite a long time. When I came to analyse it, I started talking to a guy in the UK and he had some good ideas for the analysis of the data, and so I went over there to work with him and I spent two weeks there and we did the analysis and started writing the paper and had quite a solid draft before I even left.

I had read one of his papers and it had a bunch of abundance occupancy modelling ideas in it. His paper actually had a whole lot of mistakes in it, and I was trying to use his equations and they didn't make any sense, and I didn't know if it was my bad algebra or what. So I contacted him and said "hey I can't figure this out" and he said "oh I'm so terribly sorry, I was so proud of this paper and it's got all these mistakes in it." And he was all sad, and I told him what I was doing and he thought it was really cool. And then I asked him how I could use his models and he said "oh well what about doing it this way and that way," and then he was going to visit me. But then he ended up having an unexpected baby and he couldn't come and visit, so I went and visited him the next year.

So it was really a slow process and it stalled at various stages because I guess I wasn't sure how to proceed. There were just so many options, and I tried to work through things and it was really complicated and I was just doing it on my own and so it took really a long time—much longer than it probably should have. But, you know, when you are doing things by yourself. . . . I have a lot of self-doubts, I guess, and a lot of times I just didn't think I knew what I was doing. But in the end, I went over and visited him and that was actually a really positive collaboration. I hadn't had that experience since my post-doc—of really talking with someone who wanted to listen to what I had to say and who thought that what I was doing was interesting. So it was quite refreshing. I'm not sure if it will be an ongoing collaboration. He's really busy and I'm doing other stuff now. I don't know.

It took another year to finish it off because we added some data, and changed a few things around, and so I redid the analysis and then finished off writing it up. That whole process probably took another year to do. It's quite complicated stuff.

The methods were pretty easy to write. I think I probably just wrote those and my collaborator probably wrote some of the modelling bits. And then, for the introduction, we talked about the process of what we were doing and the reasoning behind it and so I got an outline together and then he filled bits in. It was a back and forth process. Then I wrote the discussion when I got back here, so I guess we didn't have a full draft because we didn't have really a discussion

when I left. But we had introduction, methods and results which was pretty good for two weeks.

When I'm writing a paper, I have long spaces when I'm not writing, and I don't think that's actually a good way to do it because I get a bit scared of it, and I get scared to come back to it. I don't have a lot of confidence in my writing. So to get that paper done, I had a writing group. We tried to write every day and that was really what got that paper finished off—sitting down and doing a little bit every day and not feeling like I had to do the whole thing in two weeks. Instead, it was just chipping away at it and that was really good. But then once that was finished and I finished another thing, I've stopped again now. And I mostly don't write—I haven't really written anything for months.

I work in quite a large field so there are lots of people and there are people in different parts of that field: so there are theoreticians who come up with ideas, and then there are people who have a real, practical, applied focus, and then there are kind of people who might collect data to test theoretical ideas. I'm one of the people who tends to get real world data to test the theories. I don't come up with theories, I'm more just trying to understand them and see how useful they might be. But I'm also not really a conservation biologist, so I don't tend to write for an applied audience like how you could actually use this to save a species. So I tend to try to write so that all three groups can access the work. And that's quite different to how you might write if you are only writing to theoreticians—it's quite different from how you would write if you were writing for like conservation managers, so I try not to use jargon. I try to write it at the most simple level I can, just because I think it makes it easier for everybody.

I believe in making scientific writing as accessible as possible. I know a lot of people don't believe in that, they believe that what they do is too complicated for the average person. But ultimately it would be nice if people outside your field could pick up a paper and read it.

I tend to try to be quite factual about the way I write, which maybe isn't as flashy as you could be. A lot of people are very persuasive, aren't they, in their scientific writing, but I don't believe we should try to be persuasive. I think we should try to be objective and present alternatives so people can make a decision. But you do have to present the right stuff so they can make that decision, which I guess is kind of persuasive.

I think I am a bit scared of writing. I've had some bad experiences of writing. It probably stems back from my Ph.D. where I had a really funny man for an advisor. He was not very interactive; he didn't really speak, and I never really had a conversation with him—it's not a good position to be in! I had these ideas and I went out and did all this work, and I thought it was alright and I based everything that I did off the literature, and I would email various people in the

field and get their advice and help, and I went to a few conferences and talked to people and got ideas off them. But he was really not—I don't know—he just wasn't interested. We were all very scared of him because he would be quite rude if you said something that was sort of stupid, you know, so people were very intimidated by him. As I got further on in my studies, I realised that it was less my fault and more that it was him that was strange, but for a long time I thought "oh there's something funny about me," you know, as you do when somebody acts strangely towards you.

So the process of writing my Ph.D. was very solitary; I mean I did it absolutely by myself. I would give him drafts of my chapters and he would hand it back and there would be nothing on it. On the page, out in the margin, there would be like a cross or a question mark, and I would have to go back to him and say "why is this here?" I would have to go and ask him about every point. So in the end when I needed to submit, I would actually print off a sheet of paper with specific questions for him like, "do you think I should include this in Chapter 1 or Chapter 3?" because I was really struggling and looking for advice. The only other person I had who read my thesis was a master's student there at the time. She was a student of his as well and knew what he was like. She had worked in a similar system (not the same topic) but she knew a little bit about what I was doing and she was the only other person who read my thesis. I felt very uncomfortable during that process.

