Thank you for the opportunity to comment on your recent Illumina-PacBio merger decision. In short, I am strongly in favor of the merger as it is clear that short read and long read platforms don't compete directly against each other and that they serve separate markets. Additionally, while the PacBio sequencing platform is built on a very impressive technology, it has still not shown itself to be commercially viable. In the absence of this merger the most likely scenario is that PacBio will be unable to raise the capital needed to remain in business and will have to shut down, declare bankruptcy, or attempt to be acquired by a less well suited acquirer (compared to Illumina). Therefore, without this merger, it is very likely that within two years PacBio technology will no longer be available to the research and clinical sequencing markets. This would be a great loss.

Below are my specific comments and reactions to various points made in the decision. In each case the relevant paragraph (as numbered in the original document) is included followed by my comment.
Finally, I'd like to note that my opinions and understanding of the sequencing market comes from over 20 years experience as an R&D scientist, product manager, and business consultant. I have no direct relationship or financial stake in any of the companies listed in this decision. In addition to operating as a business consultant in this space I also operate a sequencing services marketplace, AllSeq, which matches researchers with sequencing service providers. While I don't own or operate any sequencers myself, the projects placed on the AllSeq Marketplace give me a unique insight into how buyers interact with this markets, including what instruments they choose for the various project types.

I'm available to discuss any of the points below with you at any time.

Sincerely,

Shawn C. Baker, Ph.D.
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67
As set out in the Merger Assessment Guidelines, the relevant product market is a set of products that customers consider to be close substitutes, for example in terms of utility, brand or quality.80

Comment: These aren't close substitutes.

68
However, the same evidence also indicates that for most other generic sequencing applications, which account for a large proportion of all sequencing applications,82 both short read and native long read technologies are technically interchangeable (ie can technically be used for the same applications and use cases).

Comment: While it's true that short and long read technologies are "technically interchangeable", this isn't very meaningful. Just because there are no physical

reasons preventing one being used where the other could, that doesn't mean they actually ARE used interchangeably. An analogy would be comparing an Aston Martin DB11 with a lorry. They can both be driven on the same roads and they can both be used to transport material from one place to another. But you would never confuse the two. If you want a fast, fun drive for two people, the Aston Martin is the way to go. If you're moving house, better get a lorry.

71
For instance, Illumina's internal documents indicate that around [90-100]% of Single Nucleotide Polymorphism Variants (SNPs)85 identified86 by Illumina's sequencing systems are also identified by PacBio's sequencing systems87

Comment: Again, true, but pretty meaningless. PacBio can (and is) used to detect SNPs. But it's done in the context of long reads and figuring out what SNPs are in long fragments (that are typically used for determining structural variation).

78
The CMA's merger investigation also indicated that short read and native long read technologies can be and are used interchangeably by customers.

Comment: That is definitely not my experience or the experience of anyone in my extensive network. I'm not sure what customers you've been talking to.

78
While third parties recognised that short read and native long read systems may be particularly suited for certain applications, given the difference in read lengths and sequencing cost, third parties generally agreed that, from a technical perspective, both sequencing technologies could be used interchangeably.

Comment: Technically true, but meaningless - please see comment for section 68

78
For example, as noted above, one third party estimated this to be true for approximately 60% of sequencing applications. Several responses suggested that the distinction between short read sequencing systems and native long read sequencing systems suggested by the Parties was over-stated, particularly in the context of WGS, and a number of third parties stated that native long read sequencing systems were generally more advantageous than short read sequencing systems on the basis that they can be used to sequence reads of any length.

Comment: Technically true, but bordering on gibberish. Long read sequencing platforms are BUILT for long reads. You could hamstring them to only produce short reads, but then the cost per Gb would become astronomical - several orders of magnitude more expensive than Illumina. It would be the equivalent of discarding 99% of the normal amount of data generated by the PacBio Sequel II (making it 100 times more expensive per base).

