Terminology for Personalized Medicine: a systematic collection

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Introduction

PACEOMICS is a stand-alone GE3LS project funded through the 2012 Large-Scale Applied Research Project Competition in Genomics and Personalized Health/GE3LS (see: http://www.genomecanada.ca/medias/pdf/en/McCabe.pdf and PACEOMICS.org). PACEOMICS aims to develop analytical tools and resources to support public and private sector stakeholders in realizing the potential of personalized medicine (PM) in Canada and around the world (see: http://paceomics.org). The PACEOMICS program of work comprises four themes: 1) social values; 2) health technology assessment (HTA) and evidence development; 3) the legal and regulatory environment; 4) technology development and intellectual property management (for details see: http://paceomics.org/index.php/the-paceomics-approach/).

As an interdisciplinary research program, an initial goal of PACEOMICS was to develop a shared vocabulary for use across research themes (Gold et al., 2004). A common vocabulary is useful in seeding research activities such as systematic or scoping reviews (Arksey and O'Malley, 2005, Centre for Reviews and Dissemination, 2009). Such reviews form an early step in establishing a new research program, enabling charting of the field and identification of key policies, challenges, recommended solutions and knowledge gaps. Here we describe the method used to develop set of synonyms for personalized medicine developed by the PACEOMICS research team that could be used across its research themes.

Evolving terminology - a shift from Personalized to Precision Medicine

The field of personalized medicine (PM) has evolved over the last decades. Reflecting its evolution has been a shifting vocabulary within and across jurisdictions. Our goal was

to compile the broadest possible set of keywords used to represent PM since the concept came into focus, around the year 2000 (Bates, 2010; Katsnelson, 2013). We use the keyword 'personalized medicine' in the searches described in this document because this name was predominant in academia, clinical, industry and policy discussions when these searches were conducted (June to September 2013) (Cherney et al., 2014). However since then, the use of 'precision medicine' has become prominent, gaining notable traction in 2015 through US President Obama's Precision Medicine Initiative (PMI) and related activities (Collins and Varmus, 2015; Precision Medicine Working Group Report, 2015). Notably, our search in 2013 captured the term 'precision medicine'.

There is no clear and widely agreed definition of PM (Cherny et al., 2014; Schleidgen et al., 2013). However, a definition derived from systematic review of the biomedical literature states: 'personalized medicine seeks to improve stratification and timing of healthcare by utilizing biological information and biomarkers on the level of molecular disease pathways, genetics, proteomics as well as metabolomics' (Schleidgen et al., 2013). This concept is consistent with the focus of PACEOMICS research activities (see PACEOMICS.org), and also with definitions of precision medicine, which emphasize evidence-based prevention and treatment through building a network of molecular and clinical data. Further, the definition of precision medicine underlines the research, regulatory and infrastructure activities that will be needed to optimize development and adoption of this healthcare approach (Collins and Varmus, 2015; Desmond-Hellman, 2012; National Research Council, 2011; Precision Medicine Working Group Report, 2015; White House Office of the Press Secretary, 2015). While a transition from personalized to precision medicine appears to be occurring, with other countries expected to follow the lead of the United States, both terms are still often used and understood in an equivalent sense (Genetics Home Reference, National Libraries of Medicine, What is the difference between precision medicine and personalized medicine?, 2016, see: http://ghr.nlm.nih.gov/handbook/precisionmedicine/precisionvspersonalized; Genome

Alberta Genomics Blog, 2015, see: http://genomealberta.ca/blogs/personalized-medicine-renamed-precision-medicine.aspx; Joyner and Panath, 2015; Katsnelson, 2013). Likewise, as our search results demonstrate, there are many other keywords used to describe the field.

To maximize usefulness, we aimed for a broad and inclusive collection of keywords and synonyms. As such, individual researchers can edit the list to fine-tune the sensitivity or specificity of their own literature searches. We identified keywords that were used in a broadly equivalent sense to PM in our data sources and also vocabulary closely related to PM (for example, terms describing diagnostics).

Methods

We identified keywords and synonyms for PM used in academic and policy contexts from five sets of documents: (1) peer-reviewed academic publications that were cited by (backward citations) and that cited (forward citations) Bates, 2010 – the publication that originally described the field of PM; (2) policy documents were cited in Bates, 2010; (3) highly-cited peer-reviewed academic articles; (4) websites of regulatory agencies, funders, and national health and biomedical organizations in Australia, Canada, the European Union, the United Kingdom and the United States; and (5) selected popular press articles. The five approaches are described in detail below. For all the searches, we limited our collection to sources written in the English language, and whose full texts were available without charge through the McGill University and University of Alberta library systems. The searches were carried out from June to September 2013.

We provide the details of each approach and the keywords complied from each source in the following sections. Note that we recorded the terminology as it appeared in the sources – we did not add plurals and other variations of the keywords. We anticipate that researchers who may use these vocabulary lists – including PACEOMICS teams and others – will incorporate such variations during the development of customized search strings (e.g. target/targets/targeted, profiles/profile/profiling; personalized/ personalization/personalizing/personalised etc.). The keywords listed below were then

edited by SA-K, RG and TB to yield the more focussed list of keywords for PM listed in the accompanying excel spreadsheet. We reference all keywords according only to the first publication/article from our search strategy that used the term.

PM keyword search 1: 'snowball' sampling

The term PM was first used in the 1940s (Cherny et al., 2014). However, it was re-coined, taking on its broad contemporary meaning, in the late 1990s as the health and economic potential of the Human Genome Project came into focus (Cherny et al., 2014; Jorgensen, 2011; Schleidgen et al., 2013). We sought to compile synonyms and keywords for PM being used in this contemporary sense i.e., broadly aligned with the definition of PM derived by Schleidgen et al, and with definitions of precision medicine (Collins and Varmus, 2015; Desmond-Hellman, 2012; National Research Council, 2011; Precision Medicine Working Group Report, 2015; White House Office of the Press Secretary, 2015).

