THE OA INTERVIEWS: KAMILA MARKRAM, CEO AND CO-FOUNDER OF FRONTIERS

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6th February 2016

Based in Switzerland, the open access publisher Frontiers was founded in 2007 by Kamila and Henry Markram, who are both neuroscientists at the Swiss Federal Institute of Technology in Lausanne. Henry Markram is also director of the Human Brain Project.

A researcher-led initiative envisaged as being "by scientists, for scientists" the mission of Frontiers was to create a "community-oriented open access scholarly publisher and social networking platform for researchers."

To this end, Frontiers has been innovative in a number of ways, most notably with its "collaborative peer review process". This abjures the traditional hierarchical approach to editorial decisions in favour of reaching "consensual" outcomes. In addition, papers are judged in an "impact-neutral" way: while expected to meet an objective threshold before being publicly validated as a correct scientific contribution, their significance and impact are not assessed.

Frontiers has also experimented with a variety of novel publication formats, created Loop – a "research network" intended to foster and support open science – and pioneered altmetrics before the term had been coined.

Two other important components of the Frontiers concept were that it would operate on a non-profit basis (via the Frontiers Research Foundation), and that while it would initially levy article-processing charges (APCs) for publishing papers, this would subsequently be replaced by a sponsored funding model.

This latter goal has yet to be realised. "We dreamed of a zero-cost model, which was probably too idealistic and it was obviously not possible to start that way", says Kamila Markram below.

Frontiers also quickly concluded that its non-profit status would not allow it to achieve its goals. "We realised early on that we would need more funds to make the vision sustainable and it would not be possible to secure these funds through purely philanthropic means," explains Markram.

Consequently, in 2008 Frontiers reinvented itself as a for-profit publisher called Frontiers Media SA. It also began looking for additional sources of revenue, including patent royalties – seeking, for instance, to patent its peer review process by means of a controversial business method patent.

The patent strategy was also short-lived. "We abandoned the patent application by not taking any action by the specific deadline given by the patent office and deliberately let it die," says Markram, adding, "we soon realised that it is far better just to keep innovating than waste one's time on a patent." (Henry Markram nevertheless remains an active patent applicant).

By the time the peer review patent had died it was in any case apparent that Frontiers' pay-to-publish model was working well. In fact, business was booming, and to date Frontiers has published around 41,000 papers by 120,000 authors. It has also recruited 59,000 editors, and currently publishes 54 journals. By 2011 the company had turned "cash positive" (five years after it was founded).

Successes not unnoticed

Frontiers' successes did not go unnoticed. Not only did it quickly gain mindshare amongst researchers, but it began to attract the attention of publishers, not least Nature Publishing Group (NPG), which in February 2013 announced that was entering into a relationship with Frontiers.

The exact nature of this relationship was, however, somewhat elusive. In its press release Nature *described it as a "strategic alliance". An associated news item in Nature reported that Frontiers had been "snapped up" by NPG, which was taking a "majority investment" in the company.*

*A post on the Frontiers web site also talked of NPG taking a "majority investment", and quoted an approving Philip Campbell (*Nature's *Editor-in-Chief) saying, "Frontiers is innovating in many ways that are of interest to us and to the scientific community".*

In reality it was Holtzbrinck Publishing Group that had invested in Frontiers, not NPG, although Holtzbrinck was the owner of Macmillan Science and Education (and thus of NPG).

It was also unclear as to whether the money that Holtzbrinck had invested in Frontiers could be described as a "majority investment". Speaking to Science in 2015, Frontier's Executive Editor Frederick Fenter described it rather as a "minority share".

Either way, the precarious nature of Frontier's relationship with Nature *became all too evident in January 2015, when it was announced that Macmillan Science and Education (along with NPG) was merging with German science publisher Springer. There was no mention of Frontiers, and the situation was only clarified when Macmillan posted a tweet in response to the enquiries it was receiving about the status of Frontiers.*

Looking back, it would appear the much-lauded relationship between NPG and Frontiers was more wish fulfilment than substance – encapsulated perhaps by a glossy 7-minute video produced at the time that (amongst other things) includes a clip of the CEO of Macmillan Science and Education (and former MD of NPG) Annette Thomas welcoming Frontiers to Macmillan's office in London, lauding its achievements and promise, but failing to specify what exactly Nature *planned to do with Frontiers.*

The true state of affairs does not appear to have been publicly acknowledged until the 2015 Science *article cited above. When asked to clarify the situation Fenter replied: "We made the decision about 6 months ago to make a clean separation and never to mention again that [NPG] has some kind of involvement in Frontiers."*

Critics

Like most successful open access publishers Frontiers has attracted controversy along the way. There have been complaints, for instance, about its peer review process (including an oft-repeated claim that its editorial system does not allow papers to be rejected), complaints about the level of "spam" it bombards researchers with, and complaints that its mode of operating is inappropriately similar to the one used by multi-level marketing company Amway. (By, for instance, requiring editors to recruit further editors within a pyramidal editorial and journal structure, setting editors targets for the number of papers they have to publish in their journal each year, and requiring that they themselves publish in the journal).

There have also been complaints about the way that Frontiers promotes itself on its blog. Its posts have attracted considerable attention (including from high-profile media outlets like the Times Higher) but critics argue that while its contributions tend to be presented as research the data is cherry-picked in a self-serving way. See, for instance, here, here, here, here, and here.

In addition, Frontiers has attracted criticism for publishing a number of controversial papers (see here and here for instance), and in 2014 it was accused of caving in to specious libel threats by retracting a legitimate paper. The latter led to Frontiers' associate editor Björn Brembs publicly resigning.

A number of other prominent researchers have publicly criticised Frontiers too. In June, for instance, a blog critique was posted by Dorothy Bishop, Professor of Developmental Neuropsychology at the University of Oxford, and another one a month later by Melissa Terras, Professor of Digital Humanities in the Department of Information Studies at University College London (UCL).

More recently, in January, Micah Allen, a Cognitive neuroscientist at UCL, rehearsed the various complaints against Frontiers in a blog post entitled "Is Frontiers in Trouble".

But the most controversial incident occurred last May, when Frontiers sacked 31 editors amid a row over independence. The editors complained that Frontiers' publication practices are designed to maximise the company's profits, not the quality of papers, and that this could harm patients.

The wave of criticism reached a peak last October when Jeffrey Beall added Frontiers to his list of "potential, possible, or probable predatory scholarly open-access publishers".

Supporters

On the other hand, Frontiers has no shortage of fans and supporters, not least amongst its army of editors and authors. It has also received public support from a number of industry organisations.

In a statement posted on its web site last year, for instance, the Committee on Publication Ethics (COPE) said, "We note that there have been vigorous discussions about, and some editors are uncomfortable with, the editorial processes at Frontiers. However, the processes are declared clearly on the publisher's site and we do not believe there is any attempt to deceive either editors or authors about these processes. Publishing is evolving rapidly and

new models are being tried out. At this point we have no concerns about Frontiers being a COPE member and are happy to work with them as they explore these new models."

And in response to questions being asked about the role that Frontiers' journal manager Mirjam Curno plays at COPE the statement added, "Frontiers has been a member of COPE since January 2015. In the interests of complete transparency, we note here also that one of the Frontiers staff, Mirjam Curno, is a member of COPE council – a position she was elected to when she was employed at the Journal of the International AIDS Society *in 2012 and which continued (with the agreement of the COPE Council and on becoming an Associate Member of COPE) after she moved to Frontiers; she is now also a trustee of COPE."*

Around the same time the Open Access Scholarly Publishers Association (OASPA) published this comment: "We are aware that concerns have recently been expressed about the publisher Frontiers, which is a member of OASPA. We have discussed the situation with Frontiers, who have been very responsive in providing us with information on their editorial processes and explaining their procedures. In light of these responses, the Membership Committee remains fully satisfied that Frontiers meets the requirements for membership of OASPA."

(We could note in passing that Frontiers' Executive Editor Frederick Fenter was a candidate for OASPA's Board in 2015).

As will perhaps be evident, a central focus for the complaints about Frontiers are its editorial processes, including the claim that its online system does not allow papers to be rejected. Markram agrees that there has been some confusion over this. While insisting that reviewers have always been able to reject papers, she acknowledges below that feedback indicated "it was not clear to them how to recommend a manuscript for rejection to the handling Editor."

This issue, she says, has now been addressed. "Based on the feedback we have now renamed this option withdraw from review/recommend rejection*, and the reasons, which reviewers can choose from to indicate why, have also been split accordingly."*

Daniel Lakens, an assistant professor at Eindhoven University of Technology, has experienced Frontiers as author, reviewer and editor. He has published several papers, and was for two years an associate editor for Frontiers in Cognition*, resigning last month due to a lack of time. He continues to act as a reviewer.*

Lakens suspects that much of the criticism comes from researchers who have failed to understand, or are not comfortable with, Frontiers' distinctive peer review process.

