A report on the anticipated acquisition by Illumina of PacBio

Appendices and glossary

Appendices

Appendix A: Terms of reference

1. In exercise of its duty under section 33(1) of the Enterprise Act 2002 (the Act) the Competition and Markets Authority (CMA) believes that it is or may be the case that:

   (a) arrangements are in progress or in contemplation which, if carried into effect, will result in the creation of a relevant merger situation, in that:

      (i) enterprises carried on by, or under the control of, Illumina, Inc. ('Illumina') will cease to be distinct from the enterprises carried on by Pacific Biosciences of California, Inc. ('PacBio'); and

      (ii) the condition specified in section 23(2)(b) of the Act is satisfied; and

   (b) the creation of that situation may be expected to result in a substantial lessening of competition within a market or markets in the United Kingdom for goods or services, including the market for the supply of DNA sequencing systems.

2. Therefore, in exercise of its duty under section 33(1) of the Act, the CMA hereby makes a reference to its chair for the constitution of a group under Schedule 4 to the Enterprise and Regulatory Reform Act 2013 in order that the group may investigate and report, within a period ending on 11 December 2019, on the following questions in accordance with section 36(1) of the Act:

   (a) whether arrangements are in progress or in contemplation which, if carried into effect, will result in the creation of a relevant merger situation; and

   (b) if so, whether the creation of that situation may be expected to result in a substantial lessening of competition within any market or markets in the United Kingdom for goods or services.

Appendix B: Conduct of the investigation

1. We published biographies on the members of the inquiry group conducting the investigation on our web pages on 27 June 2019 and an administrative timetable on 1 August 2019. We also published the issues statement setting out the areas on which the investigation would focus on 1 August 2019.

2. We invited a range of interested parties to comment on the Proposed Merger. We sent detailed questionnaires to competitors, potential competitors (as identified by the Parties), and a number of the Parties' customers.[1] In addition, several of these third parties provided us with further information on calls. We also used evidence from the CMA's phase 1 review of the Merger.

3. On 23 July 2019, members of the inquiry group, accompanied by CMA staff, visited Illumina's facility at Granta Park, Cambridge, along with the facilities of Genomics England and Wellcome Sanger, customers of the Parties.

4. We received written evidence from the Parties in the form of submissions and responses to our information requests. A non-confidential version of the Parties response to the phase 1 decision along with a non-confidential version of the Parties' merger notice was published on 1 August 2019. We also held separate hearings with each of the Parties on 18 September 2019.

5. We sent a number of working papers (including non-confidential third party evidence) to the Parties and our annotated issues statement on 6, 9 and 10 September 2019 for comment prior to the hearings with them. The Parties provided comments on those papers on 22 and 24 September 2019.

6. A non-confidential version of the provisional findings report will be available on the case web page.

7. We would like to thank all those who have assisted us in our inquiry so far.

[1] We sent questionnaires to Illumina's top 100 UK customers in terms of 2017/18 revenue, and 100 PacBio customers, including all of PacBio's UK customers/customers who had had access to the Sequel II, with the remaining 100 made up by customers with the highest 2017/18 revenue.

Appendix C: The Parties' internal documents

During the course of its investigation, the CMA has reviewed a large number of the Parties' internal documents. Where relevant, those documents are referred to in the Provisional Findings. This Appendix provides further detail on the source and date of the documents referred to, as well as any available context and screenshots of the relevant slides or paragraphs.

Illumina's internal documents

[✂]

PacBio internal documents

[✂]

Appendix D: Competitors' internal documents

Introduction

1. The CMA has requested and systematically reviewed a number of senior management-level internal documents from the following current competitors of the Parties relating to their future plans and the competitive landscape more generally:

   (a) Oxford Nanopore Technology (**ONT**);

   (b) Thermo Fisher Scientific (**Thermo Fisher**);

   (c) QIAGEN N.V. (**QIAGEN**); and

   (d) Beijing Genomics Institute (**BGI**).

2. This appendix provides further details regarding the documentary evidence used to inform the CMA assessment at paragraph 8.308 onwards. In particular, for each current competitor of the Parties a number of key documents have been extracted and are presented in the paragraphs below under two broad categories:

   (a) Documents relating to expansion plans; and

   (b) Documents relating to the DNA sequencing competitive landscape.

[✂]

Appendix E: Potential entrants

Introduction

1. This appendix provides additional information on the companies identified by the Parties as planning to launch either long-read or short-read DNA sequencing systems.[2] The Parties identified 24 companies, which are each discussed below.