We first asked Google (https://www.google.ca): 'When was the term 'Personalized Medicine' coined?'. This search yielded a publication entitled 'Progress Towards Personalized Medicine' (Bates, 2010) that discussed the development of the field of PM, including the origin of the term PM. It credits Langreth and Waldholz in 1999 (Langreth and Waldholz,1999a, 1999b) as among the first authors to describe the contemporary understanding of PM.

The Bates article discusses the development and the future of the field of PM, is well-cited and references both policy and biomedical publications. Further, it was published toward the middle of the time period over which we wished to conduct our search (1999 - 2013). Therefore, this article (Bates, 2010) seemed a reasonable starting point for our search for PM keywords.

We carried out an iterative search of forward and back citations from the Bates article. We selected four peer-reviewed academic publications that cited Bates and likewise four publications that were cited by Bates. For each of these new documents we further selected one to three publications that cited and were cited by these publications. We examined titles, abstracts and keywords to select publications whose main focus was PM (or the biomedical application of molecular knowledge more generally) and selected only those published from 1999 onwards. We aimed for representation across bio-medical science, as well as ethics, policy and commentary/thought pieces. We used

Google Scholar to retrieve citations and full-texts, and recorded the number of times each document was cited according to the number of Web of Science citations listed. Using Google, we also retrieved the full-texts of all the policy documents that were cited in Bates. For these documents (10), we collected all keywords that were used in a generally equivalent sense to PM, as well as closely related terms, from the full text and keywords.

Results:

Bates, S. (2010) Progress toward Personalized Medicine. *Drug Discovery Today*, 15 (3/4): 115-120. (cited 78 times)

Four publications citing Bates (2010) and their forward and back citations:

1. Bonter, K., Desjardins, C., Currier, N., Pun, J., & Ashbury, F. D. (2011). Personalised medicine in Canada: A survey of adoption and practice in oncology, cardiology and family medicine. *Bmj Open, 1*(1), e000110. doi:10.1136/bmjopen-2011-000110 (cited 6 times)
    Cites:
    - Issa, A. M. (2007). Personalized medicine and the practice of medicine in the 21st century. *McGill Journal of Medicine, 10*(1), 53-57. (cited 10 times)
    - Khoury, M. J., Rich, E. C., Randhawa, G., Teutsch, S. M., & Niederhuber, J. (2009). Comparative effectiveness research and genomic medicine: An evolving partnership for 21st century medicine. *Genetics in Medicine, 11*(10), 707-711. (cited 25 times)

    Cited by:
    - van Rooij, T., Wilson, D. M., & Marsh, S. (2012). Personalized medicine policy challenges: Measuring clinical utility at point of care. *Expert Review of Pharmacoeconomics & Outcomes Research, 12*(3), 289-295. doi:10.1586/ERP.12.15 (cited 10 times)
    - Shah, R. R., & Shah, D. R. (2012). Personalized medicine: Is it a pharmacogenetic mirage? *British Journal of Clinical Pharmacology, 74*(4), 698-721. doi:10.1111/j.1365-2125.2012.04328.x (cited 3 times)

2. Riegman, P. H. J., & van Veen, E. (2011). Biobanking residual tissues. *Human Genetics, 130*(3), 357-368. doi:10.1007/s00439-011-1074-x (cited 13 times)
    Cites:
    - Janssens, A. C. J. W., van Duijn, C. M. (2008). Genome-based

prediction of common diseases: advances and prospects. *Human Molecular Genetics,* 17 (R2): R166-R173.doi: 10.1093/hmg/ddn250 (cited 266 times)

Cited by:

- Knoppers, B. M., Zawati, M. H., & Kirby, E. S. (2012). Sampling populations of humans across the world: ELSI issues. *Annual Review of Genomics and Human Genetics, Vol 13, 13*, 395-413. doi:10.1146/annurev-genom-090711-163834 (cited 0 times)
- Feero, W. G., Guttmacher, A. E., & Collins, F. S. (2010). Genomic medicine: Genomic medicine -- an updated primer. *New England Journal of Medicine, 362*(21), 2001-2011. doi:10.1056/NEJMra0907175 (cited 129 times)

3. Mura, S., & Couvreur, P. (2012). Nanotheranostics for personalized medicine. *Advanced Drug Delivery Reviews, 64*(13), 1394-1416. doi:10.1016/j.addr.2012.06.006 (cited 7 times)

   Cites:

   - Sadee, W., & Dai, Z. (2005). Pharmacogenetics/genomics and personalized medicine. *Human Molecular Genetics, 14*, R207-R214. doi:10.1093/hmg/ddi261 (cited 69 times)
   - Evans, W., & Relling, M. (1999). Pharmacogenomics: Translating functional genomics into rational therapeutics. *Science, 286*(5439), 487-491. doi:10.1126/science.286.5439.487 (cited 1,249 times)

   Cited by:

   - Svenson, S. (2013). Theranostics: Are we there yet? *Molecular Pharmaceutics, 10*(3), 848-856. doi:10.1021/mp300644n (cited 0 times)

4. Shaw, K. J., Birch, C., Hughes, E. M., Jakes, A. D., Greenman, J., & Haswell, S. J. (2011). Microsystems for personalized biomolecular diagnostics. *Engineering in Life Sciences, 11*(2), 121-132. doi:10.1002/elsc.201000175 (cited 3 times)

   Cites:

   - Marko-Varga, G., Ogiwara, A., Nishimura, T., Kawamura, T., Fujii, K., Kawakami, T., Kyono, Y., Hsiao-kun, T., Anyoli, H., Kanazawa, M., Akimoto, S., Hirano, T., Tsuboi, M.,Nishio, K., Hada, S., Jiang, H., Fukuoka, M., Nakata, K., Nishiwaki, Y., Kunito, H., Peers, I. S., Harbron, C. G., South, M. C., Higenbottam, T., Nyberg, F., Kudo, S., & Kato, H. (2007). Personalized medicine and proteomics: Lessons from non-small cell lung cancer. *Journal of Proteome Research, 6*(8), 2925-2935. doi:10.1021/pr070046s (cited 24 times)
   - Ross, J. S., & Ginsburg, G. S. (2003). The integration of molecular diagnostics with therapeutics-implications for drug development and

pathology practice. *American Journal of Clinical Pathology, 119*, 26. (cited 42 times)