"The review process itself is much more collaborative. This is a good thing if you find good reviewers willing to invest time in improving manuscripts. Forcing scientist to enter a discussion, and respond to arguments from the other side, leads to bigger improvements in manuscripts than at traditional journals, in my opinion. But it really depends on the mind-set of the reviewers and authors."

The other important difference, he says, is Frontiers' commitment to publishing methodologically sound research, regardless of significance levels or novelty.

"Publication bias is probably the biggest challenge that modern science faces. I think it is important that Frontiers takes a responsibility in publishing all sound research. Some reviewers, more used to traditional journals, just want to reject papers they don't like. For example, this happened when I submitted my own article to Frontiers, where a reviewer thought there was nothing novel in my explanation of effect sizes, and withdrew from the revision process. It would have been better if this reviewer had instead provided some suggestions to improve it (which was no doubt possible), because the rather substantial interest in the article (it has been cited 200+ times) suggests his judgment about the novelty of the paper seems to have been irrelevant."

Lakens is also sceptical about claims that it is not possible to reject papers. "Every manuscript I wanted to reject as a Frontiers editor has been rejected."

Radical when it started

Lakens adds: "Frontiers was radical when it started and paved the way for even more radical open access journals. The collaborative review process is still in many ways novel and, very often, an improvement over the traditional peer review process. But now we see even more innovative journals than Frontiers emerging. One example is PeerJ, which greatly reduces the cost of open access publishing, and also embraces open reviews."

In truth, impact-neutral reviewing was pioneered by PLOS ONE in 2006, a year before Frontiers appeared on the scene. But implicit in Lakens' statement, I think, is a belief that while it has played an important part in promoting new types of peer review, Frontiers now faces competition from younger, more innovative, and less expensive publishers like PeerJ and F1000Research.

It clearly will not help that Beall has added Frontiers to his list, which Lakens believes could encourage researchers to shun the publisher. "Many scientists are sensitive to prestige, and if these researchers would not be able to evaluate the quality of science themselves, they might think twice about submitting to Frontiers, although I would hope this group is rather small."

Beall, of course, is himself a controversial figure, and his list is widely criticised by open access advocates. "I think Beall's list is not transparent," says Lakens. "Inclusions are not justified, and occur on the basis of the personal opinion of a single individual. The scientific community should ignore Beall's list, and pay more attention to the Directory of Open Access Journals (although no list will be perfect). I think Frontiers should take valid criticisms seriously, because in science, there is always room for improvement, but I don't think Beall's list falls on the category of 'valid criticism'."

It is indeed remarkable to think that the decisions of a lone librarian sitting in a university library in Denver, Colorado could have a significant (and global) impact on a publisher. Only too aware of this, in December Frontiers dispatched Fenter and Curno to Colorado to meet with Beall and try and persuade him to take Frontiers back off his list – apparently without success.

Underlying all this, of course, is the fact that the emergence of the Internet has triggered manifold controversies within the research community. Above all, it has plunged scholarly communication into a period of considerable upheaval, and put inherited ways of doing

things under growing pressure, not least traditional peer review. The cost of publishing research papers is a further source of often bitter disagreement – and open access publishing has amplified both issues.

A key question here seems to be how publishers find an appropriate role for themselves in the emerging new landscape. In the Q&A below Markram says that "dumping all content on the Internet, unchecked, in multiple versions of readiness, and as cheaply as possible, is not a service to anyone".

Many, if not most, would doubtless agree with this, which would seem to imply a continuing gatekeeping role for publishers. But who these publishers should be, exactly what kind of service they should provide, and what they should charge for that service remains unresolved.

On the issue of costs, Markram asserts that under the traditional subscription system it costs $7,000 to publish an article, a figure she says that OA publishers have reduced to around $2,000, and Frontiers to just $1,100.

I am sure many would challenge these figures, but I will finish with two (rhetorical) questions: First (leaving aside the issue of whether pedestrian papers written solely in order to bulk up CVs should in fact be formally published), if the average rejection rate at Frontiers is (as Markram says below) just 19% (i.e. 81% are accepted), and if some of those articles turn out not even to have met Frontiers' lower threshold for publication (As Markram points it, "no peer-review is bullet-proof, so problematic articles regrettably do sometimes get through) then does $1,100 (or $2,000) per paper represent good value for money? Second, how high does the acceptance rate need to go before simply dumping papers on the Internet becomes a logical way for the research community to save itself millions of dollars a year?

Please read on for Markram's detailed answers. Readers should be aware that the Q&A is long. I have chosen not to edit Kamila Markram's text and there are some repetitions, but I was keen to allow her to address my questions in her own words, and as fully as she felt to be appropriate. I have, however, made ample use of pull-quotes to guide those who might prefer to simply scan the interview.

The interview begins ….

Kamila Markram

RP: As I understand it, you founded Frontiers with your husband Henry Markram in 2007. Can you start by telling me briefly why you decided to become publishers, and why open access publishers?

KM: With approximately 2- 2.5 million peer-reviewed academic papers published per year, we see academia as a river of knowledge that powers society. We started Frontiers because we felt that a publisher should not direct the flow of research knowledge, and that all bias or political decisions in deciding whether a paper is published should be removed.

> *"Research can only have its full impact on society if all content is open to all, so open access is the only option. Information will always 'fight' to be free, so this is the inevitable direction publishing will evolve towards"*

At Frontiers our mission is to let this river flow by operating on an impact-neutral basis, leveraging from the most advanced technology to make publishing an efficient process rich with possibilities and making research open access. We don't see ourselves as a traditional publisher, but as a technology-driven service provider academia can use to communicate peer-reviewed research.

Research can only have its full impact on society if all content is open to all, so open access is the only option. Information will always "fight" to be free, so this is the inevitable direction publishing will evolve towards.

RP: Could you say something about the history of the various Frontiers organisations? When you launched in 2007 Peter Suber reported that the publisher was the initiative of an organisation called Frontiers Research Foundation (FRF), which he described as an international non-profit foundation based in Switzerland. Two years later (2009) Suber reported the launch of "Friends of Frontiers" (FoF), another non-profit organisation. Suber's links to both organisations today go to the front page of Frontiers Media, which I take to be a for-profit company based in Switzerland. Can you talk me through when, why

and how the publisher transitioned from a non-profit into a for-profit organisation and what became of FRF and FoF? Suber also reported that when it launched FoF was requesting donations. How much did it receive in donations, and what were these used for?

KM: Our first discussions on how publishers are directing science and how academics can take back control and become fully responsible for research knowledge, goes back to around 1998 with a group of neuroscientists at a conference in Japan. This included Sten Grillner who was at that time on the Nobel Committee.

The discussion continued over the years with many colleagues in neuroscience and related areas – Henry and I are neuroscientists. It was in a meeting organised by Miguel Nicolelis in Brazil in 2005 that we decided together with Idan Segev, the current Chief Editor of *Frontiers in Neuroscience*, that it was time to stop complaining about the broken system and do something about it.

In 2005, Henry and I began to formally develop the model and design the workflows. In 2006 we formed Frontiers Research Foundation, a Swiss non-profit entity, with the idealistic belief that all of academia would support the idea to regain responsibility over publishing for the benefit of society. Henry and I started the foundation with our own funds and formed Friends of Frontiers just as a concept, not as any legal entity, to raise additional funds.

While we raised a total of about 400,000 Swiss francs including that from local philanthropists, it was very difficult and we were still the largest single contributor. The Frontiers Research Foundation used these funds to support the first phase of development and the launch of Frontiers. Our first journal "*Frontiers in Neuroscience*" launched at the end of 2007 and formally opened for submission at the beginning of 2008.

We realised early on that we would need more funds to make the vision sustainable and it would not be possible to secure these funds through purely philanthropic means – a long-term solution was needed. In 2008, we formed Frontiers Media SA, a commercial entity to secure investments.

"Developing and offering for-profit-services is legitimate and a vital direction for academic publishing to evolve towards. It puts researchers back in control as they can choose a publisher based on the quality of the service it offers"

Frontiers Media SA is today still the main legal and business entity that operates our IT platform and journals. We now have close to 200 employees and multiple service providers.

The vision and mission is to move academic publishing to a service-oriented industry for science communication. We believe that by developing and offering a wide range of high-quality services the specific service of handling and publishing an article itself could be minimised. We dreamed of a zero-cost model, which was probably too idealistic and it was obviously not possible to start that way.

Developing and offering for-profit-services is legitimate and a vital direction for academic publishing to evolve towards. It puts researchers back in control as they can choose a publisher based on the quality of the service it offers – publishers should become service providers rather than knowledge holders and shapers.