2. As noted in paragraph 9.67 of the Provisional Findings, during this investigation we attempted to contact each of these potential entrants to understand their views on the market and where they were in their current development process, but not all responded, despite repeated efforts. We requested internal documents in addition to speaking with them. Where we were unable to make contact, we have relied on market intelligence.

3. The list of potential entrants covered in this appendix is included below:

   (a) DNA Electronics (DNAe)

   (b) Centrillion Technologies

   (c) Direct Genomics (Genemind)

   (d) Armonica Technologies

   (e) Personal Genomics

   (f) Singular Genomics Systems (SGS)

   (g) Agilent / Lasergen

   (h) Depixus

   (i) [✂]

   (j) Roche / Genia

   (k) Base4

   (l) GenapSys

   (m) Two Pore Guys

   (n) Stratos Genomics (SG)

[2] Parties' Merger Notice, paragraph 395.

(o) NorthShore Bio (NSB)

(p) GeneSeque

(q) Quantum Bioscience (QB)

(r) Roswell Biotechnologies (Roswell)

(s) Resonance HRT

(t) NanoString

(u) Quantum SI

(v) Apton Biosystems

(w) iNanoBio

(x) Quantapore

List of potential entrants

DNA Electronics (DNAe)

4. DNAe is a company of between 50-200 people, which was formed as a spinout of Imperial College in 2003.[3] In 2010, DNAe licensed certain intellectual property related to sequencing based on using semiconductors[4] to Ion Torrent/Thermo Fisher (on a non-exclusive and limited basis) and receives a royalty on the sales of Ion Torrent chips.[5] In 2018, it generated a total of £5.5 million of revenue.[6]

5. In 2013, DNAe decided to develop its own product lines, including a DNA sequencing platform.[7] In 2016, DNAe secured a contract with BARDA (the Biomedical Advanced Research and Development Authority, a division of the Office of the Assistant Secretary for Preparedness and Response (ASPR), in the US Department of Health and Human Services (HHS) worth up to $51.9 million, in order to develop a sequencing platform, including a diagnostic sequencing test for bloodstream infections/sepsis, with potential follow-on to an additional test for seasonal and pandemic influenza.[8] In particular, DNAe is

[3] https://www.dnae.com/company.html; [✂].
[4] Nucleotides that incorporate during DNA sequencing or amplification release hydrogen ions, which can be detected as an electrical signal using silicon transistors; https://www.dnae.com/technology.html.
[5] [✂].
[6] https://beta.companieshouse.gov.uk/company/04821572/filing-history/MzI0MDMwODQ0NGFkaXF6a2N4/document?format=pdf&download=0
[7] [✂].
[8] [✂].

seeking to develop an instrument for use in clinical settings (i.e. in hospitals themselves), with rapid turnaround times.[9,10]

6. DNAe considers that its sequencer will achieve a broad adoption within a range of healthcare institutions beyond those that utilize sequencing today, particularly due to its speed and ease of use (for example able to be run directly on a blood sample). When assessing the size of the opportunity for its product, DNAe explicitly highlights the hospital costs associated with patients with sepsis. DNAe notes that products for other infectious disease / cancer testing would likely develop subsequently.[11]

7. DNAe's statements,[12] and its annual filings, describe it as being "in the development phase of its business lifecycle" and notes the requirement to continue to raise funds in order to operate.[13]

8. DNAe's documents indicate that it is [✂].[14]

Centrillion Technologies (Centrillion)

9. Centrillion was founded in 2009 with the aim of "delivering a unifying technology that helps scientists swiftly and efficiently characterize large segments of the genome and image the expression of the genome in 3D".[15]

10. Centrillion is headquartered in California and has R&D and manufacturing facilities in the USA, Taiwan and China.[16] It currently provides a DNA sequencing service.[17]

11. Centrillion's technology is based on a new generation of sequencing compatible DNA chips.18 It has stated that this technology can be used to analyse tumour biopsies and to study the exchange of information between cells.[19]

12. In 2015, Centrillion received a grant from the National Human Genome Research Institute to help fund the company's research into the development

[9] [✂].
[10] [✂].
[11] [✂].
[12] [✂].
[13] https://beta.companieshouse.gov.uk/company/04821572/filing-history/MzI0MDMwODQ0NGFkaXF6a2N4/document?format=pdf&download=0, page 5.
[14] [✂].
[15] http://www.centrilliontech.com/wp-content/uploads/Centrillion_FactSheet.pdf
[16] http://www.centrilliontech.com/wp-content/uploads/Centrillion_FactSheet.pdf
[17] http://www.centrilliontech.com/services/
[18] http://www.centrilliontech.com/wp-content/uploads/Centrillion_FactSheet.pdf
[19] https://www.genomeweb.com/microarrays-multiplexing/dna-chip-developer-centrillion-raises-least-56m-signs-partnerships

of breakthrough genomic technologies. In July 2018, Centrillion received a strategic investment from the ARM IoT fund.[20]

13. We have not received any evidence around the likely timescales of Centrillion launching its own DNA sequencing instrument.