Cited by:

- Kiechle, F., & Holland-Staley, C. (2003). Genomics, transcriptomics, proteomics, and numbers. *Archives of Pathology & Laboratory Medicine, 127*(9), 1089-1097. (cited 30 times)
- Kiechle (2003) also cites: Kiechle, F., Zhang, X., & Holland-Staley, C. (2004). The -omics era and its impact. *Archives of Pathology & Laboratory Medicine, 128*(12), 1337-1345. (cited 14 times)

Four publications cited by Bates (2010) and their forward and back citations:

1. Davis, J. C., Furstenthal, L., Desai, A. A., Norris, T., Sutaria, S., Fleming, E., & Ma, P. (2009). OUTLOOK the microeconomics of personalized medicine: Today's challenge and tomorrow's promise. *Nature Reviews Drug Discovery, 8*(4), 279-286. doi:10.1038/nrd2825 (cited 40 times)

   Cites:

   - Goodman, C. Faulkner E, Gould C, Karnes E, Smith A, Aguiar C, Nelson C, Grover A, Berlin A, Phillips R, Horan A (The Lewin Group)(2005). The Value of Diagnostics, Innovation, Adoption and Diffusion into Health Care. *The Southern California Biomedical Council*. (no citations, as is not listed on Google Scholar)

   Cited by:

   - March, R. (2010). Delivering on the promise of personalized healthcare. *Personalized Medicine, 7*(3), 327-337. doi:10.2217/PME.10.17 (cited 2 times)
   - Crommelin, D. J. A., Storm, G., & Luijten, P. (2011). 'Personalised medicine' through 'personalised medicines': Time to integrate advanced, non-invasive imaging approaches and smart drug delivery systems. *International Journal of Pharmaceutics, 415*(1-2), 5-8. doi:10.1016/j.ijpharm.2011.02.010 (cited 5 times)

2. Jorgensen, J. T. (2008). Are we approaching the post-blockbuster era? pharmacodiagnostics and rational drug development. *Expert Review of Molecular Diagnostics, 8*(6), 689-695. doi:10.1586/14737159.8.6.689 (cited 9 times)

   Cites:

   - Woodcock, J. (2007). The prospects for "personalized medicine" in drug development and drug therapy. *Clinical Pharmacology & Therapeutics, 81*(2), 164-169. doi:10.1038/sj.clpt.6100063 (cited 75 times)
   - Garrison, L. P. Jr., & Austin, M. J. F. (2006). Linking pharmacogenetics-based diagnostics and drugs for personalized medicine. *Health Affairs, 25*(5), 1281-1290. doi:10.1377/hlthaff.25.5.1281 (cited 27 times)

Cited by:

- Jorgensen, J. T. (2011). A challenging drug development process in the era of personalized medicine. *Drug Discovery Today,* 16(19-20), 891-897. doi.org/10.1016/j.drudis.2011.09.010 (cited 22 times)

3. Hayden, E. C. (2009). Personalized cancer therapy gets closer. *Nature, 458*(7235), 131-132. doi:10.1038/458131a (cited 21 times)
   Cites:
   - Hulot, J. (2010). Pharmacogenomics and personalized medicine: Lost in translation? *Genome Medicine, 2*, 13. doi:10.1186/gm13 (cited 3 times)

   Cited by**:**
   - Ellsworth, R. E., Decewics, D. J., Shriver, C. D., & Ellsworth, D. L. (2010). Breast cancer in the personal genomics era. *Current Genomics*, 11(3): 146-161. doi: 10.2174/138920210791110951 (cited 21 times)

4. Langreth, R., Waldholz, M. (1999). New era of personalized medicine targeting drugs for each unique genetic profile. *The Wall Street Journal,* (April 16). (cited 25 times)
   Cites: no publications collected as all are pre-1999.
   Cited by:
   - Ginsburg, G. S., & Willard, H. F. (2009). Genomic and personalized medicine: Foundations and applications. *Translational Research, 154*(6), 277-287. doi:10.1016/j.trsl.2009.09.005 (cited 92 times)
   - Lunshof, J., Pirmohamed, M., & Gurwitz, D. (2006). Personalized medicine: Decades away? *Pharmacogenomics, 7*(2), 237-241. doi:10.2217/14622416.7.2.237 (cited 22 times)
   - Bereczki, D. (2012). Personalized medicine: A competitor or an upgrade of evidence-based medicine? *Personalized Medicine, 9*(2), 211-221. doi:10.2217/PME.11.93 (cited 1 time)

   Ginsburg is cited by:
   - Brunham, L. R., & Hayden, M. R. (2012). Whole-genome sequencing: The new standard of care? *Science, 336*(6085), 1112-1113. doi:10.1126/science.1220967 (cited 9 times)
   - Simmons, L. A., Dinan, M. A., Robinson, T. J., & Snyderman, R. (2012). Personalized medicine is more than genomic medicine: Confusion over terminology impedes progress towards personalized healthcare. *Personalized Medicine, 9*(1), 85-91. doi:10.2217/PME.11.86 (cited 2 times)

5. Trusheim, M. R., Berndt, E. R., & Douglas, F. L. (2007). Stratified medicine: Strategic and economic implications of combining drugs and clinical biomarkers. *Nature Reviews Drug Discovery, 6*(4), 287-293. doi:10.1038/nrd2251(cited 132 times)

Cites:

- Ziegler A, Koch A, Kockenberger K, Grosshennig A. Personalized medicine using DNA biomarkers (2012) Human Genetics. 131(10), 1627-1638. DOI 10.1007/s00439-012-1188-9 (cited 42 times)

Cited by:

- Jorgensen, J. T. (2008). Are we approaching the post-blockbuster era? pharmacodiagnostics and rational drug development. *Expert Review of Molecular Diagnostics, 8*(6), 689-695. doi:10.1586/14737159.8.6.689 (cited 9 times)
- Juengst, E. T., Flatt, M. A., & Settersten, R. A., Jr. (2012). Personalized genomic medicine and the rhetoric of empowerment. *Hastings Center Report, 42*(5), 34-40. doi:10.1002/hast.65 (cited 2 times)