We see a future where publishers strive to offer a palette of services, work towards producing the highest value and compete against each other over pricing to offer academics the best value possible.

Frontiers Research Foundation still exists today and serves as the non-profit arm of Frontiers. It funded – with donations from Frontiers Media and the Jacobs Foundation – the development and launch of "*Frontiers for Young Minds*." This is a free science journal for kids, launched based on a proposal by the current Chief Editor, Robert Knight from Berkley University.

RP: There has been criticism of the decision to make your husband editor-in-chief of Frontiers, with some complaining that it confuses the roles of editor and publisher. Is he still EiC? If so, how would you respond to such criticism?

KM: Henry developed the original model of Frontiers, and he and I evolved it together with many of the other Chief Editors over the years. As Editor-in-Chief of Frontiers, he oversees the implementation of the Frontiers model and revises the model based on feedback received from the editors and the research community.

In his capacity as Frontiers Editor-in-Chief, he has no role in deciding over content and therefore cannot influence accept or reject decisions. In the case of retractions, he does the final check by ensuring the Community Retraction Protocol was followed, but is not involved in the actual decision to retract a paper.

It is quite a different role compared to what most are used to in an Editor-in-Chief. He often publishes in Frontiers, but he also publishes in many other journals, including PLOS journals, *Scientific Reports* and BMC journals.

He also publishes in subscription journals and choses the open-access option when offered, such as by PNAS – which by the way is far more expensive than most gold open access fees.

He has no control over a paper he submits to Frontiers and the Associate Editor and reviewers are openly acknowledged on the paper for public accountability. We do believe we have managed to build a publisher that removes collusion and politics from publishing.

RP: In his 2009 report Suber commented, "In the fall of 2007, the Frontiers Research Foundation launched an OA journal, Frontiers in Neuroscience. At the time it was definitely OA and today it's less clear. All the articles I tested in the current issue are gratis OA. But the journal charges subscriptions, which cost €149 for individuals and €199 for institutions. If the full text is OA and the subscriptions are only for a print edition, then the subscription page doesn't say so." Has/does Frontiers ever sold/sell subscriptions to any of its journals or to any other products? If so, how did/does this fit with Frontier's main business model, which I take to be pay-to-publish gold OA?

KM: All of Frontiers online articles have been open access from the very beginning. As this was the early days of the open-access movement, we thought we should also produce hardcopies as an extra service.

We invested heavily into producing the most stunning hard-copy magazine for a few months. It drained almost all of our funds and no one wanted to buy hardcopies anymore. It was a lot of fun, but we were forced to abandon the hardcopy service.

RP: Frontiers is clearly keen to innovate. For instance, it pioneered something it calls Interactive Review, which I believe earned it the ALPSP Gold Prize for Innovation in Publishing in 2014. What is distinctive about Frontier's review process, and what was the logic for doing things differently, and in the way it does?

KM: Frontiers has innovated on many fronts. In fact, we assign a high fraction of our budget to IT and innovation.

Our hallmark "collaborative peer review" is founded on a number of guiding principles:

If researchers are to take control of the publishing process, there must be complete **editorial independence**. Operationally, this means that the external editors make all decisions on content through the use of the digital editorial office. Peer review is in their hands.

All reviews by our external editorial boards is carried out in **an impact-neutral manner**. This is a specialist review without the requirement to assess the significance and impact of a paper (see here for details). They are asked to apply an objective threshold for acceptance, namely, whether the paper can be publicly validated as a correct scientific contribution.

As you know, the names of all reviewers and handling editors are published on each Frontiers paper and we developed profiles so that readers can easily read up, not only on the authors, but also on the editors and reviewers.

Knowing that the people involved will be named on the paper ensures transparency and a collaborative, constructive peer-review process. It also builds a chain of accountability that becomes part of the academic record. If a problematic paper is passed into the river of knowledge, then those responsible are openly traceable.

"We've published over 40,000 papers peer-reviewed this way, and the process works extremely well"

The spirit of collaboration is further enhanced by our **interactive review** forum that strives to reach **consensus** amongst editors and reviewers. This is only possible with the technology behind our platform. In case of disputes, we have arbitrators invited by the Associate Editors.

Finally, our development of **impact metrics** is deeply connected to our philosophy on peer review. Post-publication, real-time monitoring of the actual impact of a paper replaces the need for reviewers to make subjective and isolated calls on the potential impact. It also allows

us to flag particularly successful articles for "tiering," a process in which we invite the authors to write a Focused Review of their discovery to a broader audience.

We've published over 40,000 papers peer-reviewed this way, and the process works extremely well. A recent analysis we conducted on the 16 Frontiers journals listed in the 2014 Journal Citation Reports (JCR) showed that Frontiers journals receive amongst the highest impact factors (IF) in open access, score highly compared to subscription journals and are amongst the most-cited journals in the world (see analysis for *Frontiers in* Human Neuroscience, Psychology, Plant Science, Physiology, Microbiology, Pharmacology and Neuroscience).

Such results are only possible with a rigorous peer-review by our stellar editorial boards and the strong commitment of our Chief and Associate Editors to take charge of publishing. It's really a combination between the community taking charge of publishing, the outstanding researchers that stand behind the Frontiers model, the advanced technology on which Frontiers is built and the dedicated support Frontiers provides the editors. That the Frontiers peer-review process produces high-quality open-access articles is no longer just an idea; we have objective proof that it greatly enhances article quality.

"[W]e know that no peer-review is bullet-proof, so problematic articles regrettably do sometimes get through. We have a Community Retraction Protocol so that if there is any evidence a paper is unsound or unethical, it can be reconsidered by an independent body and the paper can be retracted"

The Frontiers process for handling papers is rigorous. For example, while many publishers were caught when a "scam paper" was submitted to many journals, the scam paper was rejected within a few hours of being submitted to Frontiers.

However, we know that no peer-review is bullet-proof, so problematic articles regrettably do sometimes get through. We have a Community Retraction Protocol so that if there is any evidence a paper is unsound or unethical, it can be reconsidered by an independent body and the paper can be retracted.

No employee of Frontiers decides to retract a paper; it is the research community that is empowered to make the decision. Nevertheless, we are constantly finding ways to flag articles by authors who have not realised how such articles can damage their careers, and when one is discovered, we use it as a learning experience to improve our processes even more.

Frontiers also developed the **research network, Loop**, to help disseminate articles within relevant communities. We are now starting to see that Loop can indeed help to disseminate articles and greatly enhance article views and downloads – not only of Frontiers articles, but articles published in other journals as well.

Enabling the stream of knowledge to flow

RP: Frontiers has been innovative in other ways too. Like other publishers, it publishes original research articles and case reports etc., but it also publishes other types of research. You mentioned Focused Review. It also publishes what it calls Research Topics, Frontiers Commentary and eBooks etc. Can you talk me though these different publishing options, how they fit together, and what you feel is distinctive about Frontiers in terms of its publishing programme? What is the objective of offering publishing options that other publishers do not offer?

KM: Frontiers is trying to shift scholarly publishing to a service industry for science communication. Our mission is therefore to offer services academics want and enable the stream of knowledge to flow.

Our article types are usually proposed by researchers and editors. We offer different article types to serve the various publishing needs of researchers and adapt the APC to the specific type of article. This is not because it costs much less or more to publish each type, but because different types of articles have more or less value for the knowledgebase of research.

We have numerous types of discounts available for academics depending on the funding resources of the different communities – and some journals we will be launching in the future will need to be partially or even fully subsidised. We also grant a significant number of waivers depending on national or individual research budgets.

"We also received requests from researchers to publish hardcopies and eBooks of these Research Topics, so we published many of those as well. They are free to download and distribute. They are also listed in the Directory of Open Access Books"

Introducing **Research Topics** was also an innovation. Journals are normally constrained by a structure – the name, mission and scope. Research Topics is a service that allows unstructured niche areas for researchers to emerge spontaneously. We do not want to fix what research should become.

Research Topics cater to the most specialised communities, allowing their members to fully and independently decide on the area of focus and to shape how their own research is reported. Proposals are reviewed by Chief Editors, and then they are edited and reviewed by researchers.

At Frontiers, we have built a publishing platform to cater to this need, we promote these Research Topics, provide feedback through impact metrics, showcase the authors and editors, and so forth. We also received requests from researchers to publish hardcopies and eBooks of these Research Topics, so we published many of those as well. They are free to download and distribute. They are also listed in the Directory of Open Access Books (DOAB).

The **Focused Review** is our prestigious article type. As mentioned earlier, tens of thousands of researchers voted the article to the top. Our impact service evaluates views and downloads

over a certain period of time after publication in a specialty section and provides the Chief Editors with a selection of the most-viewed and most downloaded articles. After validation by the Chief Editor, these are selected as "tier-climbing" discoveries.