80
The UK bidding data provided by the Parties also suggests that customers do not typically specify the read length of the technology that they require, nor the particular

sequencing instrument. For instance, the CMA's analysis of this data shows that customers do not typically specify whether short read or long read technology is sought, nor do they specify a particular sequencing supplier, in the clear majority of cases (eg for 63% of customers that purchased sequencing instruments during the period between 2015 and 2019).111

Comment: This isn't surprising and is in line with what we see on the AllSeq Sequencing Marketplace (allseq.com). However, it isn't because customers don't care about read length. It's because for the vast majority of customers they equate "sequencing" with "Illumina". Your own report shows that Illumina control ~90% of the market. As such, they have simply become "sequencing". It is only those customers who have a specific need for long reads that would indicate they want PacBio or Oxford Nanopore. This is EXACTLY the behavior we see for the projects submitted to the AllSeq Marketplace. For those projects that are best served with a short read technology, they either ask for "sequencing" or "Illumina". Those with projects best served by long reads ask for either "PacBio" or "ONT". In not one single project has a customer asked from competitive bids from Illumina service providers AND PacBio (or ONT) providers. The only time both long and short reads are included is for projects where the buyer wants BOTH (e.g., short reads to polish long reads). There is NO equivalency or substitution. These are VERY clearly separate technologies used for separate projects with goals uniquely suited for either short OR long reads. Never both.

84
Sequencing cost is only one of a multitude of parameters of competition (amongst read length, accuracy, speed, output and throughput), that customers consider when choosing a sequencing instrument.

Table 1 below shows that, while the cost per million reads is significantly lower for Illumina's sequencers, sequencing costs using PacBio's instruments decrease dramatically when the read length is taken into account (cost per million reads per 300bp fragment), making the costs of the two systems much more comparable, particularly following the launch of PacBio's Sequel II instrument.

Comment: This is a bizarre metric that to my knowledge has never been used by anyone in the industry. People typically price projects "per sample", "per read", or "per Gb". When comparing ILMN to PACB, people generally compare $/Gb (where PACB benefits from their long reads). Even so, and even with the Sequel II, they are still 4-5X more expensive than ILMN

84
For example, it is unclear whether the Parties' analysis reflects the time and costs needed to assemble short reads into longer fragments.

Comment: The time and cost for this on a per sample basis is quite minimal and highly standardized. It is a very small component of the overall cost. Perhaps 5% at most.

84
Moreover, the Parties' analysis focuses only on Illumina's NovaSeq sequencer (its high throughput sequencer), while Illumina's internal documents indicate that the competitive constraint from PacBio is strongest with respect to the low and medium throughput segments, where the cost gap is likely to be smaller (for example, in relation to Illumina's MiSeq, iSeq and NextSeq instruments).118

Comment: ILMN has a wide portfolio of sequencers, but when talking about human whole genome sequencing (the only conceivable application where there is potential overlap), NovaSeq is the only sensible instrument from Illumina. Therefore, this is the only platform comparison that actually makes sense. People would choose PacBio if they want to perform a de novo assembly (or access structural variation). They would choose Illumina's NovaSeq if they want the lowest cost and/or have a large project size that requires a large amount of throughput (which the Sequel II is not remotely close to matching). Under no circumstances would a customer choose a non-NovaSeq platform if cost or throughput were a concern. They would ONLY choose a different machine if it were the only machine available to them (perhaps owned locally with outsourcing not being an option).f

100
Because of the importance of innovation, the length of innovation cycles, and the recent launch of Sequel II in April 2019, the CMA has placed more weight on forward-looking evidence than on the historical performance of the Parties and their competitors.

Comment: I understand why you might want to do this, but this industry (and PacBio in particular) has a history of making over aggressive statements about their future performance (especially when trying to raise funds). For example, several years ago (under different management) PacBio famously claimed their machine (the RS II) was going to be able to generate a human whole genome in under 15 minutes for less than $1000. They aren't close to achieving either of these claims, even after ~10 years.