I had a committee, but I'd had a very bad experience in my oral exam that you had to do a year into your thesis where they say whether or not you are good enough to continue. I found the people on my committee really intimidating. I was really quite intimidated the whole time I did my Ph.D. There was one guy who was on my committee and he was really nice; he liked my stuff and he thought it was cool and he helped me out a bit. But he was really busy. He had 15 Ph.D. students, so I couldn't get help from him.

But I knew, from talking to people, that my stuff was good and interesting. I had some confidence in my ideas, but I just had no help during that writing process. So then at the end when I handed it in and had my final defence, all the people said that it was just an awesome study and they were all like "can I get a copy of your thesis afterwards?" and, you know, blah blah blah how great it was. And I was absolutely bowled over because I had had no feedback, so I didn't know what I had done. That was the last time I saw my advisor, and he just held out this limp hand and said "congratulations." And he was horrible to me in the exam, and I just thought "what?" Anyway, by that time I had realised that it was all him and he was odd and so I just sort of said "thanks, see ya!" and I never saw him again until years later. He is an amazing guy, and he sat in his office under his little lamps and did his thing and wrote books. I think he

is a nice person, sort of, but he just had no idea how to be a mentor or how to supervise people.

Then I went into this post-doc where I had three bosses and for writing up I found it really hard because they had three different opinions and so I really struggled in the analysis part of the work, just getting what they all wanted. So that took a really long time and then when it came down to writing I guess I had had this bad experience and so I didn't have a lot of confidence. So I went to them for lots of advice and that meant that I gave up ownership a lot of the time, and I was trying to write to please them rather than sitting back and saying "OK this is my study—what did I do? What's important?" And I think I'm now, eight years later, trying to unlearn a lot of that, but I didn't even realise at the time how that was affecting me. And then my boss was totally hopeless; I could give him a draft and he wouldn't get back to me forever, and one of the papers took about five years to produce because it was just all these holdups and people disagreeing and things getting changed and reanalyzing about six times and no consensus on the writing. And then we sent something in and then the reviewers had all these problems and then we had big discussions about how to deal with those problems, and you know, just round and round and round.

So that's the context, the background to where I've ended up now. And now I find that again I am on my own, and I really haven't published a lot of papers. I only have about 12 in total, and I think I am quite good at writing; I mean if I was honest about it I think I am not bad at writing. I can write well so people can understand and I'm quite good at helping other people improve manuscripts and contributing to manuscripts. But when it comes to a study I've done by myself and sitting down and saying "what have I done?" and writing it up, I just lose all confidence and I have a fear of the blank page and I'll do anything to procrastinate my way out. Mostly what I do is analysis, and I'll just say "oh well, if I just did it this way and that way" and so I spend all my time analysing instead of actually knuckling down and picking a particular analysis and writing it up.

I learnt to write by reading other people's writing. I was lucky because I had quite a good background coming into university, and then in college I enjoyed writing; I liked doing essays; I loved all my undergrad—I had a great time—and I wrote a really good honours dissertation, and I got an awesome mark. So I was coming into my Ph.D. with a lot of confidence and thinking I was a good scientist, and it all just sort of got ripped away. So I think, ultimately, I have got quite a good writing style, but it's been 15 years since I finished my honours year, and I really don't know how much I've progressed since then. It's been a fight for me since then. Which is very disappointing to me.

Another help was, when I was working in an earlier job, I worked with a professional editor and she really helped with the quality of my publications.

She had a background in biology, so she knew the subject area and she had a lot of experience. I'm not sure how long she'd spent being an editor rather than a biologist, but she had a lot of knowledge of the subject, which I think really helped because she was able to read sentences and actually understand them. So, rather than just from a straight grammar point of view, she could make it actually make sense.

She would go through your document and not only would she make a correction, but she would put a comment in using track changes explaining what the correction was, so if you'd made some grammatical error she would tell you what that error was and why you shouldn't do it. I think she probably had a file with all these common errors and the explanations in them and she would just cut and paste it into your document. So you could learn for next time what it was that you could do better. I found that really helpful. Without that I wouldn't have been able to improve my writing to that degree.

The writing group I mentioned before was started by a friend of mine who was doing her PhD. She was quite keen to set up a writing group because she had been doing reading about how to write your Ph.D. And there was a scientist at a local research institute, and the Ph.D. team was doing some work for her, and we said we why don't we set up a writing group. And the woman at the research institute had, I think, been in a writing group before, so she had some ideas about how to do these things. That's how it started.

We met once a week for a few months—it was quite a long time actually. So each week we would, by the end, generate a “to-do” list for ourselves so we would report back on that and then just share experiences like “oh it was hard for me this week because x, y, z,” or “I'm writing a method section this week and what do you guys think about doing it this way or that way?” or stuff like that. So it was quite a free-form thing, just however people felt in any given week would be what we would talk about. Because there was only three other people, it was easy to do that.

We made a commitment to write every day. I mean, it wasn't like we all decided that we all had to do that, but two of us did anyway, and it worked really well. So the idea that they had that I used was free writing first—they were saying, “well you could do it for 15 minutes,” but what I found was as soon as I started doing it, I'd only last on other things for about 5 minutes and then eventually it would just morph into what I was working on anyway. So that's why I found it quite productive, because it was like once I'd committed to opening up that Word document on the computer it would just spontaneously turn into doing the writing that I wanted to do. I got two papers written that way.

