

Molecular Diagnostics

Part II: Regulations, Markets & Companies

By

Prof. K. K. Jain
MD, FRACS, FFPM
Jain PharmaBiotech
Basel, Switzerland

November 2018

A Jain PharmaBiotech Report

A U T H O R ' S B I O G R A P H Y

Professor K. K. Jain is a neurologist/neurosurgeon by training and has been working in the biotechnology/biopharmaceuticals industry for several years. He received graduate training in both Europe and USA, has held academic positions in several countries, and is a Fellow of the Faculty of Pharmaceutical Medicine of the Royal College of Physicians of UK. Prof. Jain's 478 publications include 30 books (6 as editor + 24 as author) and 50 special reports, which have covered important areas in biotechnology, gene therapy and biopharmaceuticals. His books include "Role of Nanobiotechnology in Molecular Diagnostics" (2006), "Handbook of Nanomedicine" (Humana/Springer 2008; Chinese edition, Peking University Press 2011; 2nd ed Springer 2012, 3rd ed 2017), "Textbook of Personalized Medicine" (Springer 2009; Japanese edition 2012; 2nd ed Springer, 2015), "Handbook of Biomarkers" (Springer 2010; Chinese ed Chemical Industry Press 2016, 2nd ed Springer 2017), "Applications of Biotechnology in Cardiovascular Therapeutics (Springer 2011)", "Applications of Biotechnology in Neurology (Springer, 2013)", and "Applications of Biotechnology in Oncology" (Springer 2014). He has also edited "Applied Neurogenomics" (Springer 2015).

A B O U T T H I S R E P O R T

Prof. Jain wrote the first commercial report on DNA Diagnostics covering scientific and commercial aspects in March 1995, which was published by PJB Publication, London. This was updated in 1997 as Molecular Diagnostics I and the next edition, Molecular Diagnostics II, was published in 1999 – both by Decision Resources Inc, USA. All the three versions of the reports were well accepted and sold widely. The current version was originally published by Jain PharmaBiotech in 2001 and is constantly updated since then. Not only was this the first such report on molecular diagnostics, it is the longest continuously published report (20 years). It is also the most comprehensive and detailed report on this topic containing profiles of the largest number of companies involved in molecular diagnostics.

**November 2018 (continuously published since 1995)
Copyright ©2018 by**

**Jain PharmaBiotech
Bläsiring 7
CH-4057 Basel
Switzerland**

**Tel & Fax: +4161-6924461
Email: info@pharmabiotech.ch
Web site: http://pharmabiotech.ch/**

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, or otherwise without the prior written permission of the Publisher. This report may not be lent, resold or otherwise traded in any manner without the consent of the Publisher. While all reasonable steps have been taken to ensure the accuracy of the information presented, the Publisher cannot accept responsibility for inadvertent errors or omissions.