111
However, while a significant number of the Parties' internal documents mention the complementarity between the Parties' technologies, a number of these documents have been prepared in 2017 and 2018139 and, hence, are examining the interchangeability between Illumina's and older versions of PacBio's sequencing instruments, which the CMA has recognised to have been more limited than in relation to Sequel II.

Comment: There is nothing fundamentally different between the Sequel and Sequel II - it's just a density change that allows 8 million sensors rather than only 1 million sensors. And keep in mind this is less than 0.1% of Illumina's 20 BILLION reads per run.

115
Some of Illumina's internal documents record sales lost as a result of customers switching to PacBio153 and several of Illumina's internal documents are dedicated exclusively to tracking PacBio.154

Comment: Yes, of course, those customers who have projects that require long reads would use PacBio. But they wouldn't have "switched" over to Illumina. If they had a project that didn't require long reads, they would use ILMN instead. If they didn't have an Illumina machine, they would outsource the project to someone who did rather than run it on their PacBio machine. Also, it is actually quite rare for a PacBio machine owner to not also have an Illumina machine (or have access to one). As for Illumina "tracking" PacBio, why in the world wouldn't they have? It's a very prudent thing to do given the dynamic nature of the market. It was probably a number of these documents that led them to the decision to try to buy their way into the long read market by acquiring PacBio. It is disingenuous and illogical to hold this against them

120
Similarly, PacBio's internal documents recognise that its throughput and cost are now competitive with Illumina in larger market segments and its sales have the potential to grow in the short term, possibly winning customers from suppliers of short read sequencing technologies, including Illumina. For example:160

Comment: If their internal documents say this then they are just fooling themselves. Internal documents are written for all sorts of reasons, including employees desperately trying to justify decisions they've made to an internal audience.

121
PacBio also appears to view Illumina as a key competitor in its internal documents, tracking Illumina's progress, often comparing the two technologies, and also exploring ways to compete and win customers from Illumina. For example:163

Comment: Again, this is a prudent measure for the company to take. Customers have a choice of what types of projects they want to run. As Illumina was creating cheaper and cheaper sequencing, PacBio was having a harder and harder time to find customers willing to spend several orders of magnitude more money on projects that require long reads. But those potential customers wouldn't pick Illumina to run the same projects - the short reads simply wouldn't work. Instead, they changed their research goals to ones that COULD use short reads (or kept the goal compatible with short reads and didn't convert to new goals that require long reads).

123
Eg, [60-80]% of new-to-Illumina labs first purchase a low-throughput instrument, low throughput segment accounts for [40-60]% of Illumina's revenue, see Illumina document: []. Benchtop sequencers (ie low to medium throughput sequencers) account for [70-90]% of all Illumina's installed sequencers worldwide, see [].

Comment: There are many more low to mid throughput machines because they are cheaper. But much more sequence is being generated on the NovaSeqs. And, again, this isn't relevant for PacBio. No one is deciding between a Sequel II and a MiSeq - those machines are worlds apart and simpler aren't used for the same project types (for MiSeq that would targeted panels which don't benefit from long reads).

126
The [] provided by PacBio also shows that various sequencing parameters, such as sequencing costs, throughput and yield, vary significantly across different sequencing instruments. The same note also estimates that with the release of PacBio's Sequel II instrument, PacBio's cost per Gb will drop from $[] to $[], achieving cost per Gb levels similar to those of Illumina's high throughput NovaSeq instrument and much lower cost per Gb levels than those of Illumina's lower throughput instruments.183

Comment: Despite whatever PacBio's internal documents say, they haven't come close to matching Illumina $/Gb metrics. Illumina is currently around $800 without large discounts while PacBio is still in the $3,000-$4,000 range. Additionally, they haven't provided a roadmap to achieving lower costs while Illumina has continued to talk about their progress to the $100 genome

127
Some third parties considered that, as a result of the recent developments in PacBio's technology, PacBio was the only supplier who could compete effectively with Illumina going forward.