The group split up because the person who was doing a Ph.D. got to the very end and just didn't have time and was finishing her writing, and then I think

the other two went off overseas at different times, and we just never ended up reorganizing the regular meeting times.

Writing does tend to be kind of a lonely thing to do, doesn't it? So just having people to talk to, not even to show the writing—we never showed writing to each other, we were just talking about it—was pretty amazing.

Oftentimes I think it's too late for people to learn to write when they're doing doctoral work. It's hard for people as it is to write a Ph.D. without having to learn how to actually write. And so I explicitly teach writing skills in undergraduate classes, and I do think it's important for people to get some of those skills under their belt before they hit that research thesis level.

I teach writing in my undergraduate classes by making a lot of work for myself which I get criticised for by my colleagues. I use a portfolio, and so for the students I look at it each week (which is where I get all the work from), and I get them to do writing every week, multiple pieces, and all sort of different things that they have to write like more lab report-y things or critiques or answers to questions or whatever. And I always correct their grammar—every time—and I explicitly teach them things like how paragraphs need to be structured. A lot of them don't like it, but usually by the end they say “oh this was really, really useful, and my writing is so much better.” I think it makes a difference and I wish I'd had that.

I think if we put people out into jobs, the best thing we can do for them is make it so they can communicate what they've done. I mean you can be the best scientist you want, but if you can't tell other people about it, there's no point in doing it.

I do feel a bit hard-done-by, but I'm trying to make the best of it; it's just finding that way forward. And really, seeing how useful that writing group was, I would like to really do something like that again. We've just got a new chair here and he actually mentioned writing groups. He also said that he expects the senior staff to be reading stuff from other people, and he's trying to introduce a more collegial culture to the department. So I'm quite encouraged by that, and I think that maybe we can do something in the department because I work with lots of really good people, and I get along with lots of them really well, and we have a lot of fun. So I don't think this would be too much to ask of various people, to get together.

To get to the next stage of my career, I need to practice. Get over the procrastination and just practice. I have lots of things to write about, it's just a matter of doing it. I had certain aims about what I wanted to do and I've just found my own way to get there. Which has been slow and I'm not really there. Do you know what I mean? So I don't think that I've been successful—I wouldn't say that I'm successful at all. I wouldn't necessarily say I'm a failure, but I'm a “work in progress”! I'm a *delayed* work in progress.

TIMOTHY

Timothy is a very senior mathematician, who has moved into interdisciplinary research and is nearing the end of his career. We sit up in his big, bright office, overlooking the city, and he oozes confidence and authority. And yet, as we talk, his narrative changes—of all the people I interviewed, he is the one who most clearly identifies as a struggling writer despite a phenomenal publication record. Perhaps what is most significant about his narrative is the way he portrays his struggles as a writer as emerging from the same attributes which make him an influential and successful mathematician. He is also the interviewee who tried hardest to work through in most detail the process of thinking and writing about his discipline, the way in which equations and language work together.

I DID MATHEMATICS, I THINK, BECAUSE I FOUND ENGLISH SO DIFFICULT

In terms of writing, I was a planner. But that was a long time ago. I'm old enough to remember writing in pen on paper, getting the document together and then giving it to a secretary to type it up. And I often look back at that now with some concern as to whether what I wrote could have been OK, because once I had given it to the secretary there were no changes—or very few changes—made. Whereas now, in the electronic age of typesetting, 20, 30, 40 incremental versions of the paper might take place before we actually get it right for publication.

One of the reasons for so many versions is that scientists do mathematical type setting, and we use LaTeX which gives published quality of text and equations—in fact that's what the publishers use to produce those pages. So we offer publishers the completed books now—basically the publishers have nothing to do to the book or paper other than just add a single line of type style which might change the house style.

Now in that process of producing papers, they're so perfect when they come out that, if there's a full stop out of place, you spend time trying to get it right. You worry about the smallest mistake which in a rougher word processing document you wouldn't be so concerned about. So we're forever correcting; we're forever updating, and scientific publishing tends to go through many corrections, and also often it's on Dropbox as well so other people are looking at it too—they open it up and do some corrections. So it's a very laborious process now by comparison with how I started out. I think in the past we must have done more processing in our heads.

That detail of getting perfection used to be down to the printer or the publisher. That detail of the perfection now is down to us. By and large, in mathe-

matics, we produce the text and we see it as in the final version, as it leaves your machine.

Let me describe my writing process. First of all we might have a theorem that we want to prove. Certainly one would do scribbling and writing it out in some form on paper. Then you would try and commit that—and perhaps the proof of that theorem—to the document. Well, as you know, with word processing you can do little bits whenever you like. That might be the way you do it. You try and get the theorem down and then you build around it. So you'd say, with the introduction, what do I need to say to get to this critical point of the paper? How do I extricate myself at the end by saying how this theorem opens out to other possibilities and its importance?

The other approach, as we're going to do with a paper I'm trying to do with some medics, is to just write down introduction, methods, results. Just write something down in a very brief form which is clearly inadequate, but then you start to expand those areas. Often our work these days is interdisciplinary, so in this particular case with the medics we'll be doing the mathematics and writing up the results; they will be putting all the physiological verbiage around it because I just don't know what it is. I'm calculating something about proteins, but I don't know what these proteins represent and the guy who's working with me, he understands it—he's actually dealing with these things every day. So, you know, we come together in an almost orthogonal way in that paper. Whereas, for other papers, you have some overview of the whole thing, and so you're able to do it all by yourself.