Keywords collected from each publication by publication year:

1. Evans, W., & Relling, M. (1999). Pharmacogenomics: Translating functional genomics into rational therapeutics. *Science, 286*(5439), 487-491. doi:10.1126/science.286.5439.487 (cited 1249 times)
   Keywords from text:
   - Genetic Polymorphisms
   - Pharmacogenomics
   - Molecular diagnostics
   - Genotype
   - Individualized drug therapy

2. Langreth, R. & Waldholz, M. (1999). New era of personalized medicine targeting drugs for each unique genetic profile. *The Wall Street Journal,* (April 16). (cited 25 times)
   Keywords from text:
   - Personalized medicines
   - Gene map
   - Single nucleotide polymorphisms

3. Kiechle, F., & Holland-Staley, C. (2003). Genomics, transcriptomics, proteomics, and numbers. *Archives of Pathology & Laboratory Medicine, 127*(9), 1089-1097.
   Keywords from text:
   - Transcriptomics
   - Proteomics
   - Genetic tests
   - Analyte-specific reagents
   - Molecular medicine

4. Ross, J. S., & Ginsburg, G. S. (2003). The integration of molecular diagnostics with therapeutics-implications for drug development and pathology practice. *American Journal of Clinical Pathology, 119*, 26-36. DOI: 10.1092/VMLL66Y5KHQ35KUE
   Author Keywords: Personalized medicine, Molecular diagnostics, Pharmacogenomics, Pharmacogenetics, Toxicogenomics.
   Keywords from text:
   - Molecular diagnostic
   - Targeted therapeutics
   - Molecular pathology
   - Personalize medical care
   - Genomic technologies
   - Proteomic technologies
   - Pharmacogenomics
   - SNP genotyping
   - Gene sequencing
   - Genomic microarrays
   - Pharmacogenetic
   - Bioassays
   - Gene expression profiles,
   - Tissue-based biomarkers
   - Toxicogenomics
   - Integrated diagnostics and therapeutics

5. Kiechle, F., Zhang, X., & Holland-Staley, C. (2004). The -omics era and its impact. *Archives of Pathology & Laboratory Medicine, 128*(12), 1337-1345. (cited 14 times)
   Keywords from text:
   - –omics
   - Molecular-based testing
   - Microarrays
   - Genomic screening
   - Transcriptomic screening
   - Proteomic screening
   - Transcriptomics
   - Pharmacogenomics
   - Proteomics
   - Genomics
   - Genetic polymorphisms

6. Goodman C., Faulkner E., Gould, C., Karnes E., Smith A., Aguiar C., Nelson C., Grover A., Berlin A., Phillips R., & Horan, A. (Lewin Group). (2005). The value of diagnostics, innovation, adoption and diffusion into health care. *The Southern California Biomedical Council*.

Keywords from text:
- *In vitro* diagnostics
- Targeted health care interventions
- Gene-based analyte specific reagents

7. Sadee, W., & Dai, Z. (2005). Pharmacogenetics/genomics and personalized medicine. *Human Molecular Genetics, 14*, R207-R214. doi:10.1093/hmg/ddi261 (cited 69 times)
   Keywords from text:
   - Personalized health care
   - Genetic polymorphisms
   - Pharmacogenetics
   - Pharmacogenomics
   - Genomic SNP maps
   - Prospective genotyping

8. Lunshof, J., Pirmohamed, M., & Gurwitz, D. (2006). Personalized medicine: Decades away? *Pharmacogenomics, 7*(2), 237-241. doi:10.2217/14622416.7.2.237 (cited 22 times)
   Author Keywords: adverse drug reactions; bioethics; clinical pharmacology; drug-metabolizing enzymes; medical education; personalized medicine; pharmacogenetics; Royal Society
   KeyWords Plus: ADVERSE DRUG-REACTIONS; ABACAVIR HYPERSENSITIVITY; CLINICAL-PRACTICE; PHARMACOGENETICS; POLYMORPHISM; GENETICS; ENZYMES; IMPACT
   Keywords from text:
   - Pharmacogenetic
   - Pharmacogenetic testing
   - Genotyping

9. Marko-Varga, G., Ogiwara, A., Nishimura, T., Kawamura, T., Fujii, K., Kawakami, T., et al. (2007). Personalized medicine and proteomics: Lessons from non-small cell lung cancer. *Journal of Proteome Research, 6*(8), 2925-2935. doi:10.1021/pr070046s (cited 24 times)
   Author Keywords: personalized medicine; biomarkers; predictive test; proteomics
   KeyWords Plus: proteome
   Keywords from text:
   - Proteomic profiling
   - Proteome
   - proteomic biomarker

10. Garrison, L. P., Jr., & Austin, M. J. F. (2006). Linking pharmacogenetics-based diagnostics and drugs for personalized medicine. *Health Affairs, 25*(5), 1281-1290. doi:10.1377/hlthaff.25.5.1281 (cited 27 times)

Keywords from text:
- Pharmacogenetics
- Genetic testing
- Genotyping
- Pharmacogenetics-based tests
- Diagnostic-therapeutic linkage

11. Trusheim, M. R., Berndt, E. R., & Douglas, F. L. (2007). Stratified medicine: Strategic and economic implications of combining drugs and clinical biomarkers. *Nature Reviews Drug Discovery, 6*(4), 287-293. doi:10.1038/nrd2251 (cited 132 times)
    Keywords from text:
    - Stratified medicine
    - 'Individualized' medicines
    - 'Personalized' medicine
    - Biomarker
    - Genotypes
    - Metabonomics
    - Clinical biomarkers
    - Stratified therapy
    - Esoteric diagnostics

12. Woodcock, J. (2007). The prospects for "personalized medicine" in drug development and drug therapy. *Clinical Pharmacology & Therapeutics, 81*(2), 164-169. doi:10.1038/sj.clpt.6100063 (cited 75 times)
    Keywords from text
    - Genomic
    - Proteomic
    - Genetic testing
    - Gene expression assays
    - Targeted therapy
    - Diagnostic biomarkers
    - In vitro assays