There are no APC fees for this article type. The Chief Editors invite these authors to write up a Focused Review that puts the original discovery into a broader context for a wider audience. In this way we highlight the best articles by combining objective article-level impact metrics with the editorial judgement of Chief Editors.

You also mention the **General Commentary**. This article type allows authors to comment on any article published by Frontiers or any other publisher. It is another of several article types that are offered at a zero APC at Frontiers because they participate in scholarly discourse.

As open-access publishing matures and as the attention of researchers shifts to a more service-providing mentality, we are confident that our approach at Frontiers to empower research communities through innovation will prove to be an important contribution.

RP: You mentioned impact metrics. I think I am right in saying that Frontiers also pioneered altmetrics before the term had been coined (which happened in 2010)? What was the logic for this innovation and how has it developed over time?

KM: We conceived of an entire suit of metrics when we created the Frontiers publishing model. We launched in 2008 with tracking of readership (views and downloads) for articles and aggregated this information at the journal level.

In 2011, we launched author-level metrics and started evaluating reviewers based on how the articles they reviewed performed in terms of views and downloads. We started working with Altmetric and implemented their suit of enhanced metric services (tweets and online media mentions) across all Frontiers articles in 2012. In 2015, we rolled out Author Impact Metrics on Loop profiles.

To us, impact metrics – views, downloads, citations, and demographics – provide objective and democratic ways to evaluate research, as it takes into account the behaviour of many readers, even social buzz about an article can be telling.

We have been developing profiles for authors and editors since 2010 as we wanted user metrics to take into account the expertise of the reader. This is still work in progress as the value of research networking takes time to prove to researchers.

RP: You said that Frontiers has published some 40,000 papers using its collaborative review process. Can you give me some more statistics to demonstrate Frontier's growth and success, including, say, page views, downloads, number of authors who have published with Frontiers etc.?

KM: In just 7 years, Frontiers has become one of the largest open-access publishers and is in the top 12% in terms of impact factor across more than ~11,000 journals in the Journal Citation Reports.

Many outstanding scientists have joined Frontiers to serve as editors. More than 120,000 authors have published with Frontiers — many of them from the world's top universities (see here).

Articles have been viewed more than 100 million times and downloaded 25 million times. Monthly article views are currently at 4 million and downloads are at 1 million. The download/view ratio is between 1:4 and 1:3.

"We do not set rejection rates. The mandate of reviewers is to improve papers and only reject a paper if it is unsound science or irreparable"

While we do not have enough data from other open-access journals, this ratio is exceptionally high in comparison. These views and downloads are translating into citations – i.e. citation a few years ahead can be predicted.

Several of our journals were the most cited open-access journals in their respective fields in 2014. *Frontiers in Human Neuroscience* and *Frontiers in Psychology* were also the #1 and #2 most cited psychology journal overall (based on articles published in 2012 and 2013). *Frontiers in Plant Science* is the #7 most cited plant science journal. Other Frontiers journals follow similar trends.

We attribute this success to our collaborative peer-review process, the remarkable researchers who serve on the editorial boards, the exceptional support we provide for these editors and the advanced technology Frontiers has developed to make the entire process efficient – and also the extensive efforts we go through to ensure each article published is read by the right audience.

The Loop platform, for example, was specifically designed to promote authors, editors and their publications and is easy for external search engines to pick up. Publishing open access is no longer enough today, we are all drowning in papers, so we built this technology to enhance discoverability and dissemination. It is all part of what we see as a high value service to authors.

RP: You mentioned APC discounts and subsidised journals. Can you tell me how many waivers have been given over the past few years, and what the trend is here?

KM: We granted US$1.9 million in full or partial waivers in 2014 and slightly above in 2015. This is an increase of 130% over 2013.

RP: And can you say what Frontiers' acceptance rates have been over the past few years. (In 2013 The Economist reported that acceptance rates were 80-90%. Is that still the case?)

We do not set rejection rates. The mandate of reviewers is to improve papers and only reject a paper if it is unsound science or irreparable.

Rejection rates vary considerably depending on article type and journal. Some article types, such as Grand Challenges by Chief Editors, invited Inaugural article types by Associate Editors, and Focused Reviews by tier-climbing authors have negligible rejection rates.

Rejection rates for Original Research Articles in some journals are above 35% and it also depends on the maturity of the journal and the community. In 2015 the average rejection rate was around 19%.

"I see researchers as the giants on whose shoulders modern society is built. Our mission is to increase their overall visibility and raise impact for their work"

We do see a trend for rejection rates of Reviews and Original Research Articles to increase, but that is not because Frontiers imposes any target rejection rate. We believe it is more important to focus on enhancing the quality of legitimate scientific papers than on rejection rates. It is a false belief to think that a target rejection rate guarantees quality. The data does not support this claim (see here).

RP: You mentioned Loop. Last year Frontiers said that Loop had 200,000 active users three months after its launch. That seems like a surprisingly high number. Is this because Loop is the latest incarnation of an earlier networking platform, and so most users have simply been imported from the existing one? And am I right in thinking that creating a Loop profile is obligatory for Frontiers' authors? Also, Loop was intended to foster and support open science. You said earlier that Loop was helping to disseminate articles and enhance article views and downloads. Is this essentially what supporting open science is, or is there more to Loop? Is it living up to Frontiers' expectation? If so, what other evidence is there to demonstrate that Loop is achieving its purpose?

KM: Loop was previously the Frontiers Research Network (read the full history here). We started with online profiles in 2010 because we believe readers should easily be able to see who the authors of a paper are, who edited and reviewed any paper and who the editors on the editorial boards are.
Transparency and accountability is part of our general strategy to shift responsibility for publishing back into the hands of researchers. Basic information on Loop profiles is obligatory, but the researcher can choose to make the profile public or private.

Loop also plays a great part in our mission to make researchers more discoverable and increase impact for their publications. In 2015, we started to integrate Loop not only into the Frontiers journal platform, but also into other academic websites, such as 34 Nature journals and Universidad Politécnica de Madrid. We also integrated with ORCID to facilitate the exchange of publication lists.

We have also been working intensely on semantic algorithms to match publications to researchers and disseminate their work in a targeted way and provide impact statistics. In January 2016, researchers confirmed more than 300,000 publications to their online profiles and their Loop profiles received close to 1 million views.

I see researchers as the giants on whose shoulders modern society is built. Our mission is to increase their overall visibility and raise impact for their work.

RP: You said that Research Topics are later published as eBooks. I was wondering why either Frontiers or authors might want to do that, so I contacted a few of the authors. Only one replied. He said, "I believe that the eBook increases the exposure of the articles. In addition, the individuals that hosted the Research Topic edit the eBook and receive 'credit' as the editor of the eBook (which receives a ISBN) when it is published". What is the credit he is referring to here, and why is it valuable to authors? And what is the benefit to Frontiers of creating eBooks? I understand that they are being sold on Amazon. Is that the point: Frontiers is generating revenue from selling them?

KM: Authors asked for eBooks for Research Topics, so we established the service for them. They are free to download and are listed in the Directory of open access Books. It helps bring all the related work together and showcase a Research Topic.

If someone is selling them on Amazon, then they have developed a business around free eBooks – Frontiers is not involved in any way. The copyrights belong to the authors under a CC-BY license to everyone to use the content as they wish provided they are properly acknowledged.

Editorial independence

RP: You stressed the importance of editorial independence. You also talked of the desire to remove "all bias or political decisions in deciding whether a paper is published." I am thinking that perhaps this can create tensions. For instance, I have had researchers tell me that they find it very hard to have papers they have been asked to review rejected. One told me that in 2012 they were asked to review a very bad paper for a Frontiers' journal, a paper that only referred to its own data and which provided an incomplete background. The reviewer was puzzled to discover that the online review system offered no option for rejecting papers. As a result, the paper's authors were allowed rebuttal after rebuttal, without being rejected. The problem was that the authors did not understand the background, so the manuscript did not improve over time. When the issue was raised with the scientific editor the reply came back: "the protocol for these things dictates that a rejection has to be approved right up the hierarchy." (Presumably Frontiers' staff). That does not seem to imply editorial independence does it?

KM: Frontiers staff do not take editorial decisions; we neither accept nor reject articles. Employees of Frontiers, journal managers, journal coordinators and assistants safeguard our collaborative peer-review principles and mostly support our editors in routine work, look out for conflicts-of-interest, perform basic quality checks on manuscripts, run iThenticate software to check for plagiarism, etc.

Potentially problematic manuscripts are of course brought to the attention of editors. I do not know what case you are referring to, but there have been individual cases of misunderstanding or genuine error in the past; I am sure other publishers would have experienced similar issues.