So, oddly enough, you could have papers with your name on where you don't actually know, in a way, what it's about. And you'll often see a paper with many, many authors on. Now that's just making a statement that these people have been involved in some way in getting that result. They may not have even seen the paper. If you have three, four, five people—the chances are that everybody's had some significant role in getting that paper together. But I'm taking the extreme case there where the person wouldn't even know what the paper was, might not even ever find out that a paper was published in their name. You know—it's a little bit like the credits at the end of a TV programme.

And the fact that we can actually move the paper around, as a result of email and Dropbox and all these tools—I've done co-editing on Google with a person on the other side of the world, in Hong Kong. In Google Docs you can both be working at the same time, and you can make great progress that way because people are adding sentences that they feel are needed, then another person looks in and moves it—everything is moving in front of you; some of it is your doing, and some of it is the work of others, but it can work well. This is a revolution in the way we work. When I started, the first 20 years of my professional life, it was

a solitary existence. I did the research and papers on my own; I was mainly sole author, but then I discovered that it was quite nice to talk to people!

You know, academics are slightly strange people. I mean, you're putting up with weirdness basically, particularly in mathematics where autism and Asperger's are helpful conditions. Actually you can be better as a result of that, having a little bit of Asperger's—it helps you to concentrate, you know. It eliminates distractions. So a lot of us were loners early in our career—for want of a better word—sad to say that, but I think it's a fair point. And then we've actually found that we quite like working with people, and the facilities have arrived that enable us to have universal word processing, universal access to the files. The grant that we're putting in for the end of this week involves academics from four other institutions. There's no point in us bothering to meet up; we'd waste a full day going somewhere when we can get on Skype and talk about it or work simultaneously. Often somebody takes charge, the paper is with you for the next 24 hours (often it's for short periods of time). We don't say "we'll have it for the next month." The pressures are on to actually develop things quickly and meet deadlines.

It's a general phenomenon that grants are now put together at a multi-institutional level. There's a major push in science for interdisciplinarity, using mathematics in the outside world. So I was just a mathematician who wanted to prove theorems on my own; I still do that in a limited way, but I've got greater respect and money and all the rest of it by going into looking at network structures and working with multidisciplinary teams. And that means we've had to change our ways and become more communal, more extrovert at some level in trying to talk to people and trying to understand their problems, which is not an easy thing to do. You have to spend a lot of time just meeting up, talking about basics.

When we're writing, we have to be more aware of our audience. At one time I didn't even think about it. Again—sorry I'm contrasting my early career with my current career, but that shows up the essence of the problem. But you could just do mathematics and nobody really worried too much what you did. Now they have an interest in you trying to raise research funding and that usually means impact to the outside world, and so we have to think about how we get impact.

One of the problems about working with people who are not mathematicians is that they think that we know it all. We don't—we know hardly anything! You know, I've written books on systems theory. But I could go to a seminar on the subject and not have a clue what the guy is talking about. And that doesn't happen in history, that doesn't happen in geography. You know, I could go to a geography seminar and I might well enjoy it, even if some of the detail is beyond me. I know that I will; I'm interested in geography, though I haven't done it since I was at school. So there is a problem in mathematics that we don't

know much and we can't do much, but other people think we know everything because it's a difficult subject. So that's an anxiety that I could be putting stuff down in a paper without full knowledge, which is the usual position of a mathematician, unless they've proved a theorem and they've got the proof of it there; then you can claim full knowledge.

But once you go away from the cosy position of pure mathematics where the theorem is stated, it is proved and it's all over (that is, it's either correct or incorrect and other people can judge it), then you get into the game of interdisciplinary mathematics and then nothing's quite correct as you are approximating the truth in many cases. Do you build a fast track line or don't you? Well, "it depends" is the true answer. Do you reduce the number of proteins measured or don't you? Again, it depends. So, anxiety comes into our profession as a result of trying to work in an interdisciplinary way. I mean, I'm very excited to be working with somebody in a medical faculty. But I'm also worried by it.

Is writing in mathematics persuasive? If I'm thinking about pure mathematics—well, yes, I think it is persuasive because I'm stating it very clearly and identifying the formula. That formula is either right or wrong, and it's persuasive in the sense that people either believe me that I've done it correctly, or they might not have the time to check it. So they have to look at it in a peripheral way sometimes to decide—"do I believe that this guy has got the right idea here and, therefore, as a result of sort of oblique or tangential information, do I think he's actually got the right formula?" Then I think it's pretty persuasive. It requires an act of faith by most people but I still think people should be easily persuaded really as to whether you're on the right track or not; you know, do you have a track record in this area? If you put in simple values, is the answer correct?

Sometimes—it's called an "engineers' induction"—you're only checking a few values and assume it's true for all values. You bring together a combination of things—almost like a doctor looking at a patient: he checks your temperature, he checks a few other things and he decides "well, basically I think you're OK unless you tell me something very specific about a pain here or a pain there." And I think for a mathematician, they'd like to check it precisely, but 40 pages of detailed work? They might not have the time or the inclination and they want to use that result. So, they have to make a decision—"do I use that result or don't I?" If you know that person to have had a decent track record in publishing, you trust their previous publications in the same area, then you'd be prepared to go ahead with it. That's certainly what I would do.