13. Janssens, A. C. J. W. & van Duijn, C. M. (2008). Genome-based prediction of common diseases: advances and prospects. *Human Molecular Genetics, 17*(R2), R166-R173. doi: 10.1093/hmg/ddn250 (cited 266 times)
    - Genetic profiling
    - Personalized medicine
    - Predictive test
    - Genetic testing
    - Genetic profiling
    - Genome-based prediction

- Biomarkers

14. Jorgensen, J. T. (2008). Are we approaching the post-blockbuster era? Pharmacodiagnostics and rational drug development. *Expert Review of Molecular Diagnostics, 8*(6), 689-695. doi:10.1586/14737159.8.6.689 (cited 9 times)
    Author Keywords: companion diagnostics; molecular diagnostics; personalized medicine; pharmacodiagnostics; stratified medicine
    KeyWords Plus: personalized medicine; pharmacogenetics
    Keywords from text:
    - Molecular diagnostic
    - Personalized medicine
    - Stratified medicine
    - Pharmacodiagnostics
    - Companion diagnostic
    - Drug–diagnostic codevelopment
    - Individualized drug therapies
    - Post-blockbuster era

15. Davis, J. C., Furstenthal, L., Desai, A. A., Norris, T., Sutaria, S., Fleming, E., & Ma, P. (2009). The microeconomics of personalized medicine: Today's challenge and tomorrow's promise. *Nature Reviews Drug Discovery, 8*(4), 279-286. doi:10.1038/nrd2825 (cited 40 times)
    Keywords from text:
    - –'omics sciences
    - Companion diagnostics

16. Ginsburg, G. S., & Willard, H. F. (2009). Genomic and personalized medicine: Foundations and applications. *Translational Research, 154*(6), 277-287. doi:10.1016/j.trsl.2009.09.005 (cited 92 times)
    KeyWords Plus: clinical decision support
    Keywords from text:
    - Genomic medicine
    - Personalized medicine
    - Health risk assessment
    - Genome information
    - Transcriptome
    - Proteome
    - Metabolome
    - Omics
    - Targeted therapies
    - Microarray-based gene chip
    - Sequencing technology
    - SNPs

17. Hayden, E. C. (2009). Personalized cancer therapy gets closer. *Nature, 458*(7235), 131-132. doi:10.1038/458131a (cited 21 times)
    Keywords from text:
    - Personalized genetic medicine
    - Genetic testing
    - Genetic screening
    - Genetic sequencing
    - Next-generation sequencing technologies

18. Jorgensen, J. T., & Winther, H. (2009). The new era of personalized medicine: 10 years later. *Personalized Medicine, 6*(4), 423-428. doi:10.2217/PME.09.24 (cited 2 times)
    Author Keywords: companion diagnostics; molecular diagnostics; personalized medicine; pharmacodiagnostics; pharmacotherapy; stratified medicine
    KeyWords Plus: pharmacodiagnostics
    Keywords from text:
    - Molecular diagnosis
    - Individualized pharmacotherapy
    - Pharmacodiagnostic testing

19. Khoury, M. J., Rich, E. C., Randhawa, G., Teutsch, S. M., & Niederhuber, J. (2009). Comparative effectiveness research and genomic medicine: An evolving partnership for 21st century medicine. *Genetics in Medicine, 11*(10), 707-711. (cited 25 times)
    Author Keywords: genomics
    KeyWords Plus: EGAPP working group; personalized medicine
    Keywords from text:
    - Genomic medicine
    - Genomic tests

20. Bates, S. (2010). Progress toward personalized medicine. *Drug Discovery Today*, *15* (3-4), 115-120. doi: 10.1016/j.drudis.2009.11.001. (cited 19 times)
    Keywords from text:
    - Tailoring of therapeutics
    - Molecularly targeted therapies
    - Genomics-based molecular diagnostics
    - Molecular medicine
    - Tailoring of medical treatment
    - Stratified medicine
    - Genomic technologies
    - Targeted therapy
    - Individualized therapy
    - Herceptin (Trastuzumab)
    - Gleevec (Imatinib)

- Molecular diagnosis
- Molecular diagnostics
- Genomic profiling
- Prognostic assays
- Predictive assays
- Gene expression profile
- Oncotype Dx
- Multi-analyte tests
- Polymerase chain reaction, micro-array, immunohistochemistry and fluorescent in situ hybridization
- Personalized therapy
- AstraZeneca's Iressa (Gefitinib)
- Companion diagnostics
- Personalized healthcare
- Selentry (maraviroc)
- Companion diagnostic assay (Trofile)
- Pharmacogenetic algorithm
- Genetic testing

21. Ellsworth, R. E., Decewics, D. J., Shriver, C. D. & Ellsworth, D. L. (2010). Breast cancer in the personal genomics era. *Current Genomics*, *11*(3): 146-161. doi: 10.2174/138920210791110951
    Key words: personal genomics, genetic test
    Keywords from text:
    - Personalized medicine
    - Personalized (personal) genomics
    - Gene expression signatures
    - Molecular signatures
    - Personalized molecular medicine
    - Personalized genomic medicine
    - Molecular-based tests

22. Feero, W. G., Guttmacher, A. E., & Collins, F. S. (2010). Genomic medicine - an updated primer. *New England Journal of Medicine, 362*(21), 2001-2011. doi:10.1056/NEJMra0907175 (cited 129 times)
    KeyWords Plus: Gene signatures
    Keywords from text:
    - Genomewide scan
    - Genetic medicine
    - Genomic medicine
    - Genomics-enabled medicine
    - Genotype
    - Genomewide association study
    - Genomewide scan

- Next generation sequencing
- Pharmacogenomics
- Single-nucleotide polymorphism (SNP)
- Multiplexed tests
- Menetic diagnosis
- Molecular diagnosis
- Gene chips
- Polymerase chain reaction (PCR)
- Microarray technologies
- Medical informatics systems
- Genomics-enabled medicine