Direct Genomics / Genemind

14. Genemind (originally Direct Genomics) was established in 2012 and is headquartered in Shenzhen, China. It is funded by institutional and private investors.[21]

15. Genemind is the first single molecule sequencing system developed for clinical use. It is developing a third-generation technology of genome sequencing targeted at non-invasive detection, disease diagnosis, and personalized treatment.[22]

16. Genemind's first instrument appears to have launched in China in a clinical setting,[23] however, we have received no evidence about its scale, no customers we spoke to referred to it as a sequencing instrument provider, and the Parties did not identify it as an existing competitor.

17. Genemind has not acknowledged any correspondence with the CMA.

Armonica Technologies

18. Armonica submitted that it is a small early stage start-up with [✂].[24]

19. Armonica was founded in 2015 based on a set of patents that were licensed from the University of New Mexico.[25]

20. [✂]. [26]

21. Armonica told us that at present it is still conducting basic research to establish the capabilities of its technology and is focusing all of its limited resources on its technical development. Accordingly, it currently has no functioning products, records of business plans, market analysis, or financial business models.[27]

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[20] http://www.centrilliontech.com/centrillion-taiwan-raises-financing-from-arm-iot/, http://www.centrilliontech.com/centrillion-receives-nih-funding-for-genomic-technology-development/
[21] http://www.genemind.com/index.php/page/index/id/8
[22] http://www.genemind.com/index.php/page/index/id/8
[23] http://www.genemind.com/index.php/page/index/id/9
[24] [✂].
[25] [✂].
[26] [✂].
[27] [✂].

Personal Genomics

22. Personal Genomics is a [✂].[28]

23. Personal Genomics submitted that [✂].[29] It also stated that [✂].[30]

24. Personal Genomics submitted that [✂].[31]

Singular Genomics Systems (SGS)

25. SGS was founded in 2016[32] and is based in California.[33] SGS is funded by ARCH Venture Partners, a venture capital company which specialises in funding disruptive scientific firms.[34] ARCH's website states that it is willing to take the long-term view when building companies,35 and has a current portfolio of over 150 companies.[36]

26. The SGS website provides no information on the company, its products, or its intentions, simply stating "We're busy in the lab" and provides generic contact details.[37]

27. We note that one of the Illumina Accelerator advisors is also on the board of directors of SGS.[38]

28. SGS has not acknowledged any correspondence with the CMA.

Agilent / Lasergen

29. Agilent describes itself as a leader in life sciences, diagnostics and applied chemical markets. The company provides laboratories worldwide with instruments, services, consumables, applications and expertise across a range of sectors, including food, environmental and forensics, pharmaceutical, diagnostics, chemical and energy, and research. As part of this, it provides a number of NGS-related products, including reagents/prep kits, and quality control software.[39] It is a public company listed on the NYSE, has nearly 15,000 employees, and generated revenues of $4.9 billion in 2018.[40]

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[28] [✂]; https://www.personalgx.com/
[29] [✂].
[30] [✂].
[31] [✂].
[32] https://businesssearch.sos.ca.gov/Document/RetrievePDF?Id=03941202-21208779
[33] https://singulargenomics.com/
[34] https://www.archventure.com/about/
[35] https://www.archventure.com/about/
[36] https://www.archventure.com/portfolio/
[37] https://singulargenomics.com/
[38] https://www.illumina.com/science/accelerator.html
[39] https://www.agilent.com/about/companyinfo/index.html
[40] https://www.investor.agilent.com/static-files/ee467aec-e2e3-4ff7-897f-d4453c03953c

30. In 2018, Agilent acquired Lasergen, a company which was focused on developing a DNA sequencing system. Lasergen had been founded in 2002, and at the point of acquisition, had 45 employees.[41]

31. Agilent's platform is aiming to provide an automated end-to-end sequencing instrument targeted at the clinical market, [✂].[42] [✂].[43]

32. [✂].[44] [✂].[45]