I find short articles easier to write than long articles. As I get older, I don't want to do as much technical checking, so that's a function of age. That extends to mathematics as well. If you give me a big equation now I'm not interested in it in the way that I was when I was younger. I'm interested in ideas and leading

things rather than being involved in the nitty-gritty. Again I think that's probably a function of age—and experience—as to what I can do best now, as against what I could do, say, 20 or 30 years ago. I like constructing something as long as it's not too large. For the grant that we got together, I've made a contribution of about three pages, and I had to worry a lot about that, but the whole thing is about 36 pages and I'm glad I wasn't involved with that. I've got younger colleagues who've done that. I wrote books—I wrote five books. One of them took four years to get together. I will never write another book!

I think in terms of developing as an academic writer, up until honours perhaps you don't even know whether you can write or not write—you just scribble stuff down, you don't quite know how it's seen. Effective writing comes sometime after the Ph.D. I went through the book stage which is making a broad statement but requiring a lot of effort which I wouldn't be prepared to do now. That sounds as though I've got a choice. I couldn't, you know, I haven't got the concentration to do that. My mind flits. That's the problem with growing old when you're a mathematician; you've been very sharp at various points of your life and perhaps you understood something that maybe only another 10 people around the world understood; you know you were in that little clique at the very top of that very vast sharp pinnacle going forward. But now, as you get older, you can make this broader contribution. You've learnt a lot. And so you use your knowledge in a different way. So it's research leadership rather than doing the research yourself; helping others to be in the right place to deliver research.

What's interesting is I did mathematics, I think, because I found English so difficult. I did actually fail an important entrance exam; I failed it on English and I was fine on mathematics. I was top in maths but I was desperate in English. I can remember the essay. The title was "My House." Now as a mathematician—and I come back to this autism and Asperger's thing—I've got to write about my house. What is my house? And I went to numbers straight away. It's got five windows, it's got one door—this is age 10 or 11. I knew it was a disaster when I wrote it. But I was incapable of doing anything better.

"The door opened . . ." was another essay I recall having trouble with. I had no imagination in that direction at all; I had imagination in math but no imagination in writing. I didn't realise you could write anything after that—basically that it didn't restrict you at all. I thought it restricted me enormously just as for the other essay with the title "My house." I could have written anything, you know—"my house is haunted" and away we could have gone. I could have written any old bunkum, but I thought I'd got to write the truth, I'd got to write the facts, strive for accuracy. Because accuracy is what mathematics is about.

So I went to a secondary school and my mother, in the first year, wrote my essays for me. Fortunately I had a very good teacher who realised my problem

and pulled me on with mathematics in that first year and then I went to a better school at 12. I always knew what was wrong with literacy; I just couldn't always correct it. And when I look back at my early papers, they're not bad. The sentences are OK, they're not too long, they seem to get to the point and then move on; so I obviously got over the crisis at some level, probably by the age of 16.

I wouldn't say I'm a good writer now. I write terrible sentences and I have to correct them. I know how to do that. But, you ask me to write a paragraph and I write it down and then I read it back and I think "oh my God!" It seems OK as it's coming out of my head, but it's not OK when you read it. For that reason I'm worried when I'm talking, that the sentences must be bad as well while I'm speaking because I'm speaking to myself when I write it down. Perhaps I'm not quite as bad as I think, but I do have trouble. It's never gone away; I never find it easy. I show something to my wife sometimes if I'm fed up with trying, and she says "you can't say that." But I do have a revision facility.

I did have a brilliant Ph.D. advisor, a brilliant man, and a brilliant expositor. Fantastic writer. I can remember writing my first paper; he said "is this your first one?" He was a very kind man as well. He said "don't try and put everything in the theorem." You know, I'd saved all the notation to this single statement. So he said "set yourself up for the theorem, put in some definitions of the things that you want to describe in the theorem." I can remember it now, he wrote on pink paper. And he said "now you can write that theorem that looks a monster piece of indigestion in just a single line because you've set up the background." And, you know, that was a critical moment—it took him 10 minutes to tell me that. But I was receptive to help; I wanted help; I knew I needed help. I wasn't a person at that stage who was saying "I don't care what he says—I'm OK." I'm quite sensitive to failing. And so I was ready to take it on board.

I think initially at school you don't need to write mathematics; you do it in forms of formulae; there are very few words you need. So it is an alternative language, and you do feel a release: "I haven't got to do English now, I can do mathematics." Of course I then realised that to actually talk about mathematics, to write about mathematics, you need English and you can't stay within the confines of mathematics.

I think I wrote a decent thesis—even though I'm quite hard on myself. And the early papers look good as well—but that first paper! In my second paper I resorted to the bad old ways of what I'd done in the first paper. And another person had a go at me. He said "oh, you've got to write it better than this." And again he helped me, he was a good writer—and I think that was a further reminder to do better. I knew that I'd got to really look at what I was doing and that other people would judge me as being a bit hopeless, that it wouldn't be

accepted for publication—not because of the mathematics, but because it was just poorly written.

I have had these traumas in writing and that's why, of course, I enjoyed writing these books later on. OK, there were co-authors and I tended to supply the mathematics and the first draft, and then the other person was keen to try and understand what I'd written down and we reconfigured some of it. He probably wrote the majority—I would say that, out of five chapters, I did about two chapters' worth on my own and he did about three. I thought it was good to have somebody around to check.