23. Hulot, J. (2010). Pharmacogenomics and personalized medicine: Lost in translation? *Genome Medicine,* 2(13). doi:10.1186/gm13 (cited 3 times)
    Keywords from text:
    - Personalized genomics
    - Mutation
    - Disease-associated/functional polymorphism
    - Single-nucleotide polymorphisms (SNPs)
    - Polymorphism-disease associations

24. March, R. (2010). Delivering on the promise of personalized healthcare. *Personalized Medicine, 7*(3), 327-337. doi:10.2217/PME.10.17 (cited 2 times)
    Author Keywords: biomarker; diagnostics; personalized healthcare
    Keywords from text:
    - Personalized healthcare
    - Biomarkers
    - Disease segmentation tools
    - Drug-diagnostic co-development
    - Prospective PHC drug-diagnostic co-development

25. Bonter, K., Desjardins, C., Currier, N., Pun, J., & Ashbury, F. D. (2011). Personalised medicine in Canada: A survey of adoption and practice in oncology, cardiology and family medicine. *BMJ Open, 1*(1), e000110. doi:10.1136/bmjopen-2011-000110 (cited 6 times)
    Keywords from text:
    - Genetic testing
    - Personalised medicine
    - '-omic' sciences
    - Pharmacogenomics
    - Targeted therapeutics
    - Companion diagnostics
    - Genetic profiling

26. Crommelin, D. J. A., Storm, G., & Luijten, P. (2011). 'Personalised medicine' through 'personalised medicines': Time to integrate advanced, non-invasive imaging approaches and smart drug delivery systems. *International Journal of Pharmaceutics, 415*(1-2), 5-8. doi:10.1016/j.ijpharm.2011.02.010 (cited 5 times)
    Author Keywords: Individualized medicine; Molecular imaging
    Keywords from text:
    - Personalized medicines
    - Biomarkers

27. Jorgensen, J. T. (2011). A challenging drug development process in the era of personalized medicine. *Drug Discovery Today, 16*(19-20), 891-897. doi.org/10.1016/j.drudis.2011.09.010
    Keywords from text:
    - Personalized medicine
    - Individualized pharmacotherapy
    - Molecular profiling
    - Biological subgroups
    - Personalized therapies
    - Companion diagnostics
    - Rational pharmacotherapy
    - Stratified medicine
    - Tailored therapy
    - Stratified pharmacotherapy
    - Drug/diagnostic combination
    - Targeted therapies

28. Riegman, P. H. J., & van Veen, E. (2011). Biobanking residual tissues. *Human Genetics, 130*(3), 357-368. doi:10.1007/s00439-011-1074-x (cited 13 times)
    KeyWords Plus: genetic research, personalized medicine, genomic research
    Keywords from text:
    - Personalised medicine
    - Biobanks
    - Tissue repository

29. Shaw, K. J., Birch, C., Hughes, E. M., Jakes, A. D., Greenman, J., & Haswell, S. J. (2011). Microsystems for personalized biomolecular diagnostics. *Engineering in Life Sciences, 11*(2), 121-132. doi:10.1002/elsc.201000175 (cited 3 times)
    Author Keywords: Diagnostics; Personalized medicine
    KeyWords Plus: On-a-chip; microfluidic device; clinical diagnostics
    Keywords from text:
    - Microfluidic methodology
    - Biomolecular diagnostics
    - Personalized medical care

- Genomic
- Personalized diagnostic medicine
- Single nucleotide polymorphism (SNP) analysis
- Targeted therapeutic
- Personalized diagnostics
- Pharmacogenomics
- Transcriptomics
- Proteomics
- Gene expression profiling
- Biomolecular analysis
- Genetic analysis
- Biomarkers

30. Bereczki, D. (2012). Personalized medicine: A competitor or an upgrade of evidence-based medicine? *Personalized Medicine, 9*(2), 211-221. doi:10.2217/PME.11.93 (cited 1 time)
    Author Keywords: biomarkers; evidence-based; medicine; personalized medicine
    KeyWords Plus: pharmacogenetics; polymorphism
    Keywords from text:
    - Biomarkers

31. Brunham, L. R., & Hayden, M. R. (2012). Whole-genome sequencing: The new standard of care? *Science, 336*(6085), 1112-1113. doi:10.1126/science.1220967 (cited 9 times)
    KeyWords Plus: mutation
    Keywords from text:
    - Whole-genome sequencing (WGS)
    - Genome-wide association studies
    - Genomic data
    - Bioinformatics
    - Genetic test
    - Genomic testing

32. Juengst, E. T., Flatt, M. A., & Settersten, R. A., Jr. (2012). Personalized genomic medicine and the rhetoric of empowerment. *Hastings Center Report, 42*(5), 34-40. doi:10.1002/hast.65 (cited 2 times)
    Keywords from text:
    - Personalized genomic medicine
    - Genomic medicine
    - P4 medicine (personalized, predictive, preventative, participatory)
    - Participatory medicine
    - Genome-wide genetic associations
    - Genomic medicine
    - Personalized medicine

- Stratified medicine

33. Knoppers, B. M., Zawati, M. H., & Kirby, E. S. (2012). Sampling populations of humans across the world: ELSI issues. *Annual Review of Genomics and Human Genetics, 13*(13), 395-413. doi:10.1146/annurev-genom-090711-163834 (cited 0 times)
    Keywords from text:
    - Personal genome information
    - Next-generation sequencing
    - Disease-specific biobanks
    - Population biobanks
    - Residual tissue banks

34. Mura, S., & Couvreur, P. (2012). Nanotheranostics for personalized medicine. *Advanced Drug Delivery Reviews, 64*(13), 1394-1416. doi:10.1016/j.addr.2012.06.006 (cited 7 times)
    Author keywords: Theranostic; Nanomedicine; Personalized nanomedicine
    Keywords from text:
    - “Nanotheranostics”
    - Theranostic nanomedicines
    - Non-invasive imaging
    - Personalized nanomedicine
    - Patient specific therapy
    - Pharmacogenomics
    - Pharmacoproteomic
    - –omic strategies
    - Genetic polymorphisms
    - Biomarkers
    - Theranostic nanodevices
    - Theranostics
    - Nanomedicines
    - Personalized therapy
    - Gene therapy