TABLE OF CONTENTS

12. Ethics, Patents and Regulatory issues	7
Introduction	7
Ethical concerns about genetic diagnosis	7
Ethical guidelines for molecular diagnostics	8
Ethical aspects of use of WGS for newborn and prenatal screening	9
Ethical aspects of direct-to-consumer genetic services	9
US public attitudes about genetic testing	10
Opinion of European geneticists about DTC genetic testing	10
Genetic testing for susceptibility to adult-onset cancer	11
Ethics of preimplantation genetic diagnosis	11
<i>Preimplantation genetic diagnosis to screen for hereditary diseases</i>	11
<i>PGD to test for susceptibility to cancer</i>	12
<i>PGD and stem cells</i>	12
Genetic research on stored tissues	12
Informed consent in clinical trials of in vitro devices	13
Concluding remarks about ethical issues	13
Insurance underwriting and gene tests	14
<i>Should genetic information be available to health insurers?</i>	14
<i>A need for the re-examination of current views</i>	14
<i>Genetic Information Nondiscrimination Act of US</i>	15
<i>Impact of the US health care reform bill on genetic testing issues</i>	15
Patents for molecular diagnostics	15
PCR patents	15
Patenting DNA sequences	15
US policy on gene patenting relevant to molecular diagnostics.....	16
The impact of disease gene patents on molecular diagnostics	17
Licensing problems associated with genetic testing	17
BRCA1 and BRCA2 gene patents	17
Role of the WHO in genetic testing standards	18
NIH's Genetic Testing Registry	19
Regulatory issues in the US	19
Assay Migration Studies for In Vitro Diagnostic Devices	19
Assessment of diagnostic accuracy	19
<i>Sensitivity and specificity</i>	20
<i>Documentation of diagnostic accuracy</i>	21
Discovery of incidental findings on genetic screening	21
Evaluation of companion diagnostics/therapeutic for cancer	22
FDA regulation of multivariate index assays	22
FDA guidance for IVDs to detect pathogens	23
FDA guidelines for devices to detect and differentiate HPV	24
FDA's Microarray Quality Control.....	24
FDA and point-of-care diagnosis	25
Genetic testing of rare disorders	25
Guidelines for developing omics-based tests.....	26
<i>Shared responsibility on oversight of omics-based tests</i>	27
Guidelines for use of sequencing for molecular diagnosis	27
<i>FDA oversight of next generation sequencing</i>	28
Quality control of molecular diagnostic laboratory procedures	29
Quality assurance of RNA expression profiling.....	29
Quality control of point-of-care tests	30
Regulation of IVD by the FDA	30
FDA guidance on research use and investigational use only IVDs	32
Regulation of in vitro companion diagnostics by the FDA.....	32
Regulation of in vivo diagnostics by the FDA.....	33
Regulation of laboratory developed tests.....	33
<i>Home-brew tests</i>	33
<i>Laboratory-developed tests used by Medicare recipients</i>	33
<i>Oversight of LDTs by the FDA</i>	34
<i>Alternative to FDA LDT guidance</i>	35
Regulatory aspects of FISH	36
Regulation of genetic testing	37
<i>Role of the FDA in genetic testing</i>	37
Regulation of direct-to-consumer genetic testing	37
<i>Need for regulatory oversight of DTC</i>	37
Regulatory issues concerning blood and plasma products.....	40
United States Diagnostics Standards	40

Regulation of in vitro diagnostics in the EU	41
EU regulations for testing of blood products	42
Regulation of genetic testing in EU	42
Evaluation of diagnostic laboratory tests in the UK	43
Pre-implantation genetic diagnosis in the UK	44
13. Markets for Molecular Diagnostics	45
Introduction	45
Methods for study of molecular diagnostic markets.....	45
The overall market for diagnostic technologies	46
Markets for in vitro diagnostics	46
Molecular diagnostic markets according to technologies	46
Marketing strategies according to technologies	47
Nucleic acid isolation market	47
Market for PCR-based tests	47
<i>Markets for PCR instrumentation.....</i>	<i>48</i>
<i>Markets for real-time PCR and qRT-PCR.....</i>	<i>48</i>
<i>PCR market players.....</i>	<i>49</i>
DNA sequencing market.....	49
Cost of NGS	49
Cytogenetic market.....	50
<i>Market for FISH technologies.....</i>	<i>50</i>
Biochip/microarray market.....	50
Biosensor market.....	51
Nanobiotechnology for molecular diagnostics.....	51
Markets for gene expression technologies	51
Reagents and other disposable laboratory materials	52
Market for immunochemistry diagnostic.....	52
Markets for tissue diagnostics.....	52
Molecular diagnostic markets according to therapeutic areas	52
Genetic disorders	53
Prenatal testing	54
<i>Non-invasive prenatal testing</i>	<i>54</i>
Cancer.....	54
<i>Potential markets for cancer diagnosis according to type of cancer.....</i>	<i>55</i>
Infectious diseases.....	56
<i>Sexually transmitted diseases.....</i>	<i>58</i>
<i>Hospital-acquired infections.....</i>	<i>58</i>
<i>Testing for HIV drug resistance.....</i>	<i>59</i>
<i>Potential markets for avian influenza diagnostics</i>	<i>59</i>
Cardiovascular diseases.....	59
Neurological disorders	60
Food testing	60
Screening of blood for transfusion.....	60
Tissue typing for transplantation	61
Molecular diagnostic markets relevant to pharmaceutical industry	61
Molecular diagnosis and personalized medicine markets.....	61
Growth of markets relevant to personalized medicine	61
<i>Point-of-care market</i>	<i>62</i>
Marketing opportunities according to geographic areas	62
Unmet needs in molecular diagnostics.....	63
Major market trends	63
Markets according to home-brew and FDA-approved tests	63
Decentralization of molecular diagnostics	64
Direct-to-consumers healthcare testing	64
Point-of-care testing.....	65
Development of personalized medicine	65
<i>Cost of sequencing the human genome.....</i>	<i>65</i>
<i>Cost of genotyping.....</i>	<i>66</i>
<i>Marketing companion diagnostics for personalized medicine</i>	<i>66</i>
Development of low-cost tests.....	67
Simplification of test procedures	67
Increasing role of proteomics in clinical diagnostics	68
Forensic and legal applications	68
Veterinary molecular diagnostics.....	68
Marketing strategies.....	68
Role of alliances in commercialization of molecular diagnostics	69
<i>Acquisitions vs collaborations</i>	<i>69</i>
<i>Analysis of collaborations in molecular diagnostics</i>	<i>73</i>
<i>Licensing of the technologies.....</i>	<i>74</i>
Strategies related to laboratory facilities and technologies	74