Comment: This completely discounts BGI (which, admittedly, hasn't branched out of China yet, but is poised to) and Oxford Nanopore. In contrast, employees of Oxford Nanopore have very publicly stated that their technology is already superior to PacBio and has a fast runway to achieving much better costs than even what Illumina is currently offering. Since PacBio and ONT are the most obvious head-to-head competitors, it seems prudent to listen to what ONT is saying. If they have indicated something different to you in private, then I would recommend that you ask them to reconcile what they've told you and what they've told the public,

135
While the Parties have submitted that [].188 This has also been supported by the responses received from actual and potential competitors. The fact that PacBio has a key product at a well-advanced stage of development should make it a more attractive target for investment compared to companies that have product offerings at a more formative stage.

Comment: PacBio has been unprofitable for their entire existence (at least 10 years). It is unclear why anyone would invest in them if this deal falls through. The most likely scenario would be bankruptcy within two years followed by a fire sale of the underlying IP.

154
In addition, Illumina's internal documents suggest that the competitive constraint posed by Thermo Fisher and Qiagen is limited to certain clinical applications, such as NIPT and oncology.229

Comment: This is generally true, but these are huge and growing markets. In fact, it is exactly the clinical market that Illumina is relying on for its future growth. Because they have dominated the short read research market, they can only grow as fast as research budgets grow (which isn't that fast). Therefore, they are spending

considerable effort to grow into the clinical market (of which NIPT and oncology are the two most important and fast growing segments).

157
The majority of respondents submitted that the Transaction would strengthen Illumina's very strong pre-existing market position, leading to a reduction in competition (including competition on price) in an already very concentrated market with very few alternative suppliers, and that this would likely limit the development of new technologies.

Comment: As PacBio is applying ZERO pricing pressure on Illumina (even with the launch of the Sequel II), there is simply no way the merger would lead to decreased price competition. It is true that Illumina currently doesn't really face any pricing competition (which is the reason pricing has been flat for the past several years), but both BGI/MGI and ONT are currently releasing systems which should provide just such a pressure that has been missing.

159
In relation to BGI, third parties raised concerns that its technology was unproven, and some expressed concerns that IP issues may limit BGI's expansion into Europe. While Illumina has often considered BGI's pricing policy as aggressive and leading to stronger price competition, BGI's presence and, hence, its competitive constraint, remains largely limited to the Chinese market, where it has acquired a strong position. BGI has said that [the majority] of its sales currently originate in China and that it is [].233

Comment: BGI has made their plans to expand outside of China very clear. They are much more likely to succeed in this than PacBio is to reduce their prices to match Illumina (especially if the deal falls through - they simply won't have the resources to achieve much of anything).

159
With respect to ONT, the evidence suggests that its technology still suffers from significant technical shortcomings, limiting its ability to constrain the Merged Entity. Several customers told the CMA that they thought that ONT's technology was not performing well and that its low accuracy, in particular, was preventing it from becoming a closer alternative to both Illumina and PacBio. []. The CMA has also heard from the Parties that ONT's sales are growing in China, where its placement of a number of new instruments with GrandOmics has led to [],234 which also suggests that ONT's competitive constraint may be stronger in some regions than others.

Comment: ONT has made very clear, bold statements about their current performance and the roadmap to improved performance. It is unclear why you seem to believe PacBio's forward looking statements while completely discounting ONT's. If both are accepted at face value, ONT will very quickly outpace PACB and had already applied tremendous pressure to them. (As a side note, while ONT has applied tremendous pressure to PACB, they have NOT done the same to ILMN, further evidence that the buyers don't consider short read and long read platforms to be part of the same market.)

168
On the basis of the evidence described above, the CMA believes that PacBio, ONT and BGI are the closest competitors to Illumina, and that ONT and Illumina are the closest competitors to PacBio.

Comment: Illumina primarily competes with Thermo outside of China (unclear why you've completely dismissed them) and BGI inside of China. ONT and PacBio are each the primary competitors of each other.