Over the years, we have built in many quality checks that are clearly communicated and we strive for continuous improvement with feedback. Overall, our peer-review enjoys 80-90% satisfaction rates based on our continuously conducted surveys on 11,000+ authors, reviewers and editors to date.

This is how accept/reject decisions are reached: The Frontiers peer-review embodies many principles designed to make peer-review a self-responsible process. It operates by putting several forces against each other.

A paper can be rejected before peer-review begins if it is judged not be reviewable by the Associate Editor, but once it is admitted through the peer-review door, the authors are given a chance to address the reviewers' comments at least once – that is our commitment to authors and one of our foundation stones for the peer-review. It is not easy to accept an article in Frontiers because the reviewers and editor agree to publicly endorse the paper with their names. This is already a strong barrier.

We developed the interactive review forum to help the authors, editor and reviewers converge. If all fails, then an arbitration is initiated to help the reviewers and editor separate subjective from objective issues. Acceptances are done directly by the Associate Editors; rejection recommendations are forwarded to the Chief Editor.

"Recommending rejection by a reviewer has of course always been possible"

In both cases the decision is sent up to the Field Chief Editor to check that all was handled appropriately (i.e. that all editor and author rights have been respected) before final rejection. If the Chief Editors does not intervene within a certain time frame, acceptances by Associate Editors go through. The editors operating the peer-review are typically among the leaders in their fields so they are completely entrusted with the process.

We have fine-tuned the model dozens of times over the past 7 years based on feedback from our editors and reviewers. It is true that we have also heard the feedback from some of our reviewers that it was not clear to them how to recommend a manuscript for rejection to the handling Editor.

Recommending rejection by a reviewer has of course always been possible. Nearly 3,000 manuscripts have been rejected just in 2015. Back when we conceived the Frontiers model we were concerned that traditionally it had been drilled into reviewers that their default mission was to reject a manuscript.

We wanted to ensure that the impact-neutral review mandate was clear to reviewers and gave them two options: endorse the manuscript or withdraw from review, which they could do at any stage. Under the withdraw option they could indicate their reason for wishing to discontinue being engaged in the discussion.

Based on the feedback we have now renamed this option *withdraw from review/recommend rejection*, and the reasons, which reviewers can choose from to indicate why, have also been split accordingly.

The model has worked extremely well for the vast majority of papers. This is demonstrated in the results achieved. Almost all Frontiers journals have become the most cited journals in their categories within just a few years.

RP: I am also conscious that earlier this year Frontiers sacked 31 editors of* Frontiers in Medicine *and* Frontiers in Cardiovascular Medicine*. They appear to have been sacked after complaining that company staff were interfering with editorial decisions and violating core principles of medical publishing. Since then a blogger has claimed that* Frontiers in Medicine *has been operating without an Editor-in-Chief and with few Chief Specialty Editors. He has also claimed that the ethical guidelines put in place by the sacked editors have been abandoned. This too does not seem to imply editorial independence does it?

"The Holtzbrinck Group, owners of Nature Publishing Group (NPG), acquired a stake in Frontiers in 2013. Holtzbrinck also have a board seat on Frontiers Media SA. This enabled collaboration with companies within this group, including NPG"

KM: Our detailed statement on this incident, including these editors' manifesto can be found on our website here. In short, the engagement was ended because these Chief Editors wanted Frontiers to change our fundamental principle of distributed editorial decision-making during peer-review and refused communication with Frontiers, some even blocking journal operations, until their demands were met.

At Frontiers, we deliberately moved away from an all-powerful single gate-keeper model. While Frontiers' Chief Editor have full authority to oversee the peer-review and can veto any accept decision or rejection recommendation, they do not have sole authority. Over 7,000 Associate Editors are entrusted with making these decisions. This balances the power across entire editorial boards, so that a broader group of leaders within any research community can shape the direction of science, rather than any single editor.

Both affected journals were appointed with new prominent Chief Editors and are operated by over 1,500 clinical researchers who safeguard the integrity of the peer-view.

RP: In 2013* Nature *reported that it had bought Frontiers, a development that was viewed as providing a powerful endorsement of what Frontiers has been doing. Earlier this year, however, the owner of* Nature *— Macmillan Science and Education — announced that it was merging with Springer (a merger that was completed in May). Frontiers was not part of that merger, and so has parted company with* Nature*. I can only assume that this must have been a great disappointment to you. Can you explain what happened and why, and say who the shareholders/owners of Frontiers are today?

KM: The Holtzbrinck Group, owners of Nature Publishing Group (NPG), acquired a stake in Frontiers in 2013. Holtzbrinck also have a board seat on Frontiers Media SA. This enabled collaboration with companies within this group, including NPG.

Frontiers has always operated independently of NPG, with separate journal publishing

programs. NPG never had any involvement in the running of Frontiers' platform, operating its journals, creating or applying its editorial policies or appointing its editors.

We initially had a joint marketing campaign where NPG promoted Frontiers via their channels. We realised that our joint communication may have been misleading and confusing and therefore stopped it and built an in-house marketing and communications team.

We cooperate generally on advancing Open Science. For example, Frontiers and NPG collaborate on Loop – as I said earlier, since early 2015, 34 NPG journals have integrated Loop to add Loop profiles for their authors.

"The problem really arises when the impact factor and journal name are used to judge authors and determine their careers. Many have argued how inappropriate this is. But ultimately it is up to universities and funders to change their decision-making process when evaluating researchers for the next position or grant"

We also collaborate on Frontiers for Young Minds, a free journal for kids aged between 8-15 years. The kids also review articles (with a mentor) that are submitted by authors of the latest breakthrough research.

I have never felt any type of disappointment about the merger – to the contrary, I congratulate Springer Nature on their merger and see it as an opportunity to enable further collaboration in the future.

Impact and metrics

RP: You said earlier that Frontiers' mission is to operate on an impact-neutral basis. I realise you were not referring directly to the Impact Factor here, but given the research community's continuing obsession with the IF I assume that it must pose problems for any publisher wanting to innovate, and presumably requires having to communicate contradictory messages. I note, for instance, that you referred me to a blog post containing an analysis of some Frontiers journals. This analysis, the post claims, demonstrates that Frontiers journals are amongst the most cited journals in the world. It goes on to report that 16 Frontiers' journals are listed in the JCR with impact factors. As you know, the impact factor is very controversial, and many claim that it has been entirely discredited. There is presumably also always a temptation to present data in a particular way in order to support a particular argument. When I tweeted the blog post you refer to Professor of Biology at the University of Washington Carl Bergstrom responded by redrawing the Frontiers' graphs with PLOS data added — see here, here and here. Bergstrom's assertion was that Frontiers had cherry-picked the data. Do you agree?

KM: Currently, Frontiers has 16 journals with impact factors, built around specific communities and which are therefore listed in 6 subject categories of the 2014 Journal Citations Reports (JCR), published by Thomson Reuters in 2015. We simply looked at our journals performance within each one of these categories and compared them to other open access journals as well as subscription journals.

We found that within 4 categories, Psychology, Neuroscience, Plant Science and Physiology, the Frontiers journals are the #1 most cited open-access journals. In the other 2 categories, Microbiology and Pharmacology, Frontiers journals are the #2 most cited open-access journals.

Even when compared to long-established subscription journals within these categories, Frontiers journals are still amongst the most cited journals. Across the 11,000+ journals listed in the 2014 JCR, our 16 Frontiers journals rank on average in the top 12% on impact factor (see the full Impact summary here).

This is simply put astonishing and outstanding for such a young publishing program that performs impact-neutral peer-review. It pays tribute to the work and dedication of our editors, some of the world's finest researchers. It also pays tribute to the collaborative principles of our peer-review, the exceptional support the editors receive from our team and the technology we built to make the entire review and publishing process as efficient as possible.

By the way, within the multidisciplinary category of the 2014 JCR (in which Frontiers journals are not listed, because we operate around field-specific communities), PLOS ONE is the most cited journal, beating many of the highest impact factor journals in the world, just like we do within our subject categories.

What this shows is that high-quality open-access is delivering a valuable service to authors that gives what they need most: to be read and cited by their peers.

RP: Do you agree that the impact factor has been sufficiently discredited (not least because journal editors/owners routinely game the system) that it should no longer be used as a measure of the quality of either journals or authors?

KM: We developed Article Level Metrics precisely in order to move the focus of attention to the actual article's performance and away from the journal it is published in – i.e. we do not support judging a scientist or a paper based on what journals the articles are published in.

Our service to the community is to deliver technology (e.g. Loop's dissemination algorithms, Article and Author Impact Metrics) and principles (e.g. open access) that will make sure that their articles are read and cited and that they are acknowledged for their actual work and not the journal's impact factor.

Having said this, the journal impact factor is a metric to judge the performance of a journal – how does this journal compare to another journal with a similar scope, operating in the same field.