33. [✂].[46] [✂].[47]

34. [✂].[48]

Depixus

35. Depixus was founded in 2012,[49] and is based in Paris.[50] It is a small, early-stage company developing and commercialising a novel technology for the analysis of nucleic acids (DNA and RNA). The company's MAGNA technology (previously known as SIMDEQ) is being developed to go beyond DNA sequencing, revealing additional levels of genetic information that are challenging to decipher with existing technologies.[51]

36. Depixus stated that sequencing of the epigenome is not easily reachable with existing technologies, and as such its new technology is "highly orthogonal" to NGS technologies.[52] [✂].[53]

37. [✂].[54]

38. [✂].[55]

[✂]

39. [✂].[56]

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41 https://www.agilent.com/about/newsroom/presrel/2018/03apr-gp18032.html
42 [✂].
43 [✂].
44 [✂].
45 [✂].
46 [✂].
47 [✂].
48 [✂].
49 [✂].
50 https://depixus.com/about/
51 [✂]; https://depixus.com/about/.
52 [✂].
53 [✂].
54 [✂].
55 [✂].
56 [✂].

40. [✂].[57] [✂].[58]

41. [✂].[59]

Roche / Genia

42. Roche describes itself as (amongst other things) the world's largest biotech company, and a leading provider of in vitro diagnostics.[60] It is split into two divisions – pharmaceuticals and diagnostics.[61] As part of its diagnostics division, it provides a number of sequencing-related products, including reagents/prep kits, and DNA enrichment products.[62] Roche Holdings (the parent company of the two divisions) is a public company listed on the SIX Swiss Exchange, has nearly 95,000 employees, and generated revenues of CHF 57 billion (circa £47 billion) in 2018.[63]

43. In 2007, Roche acquired 454 Life Sciences, a short-read DNA sequencing systems supplier, for around $150 million. However, by 2013, Roche decided to shut down 454 and stated that the instruments would be phased out by 2016.[64]

44. In 2012, Roche made a hostile bid for Illumina, but this ultimately failed.[65]

45. In 2013, Roche made an agreement with PacBio to develop and supply DNA sequencing-based products for clinical diagnostics.[66] However, at the end of 2016, this agreement was terminated.[67]

46. In 2014, Roche acquired Genia Technologies (Genia). Genia was a private company founded in 2009 in California, which was developing a DNA sequencing technology.[68] Reporting at the time indicated that Genia was aiming to commercially launch its sequencing instrument in 2015.[69]

47. [✂].[70]

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[57] [✂].
[58] [✂].
[59] [✂].
[60] https://www.roche.com/about.htm
[61] https://www.roche.com/about/business.htm
[62] https://sequencing.roche.com/en.html
[63] https://www.roche.com/dam/jcr:af865dfd-50fb-458b-9cac-34097db9d3ec/en/ar18e.pdf
[64] https://www.genomeweb.com/sequencing/roche-shutting-down-454-sequencing-business#.XWafyyhKiUk
[65] https://www.bbc.co.uk/news/business-17761674
[66] https://www.pacb.com/press_releases/pacific-biosciences-announces-agreement-with-roche-diagnostics-to-develop-and-supply-dna-sequencing-based-products-for-clinical-diagnostics/
[67] https://www.pacb.com/press_releases/pacbio-announces-termination-of-agreement-with-roche-diagnostics/
[68] https://www.roche.com/media/releases/med-cor-2014-06-02.htm
[69] https://allseq.com/knowledge-bank/emerging-technologies/genia/
[70] [✂].

48. [✂].

49. [✂].[71]

50. [✂].[72] [✂].[73]

Base4

51. Base4 is a small R&D company with [✂].[74] It was founded in 2009 and is based in Cambridge, United Kingdom.[75]

52. Base4 is developing a microdroplet based sequencing method using a single molecule of DNA.[76] Base4 told us that [✂].[77]

53. Base4 submitted that [✂].[78]

54. Base4 submitted that [✂].[79] However, its view was that [✂].[80]

GenapSys

55. GenapSys was founded in 2010 and is based in California.[81] It is developing a platform called GENIUS (Gene Electronic Nano-Integrated Ultra-Sensitive), which is based on an electronic sequencing chip.[82] The GENIUS platform is marketed as being fast (turnaround time of hours not days), affordable, simple to use (integrated workflows) and portable.[83]

56. GenapSys is currently offering researchers early access to the platform prior to commercial release,[84] which it has publicly stated is due to take place in 2019. It has developed two chips and is working on a third and intends to raise additional capital. It has stated that depending on the chip, the system will be able to o run small targeted sequencing assays up to exomes.[85]