So I think it was that first year in my secondary school and the quality and the help of the great advisor that got me through basically. It's been a big thing in my life.

But I'm pleased that I've got a job where I have to write. I guess that I could easily have taken a different path—I might have enjoyed being a plumber. But then I would have missed out completely on writing if I hadn't been lucky with my teachers.

What I continually emphasise to the students here is that they too possibly think that mathematics is an alternative language to English, and a lot of them choose mathematics, particularly from abroad, because—"oh I'm not going to do very well in English" or "that's going to be my second language" or whatever (although some people with English as a second language seem to do better than the indigenous population, but let's put that to one side). They say "I can use mathematics—I can get by with mathematics." And my entire emphasis is you must write; you must write about it in English. So you must put words around the equations. Just putting the equations down means nothing.

I said it this morning in my class at nine o'clock. "Write something down to show that you understand it." And they don't like hearing this. I said that's the skill; never mind whether you've done hydro-dynamics or calculus or algebra—it doesn't matter. How do you explain it? How do you write it down? How do you communicate it to other people? And I think that's what they've got to get. If they don't get that, they miss the point of doing mathematics. But they just don't get it. The penny has to drop in all sorts of ways for all of us, and it can take many years. The simplest things that we have to learn in life often take a long, long time to appreciate. You understand what the person said, you get what they say, but you just somehow don't believe it until it happens. So, we don't believe even simple things, do we, until we've actually experienced them?

I would say writing is not separate from mathematics but part of mathematics in the sense that I also say to these students, "when you're looking at this page, can you talk to yourself about this? You need to be able to tell yourself what you mean—you need the words." If I write $F:R \rightarrow Z$ and I can't explain

what it says, then it's not much use. If I say "we have a function F from the real numbers R to the integers Z ," the words are actually reassuring me that I know exactly what I'm talking about.

The equation is saying all sorts of things: 1. I recognise that this is a statement about functions; 2. I recognise a function maps from one set to another set; 3. The set it's taking values from is the real line in a set of real numbers and by applying the function f we obtain an integer. Now that's telling you everything about the setup by using those words. Whenever you can use a sentence you should use it, even if you don't write it down. So I would say that, coming back to your point about creativity, when I'm creating the mathematics, I am talking to myself, I'm saying "I'm looking at this, so I've got to look at the graph; I've got to find the maximum of this graph; perhaps I've got to find out where the slope is equal to 1." Now if you can't say those simple phrases it means you can't think about the problem in front of you.

So you have to talk to yourself about the mathematics while you're creating it, but then when you write that's a separate process. So when I'm doing a scribble about a calculation here, and talking myself through it, I'm not writing at that point. But then, perhaps what I write would be very different from what I said to myself; I don't need to write as much as I've said. The English has to be used the entire time, but it's used in different ways while you're working with the mathematics and while you're writing it in the paper. Does that make sense to you?

Let's see if I can explain it better. When you're working, when you're conceptualizing, you've got to be able to put words around it; but perhaps they are short phrases to compose a thought or a question. But then, once you get to the writing of the paper, then the phrases have to be composed to make meaningful sentences. So when it comes to writing the paper, I might be writing completely complementary things from the sorts of processes that were going through my head while I was creating the mathematics itself. It's not unusual, when you're writing, to discover a new idea or something you hadn't thought of originally; I mean, you might find a mistake in what you've written down. Perhaps you realise you need to put an extra step in; while you're writing it, you might actually see that it's not true anymore.

I do like to read. I'd like to be able to read novels freely, but I don't. It's easy for me to walk away from a book. I see people get into the first five pages and they can't stop reading. There have been occasions in my life where certain groups of books satisfied me like that, but only a few; as a child I couldn't put *The Famous Five* books down. But for some reason there was nothing else that captured my interest. I like biographies, so again I'm tempted towards factual things. I'm interested in astronomy, I'm interested in all these things—it's not

that I don't have an interest. I find it difficult to concentrate—I can read on holidays and I can read when I'm officially switching off. The thing I read most is the news. I read a lot of newspapers. When I read, I want it to be based on fact, I want to believe in something, so I have also have difficulty with sci-fi if it looks crazy.

But the other problem is mathematics is my hobby as well as my job, and I probably do about 55 hours a week. So I've got enough to do basically, but that's not an excuse. That's just how it is. But—final example—I've been to see Shakespeare quite often, and never really understood it—my wife has to tell me what the story is or who's the mother of who or whatever. I've been to *The Tempest* three times now; I know it's on a desert island, I know there's a storm, but if you asked me one other question about it—I wouldn't know the answer—that's disgraceful, but true! I just switch off. I just sit there and just watch it. But the Shakespeare I did at school—*Merchant of Venice*, *Macbeth*—great. I liked those stories because we kept on going through them over and over again and eventually I could get some of the nuances in the plot. I have to be in the right state of mind to follow the plot. My mind seems not to be constructed in the right way to follow them.

MASON

Mason is a solid state physicist and seriously annoyed by me. During our interview, he objects to most of the questions I ask, suggesting they are either irrelevant, ignorant, or biased towards a humanities' perspective. I struggle for a while with my own impatience, until I decide the best approach is to simply let him explain what *he* thinks is important about science and writing, without being tied to my questions. And he surprises me. He was the only person I interviewed who expressed these views in such uncompromising terms, although echoes of his perspective can be found in some of the emerging and doctoral scientists' perspectives.