As a journal metric the impact factor produced by Thomson Reuters is the current gold standard simply because they do rigorous work on evaluating the journal and the citations. Whether we agree or not, the impact factor still guides author decisions today and – as we have learned along the way – is a pre-requisite to convince authors to submit their articles to your journal in the long run.

The problem really arises when the impact factor and journal name are used to judge authors and determine their careers. Many have argued how inappropriate this is. But ultimately it is

up to universities and funders to change their decision-making process when evaluating researchers for the next position or grant.

As long as they do this based on the journal name there is little hope to break the power of the impact factor. For our part, we are focusing on building and promoting alternative, objective and transparent metrics that put articles and authors at the centre.

RP: You said that no scholarly publishing system is bullet-proof, which is clearly true. Like other publishers, Frontiers has attracted criticism for publishing controversial papers, including one linking scepticism about climate change with conspiratorial ideation (a paper subsequently retracted) and one about HIV denialism (which Frontiers later reclassified as an opinion piece). Perhaps more worryingly, a number of well-regarded researchers have publicly criticised the way Frontiers operates, including Melissa Terras and Dorothy Bishop. Do you think Frontiers' attempts to innovate have made it vulnerable to such criticism? If so, what can be done to address the matter? Is Frontiers doing anything to address it?

> *"[U]unfortunately there is lots of confusion on what it takes to build a high-quality publishing service"*

KM: We have a very strong history of responding to feedback and constructive criticism, which has been vital for the evolution of the model. The challenge is to process the many divergent views and find the one vector that separates the real issues from misunderstandings. This generally requires a much deeper analysis and consideration than is possible through social media channels.

Most often, it requires in-depth discussions with our editors. We care deeply about constructive concerns expressed, but it often takes a while to isolate the issue to find out what the best correction is – and invariably that does not please everyone. The four issues you mention above are very diverse and we have replied in detail either in person or publicly.

RP: In speaking about Frontiers' investments in open access publishing you referred me to an October blog post entitled "Frontiers' financial commitment to open access publishing". The post contains some figures from the company's audited accounts showing that it is currently costing $20 million a year to run Frontiers. Sceptics have suggested that publishing these figures was more of a PR initiative than an exercise in transparency. Walt Crawford pointed out that the post "lumps all the publishing-related stuff into one $6.8 million chunk". The post also notes that Frontiers is spending $6.5M on "innovation" and $2.1M on "growth", but does not provide particulars. As such, it is not clear exactly what this money is being spent on. Would it not have been more meaningful if you had published the complete audited accounts? After all, presumably Frontiers has each year to file its accounts with the equivalent of UK Companies House. Or is there no legal requirement in Switzerland to do this?

KM: Swiss companies are heavily regulated and our accounts are audited every year. We did not aim to publish financials in the format for financial analysts, but simply to explain to

researchers where the money goes, because unfortunately there is lots of confusion on what it takes to build a high-quality publishing service.

I have seen people argue that it only takes an off-the-shelf submission/review system, some typesetting and DOI costs and server rent – and off you go with your publishing program. By posting a detailed explanation of each expenditure category we responded to a request from our chief editors in our recent Chief Editors Summit.

- In 2014, US$ 6.8M was spent on publishing operations. This included expenditure for all our staff who support the functioning of the journals and the peer-review, also technical support staff and help desk, typesetting, copyediting, production and publication of the articles online, and also distributing articles to external repositories, such as PubMed Central, CrossRef and others. Costs for server farms to permanently store articles are also included in this figure. Staff and production around marketing material, promotion of the journals, visiting conferences and organising events also falls into this category.

- US$ 6.5M was spent on IT and Innovation. We have built, and continue to build and enhance, our entire publishing platform in-house. The blog post above specifies the many technology innovations we have pioneered to make the submission, review and publication of articles effortless, and to enhance post-publication dissemination. Frontiers is born in the digital age and is, as far as I know, the first publishing service platform built on the latest online technology. Developing high-quality IT comes at a cost, around 2/3 of our staff are IT related.

- We spent US$2.1M on growth – which was the launch of new journals. We hire staff to support new journals, talk to editors and authors, visit conferences and promote the journals to make them known. This costs. In fact, it takes many years before a new journal starts covering its costs.

- Frontiers supported the community strongly also in terms of honoraria and awards – over a $1 million was paid out.

- $1.9 million went towards waivers and discounts on Article Processing Charges (APCs). APCs should not be an obstacle to make your research results available to the world.

Overall, we employ around 160 highly skilled people in the different areas above across locations in Lausanne, Switzerland where we are headquartered, Madrid, San Francisco, London and India. They make Frontiers happen every day.

No magic, no fairy godmother

RP: In his 2007 report Suber noted that Frontiers planned to "launch with an Author-pay business model to allow open access and free dissemination of research and gradually move to a sponsored model." This transition has not yet occurred. Why not, and when do you expect it to occur? I assume Frontiers intends to abandon the APC at some point?

KM: Looking back at this statement, I think it is naïve. We did not know much about publishing back then, our experience was mostly based on the agony of submitting to traditional journals and the resolution to do it better.

Our grand plan was to build a great publishing platform around a fair and transparent review, impact metrics, etc. and then eventually start offsetting APC costs with alternative revenue streams around new types of services, such as copy-editing, event organisation, and many other ideas we had.

The reality of it is that it is very hard work to build a world-class open-access journal series, it requires the buy-in from many people and an excellent team that only comes to work for your wonderful ideas if you can pay salaries. Above all, one needs clear focus to get it done.

For example, we tried to create an events platform (you can still see it here), but it did not take off as a revenue generator, because with limited recourses you need to make real decisions, "do I focus on making this journal work or something else?"

We finally managed to build a highly successful journal series, including some of the most-cited open-access journals in the world, but this did require a lot of focus, many enthusiastic employees and the buy in from over 60,000 researchers dedicating their time as editors and reviewers.

We have not given up on our initial ideal though. We still would love to develop and offer a range of profitable services that together generate enough revenue to reduce APCs so that any researcher in the world can afford to publish OA, but we are nowhere near this scenario.

RP: When it started, Frontiers was charging APCs of between €575 ($490) and €2,000 ($2,270). Today I think the prices range from $250 to $1,900. How does Frontiers calculate its APCs and how and why has its pricing changed over time?

"We knew what we wanted to achieve and the important change in the world that Frontiers could bring, but it has been trial and error. I very much doubt we would have launched Frontiers if we knew how difficult it was going to be"

KM: We were and still are active scientists. When we started, we did not know what it would ultimately cost to build Frontiers and develop a suite of services. We knew what we wanted to achieve and the important change in the world that Frontiers could bring, but it has been trial and error. I very much doubt we would have launched Frontiers if we knew how difficult it was going to be.

Frontiers has not made a profit since it started and we will not for some time to come. This is because everything (and more) that comes in is ploughed back into building a better and better service (please see Financial Commitment blog post). We developed scalable technology to help keep costs as low as possible. The open access industry as a whole is in its infancy and is finding its way through a maze of issues.

The discussion around open access is equally immature. For example, the discussion about open access only wanting to make money is poorly informed and misplaced. Firstly, very few make profits and if they do it takes many years before they get into this position.

But more importantly, the revenue of the subscription-based publishers in 2014 was estimated to be $14 billion while the number of peer-review article published in that year was around 2 million. This means that universities paid (through overheads on researcher grants) roughly $7,000/article in the subscription model. Open access APC is averaging around $2,000/article (Frontiers averages at around $1,100).

In other words, switching to open access could free roughly $10 billion per year of research money. People are not yet looking at this bigger picture and get confused by those that are not very well informed or those that aim to slow down the transition to open access – as awareness of this spreads, researchers will become better informed on how to judge a publisher's services and understand that providing high quality services does cost, but far less than what they have been paying in the subscription model.

"It is the old model that is hugely expensive and incredibly inefficient"

RP: Earlier you said that your APC price varies not because different types of article cost much less or more to publish but because they "have more or less value for the knowledgebase of research." Does this mean that Frontiers sets it price not to reflect what it costs to publish a paper, but what it thinks researchers (or their funders) will pay?

KM: In short: The APCs cover what it costs to maintain a high-quality publishing operation. We don't spend our time thinking what people might be willing to pay. I rather focus on how to run a sustainable and high-quality publishing service that puts researchers at the centre and maximises the impact for their work.

In long: We operate on an *average* revenue per article and per journal. Over the last few years, our average revenue per article was around $1,100 (well below the industry average, see an independent analysis by 22 UK higher education institutions in 2014 here), but we currently aim for a higher average which would allow more established fields to carry younger fields or fields that do not have fund for OA, such as Humanities and Social Sciences.

Eventually, the price will have to cover costs and the price must equal the value that the service has for researchers. This is basic economics and it is high time publishing moved to healthy economics.