57. GenapSys has not acknowledged any correspondence with the CMA.

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[71] [✂].
[72] [✂].
[73] [✂].
[74] [✂].
[75] https://www.base4.co.uk/preparing-a-molecule-for-sequencing
[76] http://www.base4.co.uk/our-company/
[77] [✂].
[78] [✂].
[79] [✂].
[80] [✂].
[81] Cowen LifeSciences Toolkit, March 2018, page 81.
[82] http://www.genapsys.com/product2/productwithfeatures.html
[83] http://www.genapsys.com/product2/productwithfeatures.html
[84] http://www.genapsys.com/geniusclub2/geniusclub.html
[85] https://www.genomeweb.com/molecular-diagnostics/jp-morgan-healthcare-day-4-meridian-bioscience-genapsys-biocartis-veracyte#.XZ4KjUZKiUk

Two Pore Guys

58. Two Pore Guys is based in California and has licensed technology developed at the University of California, Santa Cruz, having been spun out in 2011. In 2017 it had 44 employees.[86]

59. Two Pore Guys submitted that it has no plans to enter the market for DNA sequencing systems or services.[87]

Stratos Genomics (SG)

60. SG was founded in 2008, is based in the United States with [✂] employees and is developing a next generation sequencing technology.[88]

61. SG's technology is based on a proprietary sequencing-by-expansion approach[89] and will be most useful for [✂].[90]

62. SG submitted that [✂].[91]

63. SG submitted that [✂].[92]

NorthShore Bio (NSB)

64. NSB was founded in 2009 as Lux Bio Group and is based in the US.[93]

65. NSB submitted that it is an early stage solid-state, synthetic, nanopore platform sequencing company.[94]

66. NSB submitted that [✂].[95]

67. NSB submitted that [✂].[96]

68. [✂].[97]

GeneSeque

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[86] Cowen LifeSciences Toolkit, March 2018, page 82.
[87] [✂].
[88] [✂].
[89] https://www.stratosgenomics.com/
[90] [✂].
[91] [✂].
[92] [✂].
[93] https://www.genomeweb.com/sequencing/northshore-bio-develops-solid-state-tunable-nanopore-chips-sequencing-degradatio#.XZ4doEZKiUk
[94] [✂].
[95] [✂].
[96] [✂].
[97] [✂].

69. Geneseque is a Norway-based company aiming to develop a single molecule sequencing technology.[98]

70. To date, it has been funded by a combination of venture, institutional and private investors, and has been supported by several research and development grants from the Norwegian Research Council and Innovation Norway.[99]

71. GeneSeque's MagSeq technology is based on using monodisperse beads and image chips which aims to provide long read lengths and high non-biased accuracy.[100]

72. GeneSeque has completed some of its technology development but has yet to develop a compatible chemistry,[101] and is currently seeking a partner to assist in finalising the technology and progress the technology for commercialisation.[102]

73. GeneSeque has not acknowledged any correspondence with the CMA.

Quantum Biosystems (QB)

74. QB was founded in 2013 and is based in Japan.[103] It currently has [✂] full time employees [✂].[104]

75. QB submitted that [✂].[105] Its planned approach is based on the principles of quantum mechanics, detecting the conductance of DNA between two electrodes with a sub-nanometre gap.[106]

76. QB is aiming to [✂].[107][108]

77. QB submitted [✂].[109] [✂].[110]

78. [✂].[111][112]

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[98] http://geneseque.com/
[99] http://geneseque.com/about-us/
[100] http://geneseque.com/our-technology/
[101] http://geneseque.com/our-technology/
[102] http://geneseque.com/partnering-opportunity/
[103] https://quantumbiosystems.com/about/info?lang=en
[104] [✂].
[105] [✂].
[106] https://quantumbiosystems.com/features/tech?lang=en
[107] [✂].
[108] [✂].
[109] [✂].
[110] [✂].
[111] [✂].
[112] [✂].