WORDS AREN'T IMPORTANT

I start writing at the beginning. I start with the title, list of authors, then I may get stuck in straight away to the introduction; but the writing isn't actually a very large part; preparing the figures is the major part. Sometimes I do some of the figures early on. But really I start at the beginning and go to the end. I've usually got a pretty clear idea of what's going to be in the paper. Because you do the research, you get the results, you say "this is publishable"—so you write up. It's quite straightforward. It comes out fully formed. I don't have to do a lot of

revision if I'm writing it by myself. If there are co-authors involved, obviously they then would do some editing, make some changes—and then I might want to make more changes in response to what they've done. But if I'm a sole author, then I get the final form—until it's been to referees, that is. The final form isn't very different from the first draft.

If I'm revising stylistic issues, I work intuitively. If it's actually a matter of scientific content then obviously it's deliberative. Saying “this argument doesn't hang together” is scientific logic and needs thinking about. If it's stylistic it is just a question of how it reads.

What you call “structure” I'm not giving a name to. It's impossible to make a distinction between what you call “structure” and style. Style appears at all levels. Even though someone would have written a paper differently, their personal style is different from mine and that shows at all levels. The content is another matter. You see, scientific papers actually have content, and you might guess that I suspect that's not always true in the arts and humanities.

So, you take a math proof; it is an entirely different matter whether each step leads rigorously to the next—that's structure. Style covers such things as how you choose to lay it out. If there are parallel paths in it, how you prefer to set that out may be different—two different mathematicians can present the same proof very differently because they have different styles. But it's the same proof. The content is the same. Everything which is not content is style, which belongs to the person. All the content is objective and comes from, if you like, the experiment or the theory.

I'm not quite sure if I think about the audience, but I certainly think about what I would be saying—because, after all, a great many times a paper is connected with a conference presentation and for a conference presentation I would certainly be thinking “what am I going to say?” Now that, I suppose, implies an audience because I would never read it aloud in a room without an audience. I don't do popular writing and even with what we might call interdisciplinary stuff, or specialised stuff, I believe in making it as clear as possible to any colleague. I haven't tried writing for undergraduate students; I write for people who are interested in and knowledgeable about the subject. And if they're not knowledgeable then there are references for them to find out what background they need.

The physicist and mathematician spend all their time adapting to new results, new information, new problems. Whether they're writing in new and different ways is not something I've really thought about.

I think *convincing* is a word I'd rather have attributed to my writing than *persuasive*; persuasive carries a slight connotation of trying to sway people by emotion rather than by the logic. Maybe convincing does too a bit. I'd prefer the

material to be convincing rather than the way I write. The figures, of course, are crucially important in any scientific paper in terms of conveying what it is you want to convey, in terms of actually telling the audience something. In that connection, I must say I learnt a lot from a French professor, a very great man, very eminent. I didn't speak French, but I went to a research seminar that he gave in Paris, and I was able to follow completely what he was saying. I mentioned this to him afterwards and he just said "that's a tribute to my diagrams." He said explicitly that for writing papers, what he always does is lay the figures out on a table, make sure they tell the full story, and then throw some unimportant words around them.

Words aren't important in science or engineering. I've had this discussion with philosophers frequently and they claim they can't think without words. Of course every scientist and mathematician and engineer thinks without words. And if you ask why use the words, it's like using prepositions in writing—why do you use prepositions and things, linking words that intrinsically have no meaning? The words, if you like, are the prepositions between the figures.

I would never read a paper from beginning to end, absolutely not. I would ask "now, what's he actually saying? Oh yeah, now why's he saying that?" and I don't need to read the rest. I go to the conclusion and then to the graphs. The conclusion was what I thought was important; and I might find the conclusion is sufficiently well stated in the title or at the end of the abstract.

You might say a good writer is one whose work goes sailing through the referees every time, whose papers always are published and accepted as first submitted. I'm not so sure that's true because in my experience it's the boring papers that have very little new in them that sail through. When you're sending in anything new, the referees are a random selection from the potential readers and every referee would make different objections and raise different difficulties. I wouldn't say even your person who rated 10 on a scale of writing competence would be able to preempt all the referees. So I don't think the measure of a good writer is whether a person's papers go sailing in, I think the measure comes later in whether people find it easy to grasp what quality the paper is; I don't think my readers have any difficulty doing that with my work.

I find it easiest to write a paper with a very clear central idea and good data to support it. But I don't think there's very much difference in difficulty between different kinds of writing—a report to a client is simply a scientific paper that's not going to be published, and a grant proposal is (until they started putting all these extra requirements in sections on impact and so on) very much the same except they're in the future tense instead of the past.

I write because there's no point doing research if you don't publish; and research is fun. But you can't just do it for fun and not publish. Who'd pay for

it? No, there is a famous physicist who did that—he’s the one the Cavendish Laboratory in Cambridge is named after—Henry Cavendish.⁶ He was about 20 years ahead of his time. He got most of the results that other people got later but he did this purely for fun and he didn’t publish anything. It wasn’t known until after his death that he’d been doing it! Well that’s crazy. He was a rich man and did it as a hobby. I would have thought there would be a totally natural urge to tell other people about interesting things he’d done if only going down the pub and saying “you won’t believe what I found.”