Digital and internet technologies bring efficiency, and they also greatly shrink the global cost of traditional scholarly publishing, which averages right now at a cost of about $7,000 per article. Our average price tag is ~5x lower and a reflection of this disruption and efficacy gain.

In addition, impact-neutral peer-review as operated by Frontiers and many other OA journals, will bring even greater cost savings by removing the wasted costs of researchers spending their time going from one journal to the next to eventually get their work published – a cost that probably dwarfs the actual visible costs, especially if one also considers missed opportunity costs.

It is the old model that is hugely expensive and incredibly inefficient. The hallmark of disruption is that the new model is much more efficient, allowing costs to come down to match the value of the service provided (see here).

Looking at the bigger picture and the open access industry, we are just now at the end of a period during which APCs were subject to lots of experimentation and the huge range we see now across open-access publishers reflects the levels of services provided and the hugely diverse costs to run the operation (salary levels across countries are very different).

In the short-run, as the industry learns to understand costs and establish itself we will see increases in APC as the industry (and researchers) comes to grips with the fact that there are real costs involved in developing, maintaining and offering high-end services.

Once a clear link between the value for services and the APC has been established, new technological advances and disruption, as well as competition for services will likely push prices down.

When publishers find alternative revenue from extra and optional services, prices will also come down. Metrics will insure transparency, as researchers compare the value of services offered versus prices charged by publishers.

For example, there may be a plot of article views, downloads, impact factors and total citations in a journal against its APCs to help researchers assess what value they can expect from a publisher.

There is no magic and no fairy godmother. It costs to develop, maintain and offer high-quality services. You can do it cheaply, but don't expect much. A more detailed picture of the APC landscape is presented here.

RP: You say that the discussion about open access is immature, that the research community does not understand that it costs money to publish journals, and that there is an assumption that OA publishers only want to make money. But that doesn't fully capture the situation I think. After all, we are seeing a growing number of "predatory publishers" emerge, and these companies are quite clearly preying on authors for financial gain, so there are good reasons for suspicion are there not? I am assuming here that you agree there is a problem with predatory publishing. If so, what should the research community be doing about this in your view?

KM: Researchers are in the top 1% most educated people on earth, and I think by far the majority of them should easily be able to judge where to send their paper. Checklists, such as the one on thinkchecksubmit.org provide guidance in case of doubt: "Do I recognise the editors? Are my peers submitting to this journal? Are the contact details clear? Is the website well maintained? Etc." All very obvious things.

There are also long and well-established criteria available through several organisations that perform a series of rigorous quality checks on publishers and journals. Based on the outcome of these quality checks, the organisations include them into their lists and repositories, such as PubMed Central, Medline, Thomson Reuters' Journal Citations Reports, Scopus, Directory of Open Access Journals (DOAJ), OASPA, COPE and others. Authors are usually aware of these lists and use them to see if journals are listed in them.

The purpose of all companies is to provide a service people are willing to pay for and make money in the process. Providing these services costs money. Also non-profit organisations and universities have to pay salaries and infrastructure, to say the least, so there is no free ride here for anybody. Ultimately, it is up to the customer to decide whether the service is worth the price it charges. If the service is not good, customers will dwindle. That should sort out the good from the bad crop.

Finally, and this is the rather cynical aspect in this entire discussion, when it comes to financial gain, the BIG money lies in subscription publishing, an industry that made revenues in excess of $14 Billion on around 2 Million articles published in 2014, averaging the price per article to $7,000.

"No system is perfect and a few papers that should not have got through peer-review will invariably happen"

Whether people have been aware of it or not, $7,000 on average is what it costs researchers, their universities and the public to publish a scholarly article in the subscription model. The uptake of open access is already around 30% and will reach 50% within 3 years.

At an average cost of ~$2,000 per open access article, this implies that the transition to open access will shrink publishing revenues by ~60%, freeing ~$10 Billion in the process to remain at universities for research. This is the power and definition of disruption. Focusing the financial discussion on open access, while leaving out subscription publishing in this context, is not only simple-minded but deliberately smoke and mirrors to slow down the inevitable transition to open access.

Responding to Beall

RP: As it happens, the issue of predatory publishing has become personal for you: Last October Jeffrey Beall added Frontiers to his list of "Potential, possible, or probable predatory scholarly open-access publishers." What is your response to Beall's decision? And is Frontiers appealing being blacklisted in this way, as MDPI did (eventually successfully)?

KM: I think that results speak for themselves and tell a more balanced and factual story: our journals are amongst the most-cited journals in the world when compared within their JCR categories to other open-access journals and even decade old subscription journals (see Summary Impact Blog) and are operated by 65,000 researchers from top institutions (see details).

As noted earlier, our review platform has been awarded the ALPSP Gold Award in Publishing for its transparency, efficiency and collaborative spirit and enjoys very high satisfaction rates based on our surveys conducted on ~ 11,000 authors, reviewers and editors to date.

Frontiers journals are listed in professional organisations that perform actual and rigorous audits on their members (such as PubMed Central, Thomson Reuters' Journal Citations Reports, Scopus, Directory of Open Access Journals, OASPA, COPE and others) and we are part of several Horizon2020 grants.

Innovation and open access do not necessarily please everybody. But we evolve with feedback and have a long history of reacting to feedback and criticism. So while this sudden situation was certainly baffling, we have contacted Beall to learn directly what his reasons were.

His concerns seemed to be around: a) 2-3 controversial papers that were published (out of more than 40,000) and that you mentioned earlier. b) The medical editor situation in *Frontiers in Medicine* and *Frontiers in Cardiovascular Medicine* you referred to above. c) Reviewers confusion on the rules of rejection at Frontiers. d) He was very upset we launched so many new journals (in particular the preparations for launching *Frontiers in Library and Information Science*) because "there are already enough journals in the world".

We have heard some of this feedback earlier either directly or via our surveys and addressed them with our editors where necessary. For example, while rejections were always of course possible in Frontiers (we had close to 3,000 article rejections in 2015), we made this option even clearer and even more obvious for reviewers recently.

However, we stand by our mandate of improving papers and only rejecting papers that are not sound science. For the two medical journals, new and prominent Field Chief Editors were appointed who, together with a large editorial board of over 1,500 medical researchers, safe-guard the quality of the medical articles.

Our peer-review is rigorous and transparent. No system is perfect and a few papers that should not have got through peer-review will invariably happen. Even the most prestigious journals have cases where bad papers get through (in fact far more than in Frontiers).

So, to use this to judge a whole publishing program is neither objective nor does it make sense. Nevertheless, we learned from these few papers and have improved our retraction protocol over the last 3 years and are constantly finding ways to alert to editors to such potential cases.

When it comes to launching new journals – well, we disagree. Academia is currently fragmented and communities are stranded in silos. It is difficult, if not impossible, for a researcher to know how to navigate and find relevant and related information in a discipline. If we can bring all academic disciplines under one roof with the Frontiers model, the potential for integration, collaboration and education across disciplines will be enormous.

We aim for all readers and authors to easily move across academic fields and to easily see the potential relevance of work coming out in remote disciplines. This is our goal in launching all these journals.

RP: You talk of the need for greater transparency, and you flagged the merits of attaching reviewers' names to Frontiers' reviews. I am thinking that if you wanted to push transparency all the way you would make the reviews themselves open too. Apart from anything else, would this not make you less vulnerable to criticism, and being blacklisted? Is this something you plan to do?

KM: We have evolved the model dozens of times according to constructive discussion and feedback with the editors since we began, so we have all the mechanisms in place to adapt and improve.

Opening the reviews can easily be done, but our editors, reviewers and authors have not requested it broadly. There are pros and cons and while I am open to any direction, it would require much more analysis and an in depth discussion with our community.

RP: You said that Frontiers has not made a profit, and will not do so for some time. In 2013* Nature *reported that Frontiers had "turned cash-positive in 2011". I am no accountant but assume that is not the same thing as making a profit. Can you explain why a company that is cash positive might not expect to make a profit for some time to come? Is it simply because, as you note, you are using the profits to build new technology? If so, how do you justify (effectively) taxing researchers for this work through the APCs they pay. After all, there are open source publishing platforms available today, not least Open Journal Systems (OJS)?

"Our goal is not to provide a 'cheap' open-access solution. Our goal is to provide the best possible publishing platform and technology that will empower researchers to take charge of the publishing process and maximise readership and impact for their research. That is the service and value we are working to bring to the community"

KM: We invest in growth and innovation to bring high quality services to researchers, in supporting our editors and making sure we have a strong waiver program (no paper has ever been turned away because of an inability to pay).

Our goal is not to provide a "cheap" open-access solution. Our goal is to provide the best possible publishing platform and technology that will empower researchers to take charge of the publishing process and maximise readership and impact for their research. That is the service and value we are working to bring to the community.