35. Simmons, L. A., Dinan, M. A., Robinson, T. J., & Snyderman, R. (2012). Personalized medicine is more than genomic medicine: Confusion over terminology impedes progress towards personalized healthcare. *Personalized Medicine, 9*(1), 85-91. doi:10.2217/PME.11.86 (cited 2 times)
    Author Keywords: genomic medicine; personalized healthcare; personalized medicine
    KeyWords Plus: systems biology
    Keywords from text:
    - Personalized healthcare
    - Personalized medicine

- Genomic medicine
- Patient-centered care
- P4 medicine
- Targeted therapies
- Companion diagnostics
- Theragnostics
- Genomics
- Transcriptomics
- Proteomics
- Pharmacogenomics

36. Shah, R. R., & Shah, D. R. (2012). Personalized medicine: Is it a pharmacogenetic mirage? *British Journal of Clinical Pharmacology, 74*(4), 698-721. doi:10.1111/j.1365-2125.2012.04328.x (cited 3 times)
    Author Keywords: pharmacogenetics
    KeyWords Plus: polymorphism
    Keywords from text:
    - Pharmacokinetics
    - Pharmacogenetics
    - Biomarkers
    - Pharmacogenomics
    - Genomes
    - Pre-treatment Genotyping
    - Genotype-guided therapy
    - Genome wide association study
    - Pre-treatment genotyping

37. van Rooij, T., Wilson, D. M., & Marsh, S. (2012). Personalized medicine policy challenges: Measuring clinical utility at point of care. *Expert Review of Pharmacoeconomics & Outcomes Research, 12*(3), 289-295. doi:10.1586/ERP.12.15 (cited 1 time)
    Author Keywords: genomics; personalized medicine; pharmacogenomics
    Keywords from text:
    - Pharmacogenomics
    - Genomic testing
    - Genomic datasets
    - Bioinformatics
    - Pharmacogenomics diagnostics
    - Genomics-based tests
    - Genomics
    - Personalized medicine
    - Biomarkers
    - Trastuzumab (Herceptin)
    - Imatinib (Gleeve)

- Geneotyping
- Pharmacogenomic marker

38. Ziegler A, Koch A, Kockenberger K, Grosshennig A. (2012). Personalized medicine using DNA biomarkers. *Human Genetics, 131*(10), 1627-1638. doi: 10.1007/s00439-012-1188-9
    Keywords from text:
    - Personalized medicine
    - Biomarkers
    - Stratified medicine
    - Targeted treatment
    - Companion diagnostics
    - Biomarker guided treatment
    - Individualized treatment

39. Svenson, S. (2013). Theranostics: Are we there yet? *Molecular Pharmaceutics, 10*(3), 848-856. doi:10.1021/mp300644n (cited 0 times)
    Author Keywords: theranostic nanocarriers; liposomes; polymersomes; polymeric micelles; polymeric nanoparticles; diagnostic and therapeutic agents; functionalized polymers; nanomedicine
    KeyWords Plus: TARGETED DRUG-DELIVERY; CANCER THERANOSTICS
    Keywords from text:
    - Theranostic
    - Multifunctional therapeutics
    - Theragnostic
    - Theranostic nanocarriers
    - Multifunctional nanocarriers

PM search 2: Keywords from policy documents referenced in: *Bates, S. (2010).* Progress toward Personalized Medicine. *Drug Discovery Today*, *15*(3-4): 115-120.

40. President's Council of Advisors on Science Technology. (2008). Priorities for Personalised Medicine. (http://www.whitehouse.gov/files/documents/ostp/PCAST/pcast_report_v2.pdf) (cited 24 times)
    Keywords from text:
    - Genomics-based molecular diagnostics
    - Personal genome
    - Genetic profile
    - Pharmacogenomics-based patient management
    - Genomics-based diagnostic test

41. Genomics and Personalized Medicine Act of 2006 (2006) (http://www.govtrack.us/congress/bills/109/s3822/text)

Keywords from text:

- Pharmacogenomics
- Biomarker
- Laboratory-developed genetic test
- Molecular genetic test
- Pharmacogenetic test
- Genetic research
- Genomic research
- Population-based studies of genotype prevalence
- Gene-disease association
- Gene-drug response association
- Gene-environment interactions
- Human genome epidemiology
- Molecular genetic screening tools
- Biosurveillance
- Molecular genetic tests
- Genetic tests
- Biobanking
- Molecular genetic screening
- Genomics
- Companion diagnostic test

42. Genomics and Personalized Medicine Act of 2008 (2008) (https://www.govtrack.us/congress/bills/110/hr6498/text)
    Keywords from text:
    - Personalized medicine
    - Pharmacogenomics
    - Genomic tests
    - Genetic tests
    - Pharmacogenetic test
    - Genotype
    - Molecular genetic screening tools, diagnostics and therapeutics
    - Biomarkers
    - Laboratory-developed genetic test
    - Companion diagnostic testing
    - Molecular genetic test
    - Genetic research
    - Genomic research
    - Gene-disease association
    - Gene-drug response association
    - Gene-environment interactions
    - Biobanking

43. HHS Secretary's Advisory Committee on Genetics Health Society (SACGHS) Report. (2008). Personalized Health Care: Pioneers, Partnerships Progress. (http://hhs.gov/myhealthcare/news/phc_2008_report.pdf) (cited 1 time)
    Keywords from text:
    - Personalized health care
    - Molecular-based diagnostics
    - Direct-to-consumer genetic information services
    - Gene/protein expression diagnostics
    - Multi-biomarker panels
    - Gene sequencing test
    - Genomics-guided medicine

44. US Food and Drug Administration. (2004). Innovation or Stagnation: Challenge and Opportunity on the Critical Path to New Medical Products. (http://www.fda.gov/downloads/ScienceResearch/SpecialTopics/CriticalPathInitiative/CriticalPathOpportunitiesReports/UCM077254.pdf) (cited 110 times)
    Keywords from the text:
    - Individualized therapy
    - Pharmaceutical
    - Biotechnology
    - Gene therapy
    - Individualized drug therapies
    - Proteomic
    - Toxicogenomic
    - Biomarkers