Roswell Biotechnologies (Roswell)

79. Roswell was founded in 2014 in San Diego. It is a start-up enterprise with around 50 employees,[113] and is aiming to produce an "end game" sequencing platform to disrupt current technologies.[114] In particular, it sees an opportunity to shift adoption from research centres to clinical labs.[115]

80. Roswell is aiming to produce accurate, long-read sequences, in under an hour, and at a cost of less than $100 per genome. It further predicts that it will reach $10 genomes in 10 minutes within a decade.[116] Roswell has publicly stated its intention to offer $100 per genome in under an hour.[117]

81. Roswell is planning to initially enter the "targeted" applications of DNA sequencing but expand from there to potentially address the full market.[118]

82. [✂].[119] [✂].[120]

83. [✂].[121]

84. [✂].[122]

85. [✂].[123]

Resonance HRT

86. Resonance HRT submitted that is a small company founded in August 2017 and is based in the United States. It currently has [✂] employees.[124] Resonance HRT told us [✂].[125] Its website states that it is "currently operating in stealth mode" and provides no other information.[126]

87. Resonance HRT is working on research and development of a new sequencing technology which uses resonant tunneling to sequence molecules as they pass through a nano-channel.[127]

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[113] [✂]; https://www.roswellbiotech.com/contact/
[114] https://www.roswellbiotech.com/company/
[115] [✂].
[116] [✂].
[117] "Delivering the $100, 1-hour Genome for precision medicine." https://www.roswellbiotech.com/applications/
[118] [✂].
[119] [✂].
[120] Parties' Merger Notice, paragraph 412.
[121] [✂].
[122] [✂].
[123] [✂].
[124] [✂].
[125] [✂].
[126] http://resonancehrt.com/
[127] [✂].

88. Resonance HRT submitted that [✂].[128]

89. Resonance HRT submitted that it had meetings with Illumina and Illumina Ventures. [✂].[129]

NanoString

90. NanoString is a company of 520 people based in Seattle. It was founded in 2003 and produces life science tools for translational research and molecular diagnostics, in particular instruments which measure the expression and existence of certain genes and proteins.[130] It had revenue of $107 million in 2018, and is publicly listed on NASDAQ.[131]

91. NanoString told us that it has spent the last four years developing a new sequencing technology targeting clinical customers, particularly aiming to compete with Illumina and Thermo Fisher's mid-throughput diagnostic instruments.[132] In mid-2017, NanoString partnered with Lam Research (a semi-conductor manufacturer) which provided $50 million of funding to support this development.[133]

92. In January 2018, NanoString was aiming to produce a prototype by the end of 2019 and produce an FDA-exempt system in mid-2020.[134] However, because of the technical complexity of the project and the prioritisation of nearer-term product launches, NanoString determined that additional time and funding would be needed in order to complete development and launch its platform.[135]

93. The latest documents available indicate that NanoString is planning to launch a prototype at the end of 2020 at the earliest.[136] Furthermore, there would then be a period of seeking regulatory approval and commercialisation which is expected to take at least a year.[137]

94. [✂].[138] [✂].[139]

95. [✂].[140]

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[128] [✂].
[129] [✂].
[130] https://www.nanostring.com/company/about-us
[131] http://investors.nanostring.com/static-files/f9d6c483-e176-45d4-be8d-96d596a7e1c9
[132] [✂].
[133] [✂].
[134] [✂].
[135] [✂].
[136] [✂].
[137] [✂].
[138] [✂].
[139] [✂].
[140] [✂].

Quantum SI

96. Quantum SI is owned by 4Catalyzer,[141] a startup technology incubator focused on life science research tools, medical devices and therapeutics, led by Jonathan Rothberg who previously founded Ion Torrent and 454.[142]

97. 4Catalyzer does not refer to Quantum SI on its own website, instead only referring to three other life science companies.[143]

98. Quantum SI is incorporated in the US,[144] and states that it is fully funded by its founders.[145] However, its website provides no additional information on the technology, progress, or intentions of the company.[146]

Apton Biosystems

99. Apton Biosystems is based in the United States[147] and has 16 employees.[148]

100. Apton Biosystems submitted that it is an early stage, pre-revenue startup and its sole operations consist of research and development in the US.[149]

101. Apton Biosystems submitted that [✂].[150]

102. Apton Biosystems submitted that [✂].[151]

iNanoBio

103. iNanoBio was incorporated in 2014[152] as a spinout of Arizona State University and is based in the United States.[153] It is aiming to develop high-accuracy early stage disease diagnostics using nano-biotechnology platforms and machine learning.[154]

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[141] http://www.quantum-si.com/
[142] https://www.4catalyzer.com/#aspirations
[143] https://www.4catalyzer.com/#companies
[144] https://www.concord-sots.ct.gov/CONCORD/online?sn=PublicInquiry&eid=9740
[145] http://www.quantum-si.com/
[146] http://www.quantum-si.com/
[147] http://www.aptonbio.com/contact/
[148] [✂].
[149] [✂].
[150] [✂].
[151] [✂].
[152] https://www.sec.gov/Archives/edgar/data/1639635/000163963518000001/xslFormDX01/primary_doc.xml
[153] https://www.genomeweb.com/sequencing/asu-spinout-inanobio-aims-develop-nanopore-transistor#.XZ78VUZKiUk
[154] https://inanobio.com/#company