Strategies relevant to the healthcare system	74
<i>Cost-Benefit studies</i>	74
<i>Genetic susceptibility testing</i>	74
<i>Preventive medicine strategies</i>	75
<i>Targeting treatable and common diseases</i>	75
Information/education	76
<i>Physician education</i>	76
<i>Patient education</i>	76
<i>European diagnostic information platform</i>	77
Regulatory strategies	77
Merger of in vitro and in vivo diagnostics	77
Integration of diagnostics with therapeutics	78
Diagnostic applications in clinical trials	78
Prospects for development of new technologies.....	78
Drivers for the development of molecular diagnostics	78
Factors slowing the development of molecular diagnostics	79
Cost of sequencing the human genome	79
Challenges and future prospects for diagnostic applications of sequencing	80
US organizations for advancing molecular diagnostic industry.....	81
<i>AdvaMedDx</i>	81
European projects for improving molecular diagnostics	81
<i>European Consortium for developing new DNA analysis tools</i>	81
<i>EU project for improvement of IVD tools procedures</i>	82
<i>Genetic knowledge parks in the UK</i>	82
Molecular diagnostic opportunities in defense against bioterrorism	82
Molecular diagnostics for food safety	83
POC diagnostics for the Asian countries	83
14. Companies involved in molecular diagnostics	86
Introduction	86
Major players in molecular diagnostics	86
Profiles of selected companies.....	87
Collaborations.....	453

Tables

Table 13-1: Share of in vitro diagnostics in the global diagnostic market 2017-2027	46
Table 13-2: Molecular diagnostics markets according to technologies from 2017-2027	47
Table 13-3: PCR market 2017-2027	48
Table 13-4: Molecular diagnostics markets according to applications 2017-2027.....	52
Table 13-5: Markets in 2017 for tests to screen healthy persons for genetic disorders.....	53
Table 13-6: Markets in 2017 for molecular diagnostic screening tests for cancer.....	55
Table 13-7: Molecular diagnostic markets for selected cancers 2017-2027	55
Table 13-8: Markets value in 2017 for molecular diagnostic screening for infections.....	57
Table 13-9: Future markets for HAI diagnostics 2017-2027	58
Table 13-10: Growth of markets relevant to personalized medicine 2017-2027	61
Table 13-11: Molecular diagnostic markets according to geographical areas 2017-2027	62
Table 13-12: Molecular diagnostic markets according to home-brew and approved tests	64
Table 13-13: Marketing strategies for molecular diagnostics	68
Table 13-14: Acquisitions of molecular diagnostic companies	69
Table 13-15: Advantages of the integration of diagnostics with therapeutics	78
Table 14-1: Top ten players in molecular diagnostics	86
Table 14-2: Collaborations of companies in molecular diagnostics.....	453

Figures

Figure 13-1: Unmet needs in applications of molecular diagnostics	63
---	----