Scientific writing evolved out of correspondence, out of people like Galileo and Newton writing to other people who they knew were interested in telling them what they’d done. So growing out of that I would say the writing isn’t part of doing the science; it’s part of telling other people about it. But, that’s where figures and math come in because, of course, they’re both involved in putting pen to paper and they are both part of doing the science. So doing the graphs is part of the science, doing the figures, and seeing if the theory lines go through the data points—and being very pleased when they do. That’s all part of doing the science.

Does writing help develop new ideas? Your writing could do that I suppose, or you could say it’s the figures that did it. Or it was the referee who didn’t understand something and needed another figure. Where you get ideas from is a completely different question. I don’t particularly get ideas from writing. You get more ideas through sitting in a pub with a pint of beer, staring at the beer mat.

I have no urge to start writing for the government; I’ve no urge to write books. I’ve only written a couple of review articles, and both times it was because someone twisted my arm. As for books—I certainly learnt when I was a Ph.D. student that most of the famous textbooks are written by people who haven’t done any research for quite a long time. When you can’t do anything original you start writing review articles.

The other point was about this phrase “learning to write.” Some people might do that, like some people actually have to learn to spell. Other people don’t need to learn to write because they do enough reading.

Solid state physics overlaps with a lot of other disciplines, and we actually find it relatively hard to communicate with those other disciplines because their style is so different. One of my colleagues found it very difficult to write a paper with a chemist as a co-author because the chemist wanted to put in all sorts of things that the physicist thought detracted from the paper, detracted from the point. So, it’s hard to say what is distinctive about the style of a solid state physicist rather than a material scientist, but it clearly *is* different.

Too much detailed knowledge is something a physicist never has, because physicists are fundamentally lazy. I tell the students that we need to have the

right amount of laziness. Not so much laziness that you don't solve the problem, but enough laziness that you actually put a lot of effort into finding the easiest way to do it.

I didn't like writing as a child. I don't think I was taught the basics at school either. I only took writing-based courses to the age of 14. I dropped them as soon as possible. We did very little writing in science at school. I learnt to write science by reading, reading broadly. As for how to write a scientific paper, as soon as I started reading I was immediately learning how to write and that would have been when I started my Ph.D. I'd say my Ph.D. advisor didn't teach me how to write—not in the slightest. I mean obviously he wrote some papers with me as a co-author, but I didn't see any particularly different about the papers he was writing than the rest of the literature I was reading. It was almost effortless to learn to do this.

I don't think I have a role of teaching writing. With my Ph.D.s, I'll push them out of the way and get on with the writing myself if necessary, because I'm not going to sit over a text with them explaining to them why you have the word "introduction" in bold here and what it is that follows it. But when the question does arise I always tell people to Google Boxman Tel Aviv.⁷ I was at a conference a few years ago where this guy was giving a lunchtime talk with free sandwiches and, out of curiosity to know what he might be talking about, I went and had a sandwich and what he was giving was a lecture on how to write up a paper.

So if you want to know how to write physics go and read Boxman—you don't need me to tell you how to write a good paper, Boxman does that. And the point he makes is that each section and paragraph should actually have that same structure. And I've often said that really out of the 80-odd slides, slide 18 is the only important one. I often lay it on its side and call it the jet engine model of writing, because if you lay it on its side then you've got the air intake on the left, you've got the reactor where the work's done in the middle, and then you've got the cone at the back which actually makes the output do something useful.

Oh, and as well I think I'll say to them—for example, yesterday I had a new Chinese research student preparing a talk for a conference and he wants to know whether his outline is suitable. So I glanced at his outline and I said "what do you want the audience to remember the next day?" And he hadn't thought about that. If I have a Ph.D. student who comes back with a mess, I point him to books.

I don't actually enjoy the mechanics of writing, it's the product. So the question of liking to do a kind of writing, the actual process of writing—whether pen on paper or with a keyboard—is in itself not very pleasant. So I only want to write things that need writing.

Words have a purpose but that purpose is less clear than the purpose of scientific symbols and mathematical symbols in writing. I guess the question you haven't really asked is what language do I write in. Accidentally English, but, of course, that's just because the entire scientific literature is in English these days, but it wouldn't be any different if it was another language. But we've learnt to write in it, perfectly competently, just by reading it—this is how the Chinese can write papers in English—not that they speak English very well, not that they're fluent in it. But it's a language which is scientific English, which they can learn. It's no harder than learning algebra. Writing academic English is much easier than writing conversational English. I mean, if I wrote conversational French, then the French would laugh at me; if I write scientific French it's a bit of an improvement, and if I actually wrote very much scientific French it would soon become indistinguishable from a French scientist's.

The language is simpler. It needs to be, just because it is international. While there's no way I could write like a French novelist—I could read any amount of that and not be able to write in that style because there's far too much that I didn't learn through not having French as my mother tongue. But scientific French is absolutely no problem. Same with reading. I examined a Ph.D. in Spanish and I don't speak Spanish. I arrived there—I'd got the thesis with me—and I spent the entire afternoon on the beach reading the thesis in Spanish. And it started off rather difficult, and I was relying mainly on the figures, but after three or four hours, it's so repetitive, the same use of the same structures, I was actually reading it quite fluently. Then I went to the defence the next day, and the student had told me that he would start with a minute in Spanish and then switch to English for the rest of the presentation, and after his minute in Spanish I just could not pick out a single word of that; I couldn't even detect the title of the thesis—and this after spending the whole of the previous afternoon reading. That's the difference between the scientific writing and the rest of language.