104. iNanoBio's technology is based on an advanced 3D nanopore which is a transistor device for sequencing the whole human genome with high accuracy.[155]

105. iNanoBio's press releases indicate it has received $6.1 million in grants from the National Institute of Health and the Defense Advanced Research Projects Agency.[156]

106. iNanoBio has not acknowledged any correspondence with the CMA.

Quantapore

107. Quantapore was founded in 2009,[157] is based in the United States, and its website lists 22 employees.[158]

108. Quantapore is working on the development of a high-throughput, single molecule sequencing technology capable of sequencing *"massive amounts of DNA in unison"*.[159]

109. In 2018, Quantapore raised $17 million of funds through a stock sale.[160] Its investors primarily consist of a number of venture-capital firms.[161]

110. Quantapore submitted that its sole focus has been technology development and as such its viewpoints on market conditions are no more insightful than what can be read in current articles and publications. [✂].[162]

[155] https://inanobio.com/#technology
[156] https://inanobio.com/press/
[157] https://quantapore.com/about/board/
[158] https://quantapore.com/about/team/
[159] https://quantapore.com/technology/
[160] https://quantapore.com/2018/07/18/effective-product-promo-videos/
[161] https://quantapore.com/about/investors/
[162] [✂].

Appendix F: Valuation

Introduction

1. This appendix provides additional information on the valuations which PacBio and Illumina attributed to PacBio.

2. We reviewed the documents and supporting evidence from both PacBio and Illumina relating to the valuation of the transaction. These appeared to indicate that the value primarily resulted from the expectation of PacBio significantly growing its revenue, as well as an intention to grow gross margins, even on a stand-alone basis. Together, these resulted in an expectation that PacBio would generate substantial levels of cash in the future.

PacBio valuation analysis

3. PacBio appointed an investment bank ([✂]) to assist in developing a valuation (including a valuation model) which was used for a fairness opinion of the deal.[163]

4. The valuation model forecasted revenue up until 2028 with revenue expected to grow from $[✂] in 2019 to $[✂] by 2028.[164] This included an expectation that PacBio would achieve positive free cash flow in [✂].[165]

5. In order to estimate the standalone value of the company, PacBio and its advisor produced a discounted cash flow (DCF) model based on the above forecasts, which indicated a valuation range of between $[✂] and $[✂] per share.[166] [✂].

6. This analysis was tested against other valuation approaches, including PacBio's historical trading range, equity analyst's price targets, trading multiples of other public companies, and precedent transactions.[167] This is shown in Figure 1 below:

Figure 1: [✂]

[✂]

Source: [✂].

[163] [✂].
[164] [✂].
[165] [✂].
[166] [✂].
[167] [✂].

Illumina valuation analysis

7. Illumina's revenue model forecasted that, as an independent entity, PacBio's revenue would [✂].[168]

8. Illumina's model forecasted that, as an independent entity, the future share of PacBio's revenue derived from the clinical segment [✂].[169] This is shown in Figure 2 below:

Figure 2: [✂]

[✂]

Source: [✂].

9. Illumina conducted a DCF valuation using these forecasts, which indicated a price range of [✂] per share (implying an enterprise valuation of PacBio of [✂]).[170]

10. Illumina's forecasts indicated an expectation that as a standalone entity PacBio would start to generate positive free cash flow in [✂], [✂].

11. In addition to the standalone value of PacBio, Illumina estimated the value of potential synergies arising from the Proposed Merger. [✂], with the difference between standalone and synergised revenues shown in Figure 3 below:

Figure 3: [✂]

[✂]

Source[✂].

12. There are also additional expected synergies from the deal including [✂], with the overall impact shown in Figure 4 below:[171]

Figure 4: [✂]

[✂]

Source: [✂].

13. Illumina's valuation model indicated [✂].[172]

[168] [✂].
[169] [✂].
[170] [✂].
[171] [✂].
[172] Illumina Response to Valuation Working Paper, slide 12; [✂].