173
Entry, or expansion of existing firms, can mitigate the initial effect of a merger on competition, and in some cases may mean that there is no SLC. In assessing whether entry or expansion might prevent an SLC, the CMA considers whether such entry or expansion would be timely, likely and sufficient.236 In terms of timeliness, the CMA's guidelines indicate that the CMA will generally look for entry to occur within two years.237

Comment: It seems unreasonable to use a 2 year timeline here but use a 5-10 year timeline when taking about when PacBio might take over ILMN market share. Also, both BGI and ONT have claimed they will capture significant market share in this two year timeframe.

181
The majority of potential entrants had little certainty regarding when they were going to be able to commercialise their technologies, nor had they a clear idea of the probability of their success. Even respondents with projected launch dates within the next couple of years acknowledged that ongoing developments could impact and delay their planned entry. For example, one potential entrant confirmed to the CMA plans for upcoming entry but was unable to confirm the projected timing for the commercialisation of the technology because of a number of challenges which would impact the timescales for the launch; the potential entrant also expressed some uncertainty regarding the projected success of the technology.

Comment; This is all true, but it would also apply to future PacBio improvements (which are required for them to improve their current $3k-$5k human whole genome price down to the ~$800 level that Illumina is already at).

185
In particular, one third party suggested that the larger combination of patents would make it difficult for competitors to modify their technology, where required, to avoid infringing a narrower set of patents.

Comment: This doesn't make any sense as the merger won't result in the creation of any new patents. Therefore, it shouldn't change the response of any competitor trying to avoid a particular patent - you can't just get around an Illumina patent by infringing on a PacBio patent, so nothing would change in this regard for the combined company.

185
Many third parties said that Illumina would aggressively protect its IP, perhaps more so than PacBio would have done.

Comment: While Illumina MAY be more aggressive with the PacBio patents, PacBio has already been pretty aggressive with them against ONT. And, so far, they have been losing badly. It is unclear how Illumina would fare better.

189
Within the context of this Transaction, several third parties suggested to the CMA that part of the rationale for the Transaction could be the acquisition of patent rights, allowing Illumina an extension on the time period before which the key patents in its (newly expanded post-Transaction) portfolio might expire.

Comment: Again, this doesn't make any sense. The merger would NOT extend any of Illumina's or PacBio's patents. Nothing would change in terms of patent expiry dates. The PacBio patents that Illumina would gain wouldn't apply to the current Illumina technology (if they did, PacBio would have sued them a long time ago). The Illumina patents that are about the expire will still expire. The merger won't change anything on this front.

193
The CMA has, therefore, examined whether the Merged Entity would have the ability and incentive to be able to offer targeted discounts to customers who purchase both types of sequencing instruments and whether this could act as a barrier to entry and expansion by increasing the strategic advantage that Illumina would have over rivals seeking to enter or expand within the market.266

Comment: Disallowing this kind of anti-competitive bundling strategy would be a reasonable remedy for the merged company. I'm not sure if they would try to do something like this, but it would be hard for them to argue that they shouldn't be prevented from doing it.

195
While PacBio's and ONT's sequencing technologies are differentiated, third-party responses nevertheless suggest that customers do consider options from both providers when making their purchasing decisions. As PacBio's costs continue to decrease following the launch of Sequel II, the CMA believes that even more customers may start viewing PacBio as an alternative to ONT;

Comment: First, PacBio hasn't provided any roadmap that suggests prices will continue to drop. The 8M chip with Sequel II has already been launched. Without further developments there won't be any further price decreases.

As for PacBio and ONT, they are already seriously considered as alternatives to each other. But PacBio won't be competing with ONT in terms of price - both capital costs and operating costs are already lower for ONT (and dropping). The only advantage PacBio currently has is the quality of their sequence (as their reads, while long, are MUCH shorter than what ONT is able to generate).

Shawn C. Baker, Ph.D.
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