For that purpose, we built the review forum to make peer-review constructive, transparent and efficient. We built the Loop profiles to give a face to authors, reviewers and editors and to be able to promote their research better.

We built impact metrics for articles and authors to give feedback on article performance and with Loop we invest in technology that disseminates articles to the relevant communities, enhancing views and downloads of papers. We launched Frontiers for Young Minds to explain research to kids and the public. And there is so much more to be done (see here).

It is good that there are many different models and publishers out there – no one model fits all needs and preferences. Everyone must decide for themselves what service is best for them and how much they are prepared to pay for that service – ranging from cheap repositories, over to various levels of gold open access publishers that offer a range of basic to advanced publishing services, and to the most selective journals.

Captured by the process?

RP: I can see why OA publishers wanting to disrupt the traditional system might feel the need to generate a lot of revenue to achieve that goal. But I wonder if there is not a danger that they could be "captured" by the process and end up propping up, rather than disrupting, the traditional system (as perhaps has happened with PLOS). Certainly Frontiers has been criticised for its business model, with some complaining that it is very similar to the* modus operandi *of Amway — i.e. a form of multi-level marketing. An associated danger, perhaps, is that the pay-to-publish system that has evolved could lead to OA publishers (in their need to generate a lot of revenue) losing sight of the ultimate goal — to communicate research. How would you respond to this?

KM: It is a good question and there is a lot of confusion about this issue. Firstly, the ***BIG revenue*** is in the subscription model (see here). Publishing a few papers selectively and charging libraries hefty fees to get access is a very powerful model.

Authors have been paying over $7,000 per article on average for a long time in the traditional system (and much more in the very high impact factor journals), mostly unwittingly. Secondly, the ***BIG inefficiency*** is in articles starting at the "top" of the impact factor game and eventually submitting to lower impact factor journals to eventually get published somewhere. This journey can take a year or often more. This bouncing from journal to journal is not about increasing quality; it is about finding a publisher that finally says, "it fits in my journal".

Imagine all the work that could have gotten out there much earlier and changed the next study, changed the world. If anyone has lost sight of how publishing should benefit society it is this extremely archaic, inefficient and extremely expensive process that hunts for "big" papers and charges the world to read it.

Gold open access journals collapse these direct costs to more around $2,000 – $3,000 on average per article. This can ***free up around US$10 Billion each year for research***. Most innovation in publishing is coming from open-access models: customised software for managing peer-review, article and author impact metrics, author discoverability, efficient technology to drive smart article dissemination, etc.

Even with the cost of these innovations, Frontiers' model is collapsing costs and getting rid of gross long-standing inefficiencies in the publishing process.

Our structure is motivated by a missing need to help the reader and author integrate across specialties and fields of academia, and a novel solution of using crowd sourcing to measure the discoveries that should climb the tiers. Fragmentation of the disciplines is a serious impediment in science communication that was driven by the serials crisis. As far as I know, no other publisher has proposed any other way to address this problem head-on.

You are correct that gold open access does need volume to be financially viable, which is comparable to subscription journals' need to engineer their impact factors to stay in business. What should happen to all other legitimate papers?

Is shuffling down the impact factor ladder good for science? The idea that rejecting papers ensures quality is deeply engrained in our publishing culture, repeating the mantra that only selective low volume publishing leads to quality. Well, this is wrong. It is difficult, if not impossible to predict the impact of a paper.

Look at the data: Frontiers journals have quickly risen to the top in terms of the total citations and in the high percentiles for Impact Factors – despite also having some of the highest publishing volumes. So once again, we must use data to judge publishers. I hope we will soon see metrics to objectively judge the value any publisher is bringing to academia – what we call Journal Service Metrics.

Open access is also bringing the discussion of costs out into the open – as in this interview, which is a great thing – even just to begin understanding that value costs and that there is no fairy godmother that can take on these costs.

"I don't think spam is the correct wording for when a researcher gets emailed about something related to their research"

RP: Another frequent complaint is that Frontiers spams researchers (e.g. here, here and here). Can you respond to these criticisms, say exactly how Frontiers recruits authors, and indicate roughly how many invitations are sent out each week? Is it possible for an author-pays OA publisher to avoid spamming researchers if it wants to grow rapidly?

KM: I don't think spam is the correct wording for when a researcher gets emailed about something related to their research, but I do agree it can be annoying to some. I also don't believe this problem is particular to OA publishing.

If you published a paper even in a distant past, visited and registered for some other reason, even the most prestigious publishers start emailing you – very frequently and about anything related to that journal. You attended a conference many years ago and got scanned, or just expressed somewhere an interest in a specific product, any company starts sending you emails on their products and services.

Lists are also big business. When one starts a new journal or launches a new journal service, one promotes it to those within that specific community. This is researcher territory. The emails are not completely out of scope.

However, I do appreciate the frustration and we have actually devoted significant resources to improve the technologies so that anyone gets an email that is of value to them. We developed a review suggestion algorithm, that are then given to the Associate Editor for their consideration.

We have developed technology to help readers, editors and authors more easily suggest a Research Topic, and we have improved technology when building the editorial board of a new journal. So we are evolving from broader mailings to targeted and personalised mailing with highly relevant information.

> *"In the end, innovation and disruption and competition is what we think will eventually create alternative revenue streams and start decreasing APCs. We are certainly not there yet, but I still hope we will get there"*

RP: I am not entirely sure from what you said whether it is still planned to phase out the use of APCs at Frontiers. But as you will know, there is a view that says that pay-to-publish open access inevitably leads to lower quality. Harvey Kane put it this way recently on The Scholarly Kitchen: "The problem with OA is that one has to constantly feed it more and more articles or it is not self-sustaining. As one feeds the beast, quality goes down, for instance the decline of serious peer review." Would you agree with Kane? If not, why not?

KM: The first part of this question is addressed above. The notion of setting a rejection rate and publishing only low volumes to achieve quality is seriously problematic and false (see details). All legitimate science papers will eventually get published somewhere. It serves nobody to shuffle them for years from one journal to another to find a home. In all categories where our journals are listed in the latest Journal Citation Reports, the Frontiers journals score high on volume and Impact Factor as compared to all other journals, including subscription journals.

In Frontiers, Impact Factors have actually gone up for most of our journals even despite big increases in volume. We should all be more careful with statements that sound intuitive or that we think of as true because everybody says so, but are simply not based on data.

RP: OA advocates tend to get a little grumpy when people say, or imply, that OA publishing inevitably involves article-processing fees. This was another complaint Walt Crawford aired when commenting on Frontiers' post about its financial commitment to open access. The truth is, he says, "Most OA journals do not have Article Publishing Charges." Of course he may be right today, but as legacy publishers increasingly offer both gold and hybrid OA it seems to me that, if not now then at some point in the not too distance future, the majority of articles published in OA journals will be subject to article-processing charges. What is your take on this? Might it mean that your hope of eventually moving beyond the APC can never be realised?

KM: I don't think this is such a complex equation. You can provide OA for seemingly "free" if you have a fairy godmother (a foundation, a donation, a university, a funding agency, an

angel philanthropist – well, it is actually not really "free" …), but even the fairy will tire and leave at some point.

A university also needs to employ people and pay for infrastructure to operate a repository – even if the author does not experience the costs directly. It **always** costs and the cost depends on the level of service that the publisher wants to provide.

In my view, with already over 2 million articles being published each year, dumping all content on the Internet, unchecked, in multiple versions of readiness, and as cheaply as possible, is not a service to anyone – or at least I don't find it an interesting problem to solve.

What is interesting and important is to provide researchers tools to structure academia (hence the Frontiers taxonomy of fields, specialties and spontaneously emerging research topics), solve the problem of massive fragmentation of academia (hence multi-disciplinary titles, tiering of discoveries, cross-listing of specialties and research topics, cross-disciplinary discussions), and solve the already-impossible-to-read-it-all problem (hence Loop).

The researcher should have metrics to judge services (will I be read, will I be cited, will my article be promoted, will I be promoted, etc.) and freely choose what is best and what fits their budget. OA already shrinks article costs so much that there will be plenty of room for many interesting new innovations without getting anywhere near the costs in the old model (which charges around $7,000 per article).

Some publishers like Frontiers and PLOS readily grant waivers when an author cannot pay so payment is not an obstacle (Frontiers awarded nearly $2 million in discounts and waivers in 2014 and even more in 2015). Eventually, the APCs paid by those that can pay will help cover the costs of those that cannot – together, research content gets out there for all to read for free and innovate with. It is just so much better than a few-pay-a-lot-for-a-few-to-read model.

In the end, innovation and disruption and competition is what we think will eventually create alternative revenue streams and start decreasing APCs. We are certainly not there yet, but I still hope we will get there.

Richard Poynder 2016

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