14. The model also included [✂].[173] [✂].[174] We note that these reductions would still appear to be merger-specific.

15. On a synergised basis Illumina's DCF valuation [✂] to a range of [✂] per share, equivalent to around a [✂] on the unsynergised estimates.[175]

16. Illumina's valuation model does not [✂],[176] [✂].[177]

17. Illumina also considered other valuation methods, including the variation in PacBio's share price, precedent transactions, analyst price targets, and comparable trading companies, to benchmark against a potential acquisition valuation as shown in Figure 5 below:

Figure 5: [✂]

[✂]

Source: [✂].

[173] [✂].
[174] Illumina Response to Valuation Working Paper, paragraph 14.
[175] [✂].
[176] Illumina presentation at Main Party Hearing, slide 13.
[177] [✂].

Glossary

Acronym	Definition
the Act	The Enterprise Act 2002
ASPR	Assistant Secretary for Preparedness and Response
ATM	At the Market
BARDA	the Biomedical Advanced Research and Development Authority
BGI	Beijing Genomics Institute
bp	Base Pairs (unit of measurement)
CAGR	Cumulative Annual Growth Rate
CCS	Circular Consensus Sequencing
CEO	Chief Executive Officer
CFIUS	Committee on Foreign Investment in the United States
CG	Clinical Genomics
CMA	Competition and Markets Authority
CMOS	Complementary Metal-Oxide Semiconductor
Counterfactual	The counterfactual is a benchmark against which the expected effects of the Proposed Merger can be assessed. The counterfactual takes events of circumstances and their consequences into account to the extent that they are foreseeable
DNA	Deoxyribonucleic acid
DNAe	DNA Electronics
EMEA	Europe, Middle East and Africa
FDA	Food and Drug Administration
FISH	Fluorescent In-Situ Hybridisation
FY	Financial Year
Gb	Gigabase
Genemind	Direct Genomics
Genia	Genia Technologies
GENIUS	Gene Electronic Nano-Integrated Ultra-Sensitive
HHS	US Department for Health and Human Services
HLA	Human Leukocyte Antigen
HS	HiSeq
HT/LT	High Throughput/Low Throughput
hWGS	Human Whole Genome Sequencing
Illumina	Illumina, Inc.
ILMN	Illumina
IPO	Initial Public Offering
ISO-Seq	Isoform Sequencing
IVD	In Vitro Diagnostic
KOL	Key Opinion Leader
Linked Long Reads	Also known as “associated short read” technologies, and consist of using library preparation methods such as labelling the fragments to help with reassembly of the original “parent”.
LLR	Linked Long Read
LP	Library Prep
LR	Long Read
MAGs	Merger Assessment Guidelines
The Merged Entity	Illumina and PacBio, together

Acronym	Definition
The Merger Agreement	Merger agreement signed by the Parties on 1 November 2018 and amended on 25 September 2019
NASDAQ	National Association of Securities Dealers Automated Quotations, an American Stock Exchange
NGS	Next-Generation Sequencing
NHGRI	National Human Genome Research Institute
NIPT	Non-Invasive Prenatal Testing
NS	NextSeq
NSB	North Shore Bio
NYSE	New York Stock Exchange
ONT	Oxford Nanopore Technologies
PAC	Product Approval Committee
PacBio	Pacific Biosciences of California, Inc.
The Parties	Illumina and PacBio
PCR	Polymerase Chain Reaction
PIPE	Private Investment in Public Equity
PopSeq	Population Sequencing
project	Our understanding of the term project, in this report, is an individual or collaborative enterprise (often a team at a university or research institute), planned to achieve a particular scientific goal
The Proposed Merger	The anticipated acquisition by Illumina of PacBio
QB	Quantum Bioscience
QIAGEN	QIAGEN N.V.
R&D	Research and Development
Roswell	Roswell Biotechnologies
RNA	Ribonucleic acid
RUGD	Rare and Undiagnosed Genetic Disease
Sanger Sequencing / Sequencers	The first generation sequencing method or “chain termination method” to identify the nucleotides on a DNA strand
SBS	Sequencing By Synthesis (technology used by Illumina)
SG	Stratos Genomics
SGS	Singular Genomics Systems
SIMDEQ	Single-molecule Magnetic Detection and Quantification
SKUs	Stock Keeping Unit
SLC	Substantial lessening of competition
SMRT	Single Molecule, Real Time (technology used by PacBio)
SNV/SNP	Single Nucleotide Polymorphism Variant
SR	Short Read
SV	Structural Variant
TLR	True Long Reads
Thermo Fisher	Thermo Fisher Scientific
TMO	Thermo Fisher
UK	United Kingdom
WGS	Whole Genome Sequencing