45. US Food and Drug Administration. (2007). Draft Guidance for Industry, Clinical Laboratories and FDA staff: In vitro diagnostic multivariate index assays. (http://www.fda.gov/downloads/MedicalDevices/.../ucm071455.pdf)
    Keywords from the text:
    - In vitro diagnostic multivariate index assays
    - Patient-specific result
    - Genotype determination
    - Chromosomal copy number determination
    - Gene expression profiling

46. The Personalized Medicine Coalition. (2009), The Case For Personalized Medicine. (http://www.ageofpersonalizedmedicine.org/objects/pdfs/thecase.pdf)(cited 8 times)
    Keywords from text:
    - Molecular diagnosis
    - Molecular medicine
    - Proteome

- Metabolome
- Epigenome
- Genetic screening
- Molecular screening
- Tailored therapeutics
- Targeted therapies
- Genetic tests
- Genetic markers
- Biomarker
- Genetic diagnosis
- Predictive medicine

47. US Food and Drug Administration. (2005). Drug-Diagnostic Co-Development Concept Paper. (http://www.fda.gov/downloads/drugs/scienceresearch/researchareas/pharmacogenetics/ucm116689.pdf) (cited 8 times)
    Keywords from text:
    - Target therapy
    - Pharmacogenetics
    - Biomarkers
    - Multi-analyte diagnostic test
    - Gene expression array
    - Pharmacogenetic tests
    - Pharmacogenomics tests

48. US Food and Drug Administration. (2005). New labeling and Distribution program for Iressa. (http://www.fda.gov/Drugs/DrugSafety/PostmarketDrugSafetyInformationforPatientsandProviders/ucm163112.htm)
    Keywords from text:
    - None found except for specific drug names

49. Committee for Medicinal Products for Human Use, (2009) Summary of Positive Opinion for Iressa. (http://www.ema.europa.eu/docs/en_GB/document_library/Summary_of_opinion_-_Initial_authorisation/human/001016/WC500059872.pdf)
    Keywords from text:
    - None found except for specific drug names

PM search 3: collection from highly-cited academic publications

We then focussed on collecting PM keywords from highly-cited peer-reviewed academic literature published from Jan 1 1999 - July 31 2013. We selected this start date based on the finding discussed in PM search 1 (see p.5), that the term PM became widely used from about 1999 onwards. We divided this time span into four year periods. We then searched Web of Science (WoS) (Thompson Reuters, http://apps.webofknowledge.com/) using the keywords 'personalized medicine', 'personalised medicine' 'individualized medicine' and individualised medicine' combined with the Boolean operator OR. We used WoS to count citations. In each time period we selected three to five publications whose main focus was PM or genetic/molecular testing that were cited ≥ 50 times, or if there were more than three publications that were cited ≥ 50 times, we retained the top three most highly cited articles. We examined titles, abstracts and keywords to select publications whose main focus was PM. We aimed for representation across biomedical science, as well as ethics, policy and commentary/thought pieces. We then obtained the full texts. We collected keywords that were used in a generally equivalent sense to PM, as well as closely related terms, from the full text and keywords of the publications.

Publications from 1999 - 2002 (note that the page numbers where the keyword was first found in the text are listed after each term).

1. Ginsburg, G. S., & McCarthy, J. J. (2001). Personalized medicine: Revolutionizing drug discovery and patient care. *Trends in Biotechnology,* 19(12), 491-6. doi:10.1016/S0167-7799(01)01814-5 (cited 135 times).
   Keywords from text:
   - Marker-assisted diagnosis, 491
   - Toxicogenomic markers, 491
   - Pharmacogenomic markers, 491
   - Monitoring markers, 491
   - Molecular diagnostics, 491
   - Targeted therapies, 491
   - Pharmacogenomics, 491
   - Biological markers, 491

- Molecular phenotype, 491
- Molecular classification, 491
- Genomic technologies, 491
- Transcript profiling, 491
- Proteomics, 491
- Genomics, 491
- Biomarker, 491
- Toxicogenomic markers, 491
- Gene expression, 492
- Predictive toxicogenomic screening, 492
- Pharmacodynamic markers, 492
- Diagnostic risk-assessment, 492
- Genetic heterogeneity, 493
- Global molecular view, 493
- Protein-based markers, 493
- Serum analytes, 493
- Molecular imaging, 493
- Molecular markers, 493
- Proteomic analysis, 494
- Genotyping, 494
- Molecular profiling, 495
- PGX, 492

2. Oliphant, A., Barker, D. L., Stuelpnagel, J. R., & Chee, M. S. (2002). BeadArray technology: Enabling an accurate, cost-effective approach to high-throughput genotyping. *BioTechniques*, *Suppl.,* 56-58, 60-61. (cited 101 times).
   Keywords from text:
   - Genotyping system, 56
   - Single nucleotide polymorphisms, 56
   - DNA sequencing, 58
   - Genotyping, 58
   - Gene detection technique, 61

3. Smith, D.J., & Lusis, A.J. (2002). The allelic structure of common disease. *Human Molecular Genetics, 11*(20), 2455-61. doi: 10.1093/hmg/11.20.2455 (cited 60 times).
   Keywords from text:
   - Human disease loci, 2455
   - Genotyping, 2455
   - DNA sequencing, 2455
   - Genotyping, 2455
   - Phenotype, 2455
   - Genetic heterogeneity, 2455
   - Individualized genotyping, 2460

- Genetic mutation, 2460
- Molecular genetic, 2461
- Single nucleotide polymorphisms, 2461

4. Jain, K. K. (2002). Personalized medicine. *Current opinion in molecular therapeutics, 4*(6), 548-558. (cited by 58).
   Document not available through the McGill Libraries system.

5. Watkins, S.M., & German, J. B. (2002). Metabolomics and biochemical profiling in drug discovery and development. *Current opinion in molecular therapeutics, 4*(3), 224-228. (cited by 60).
   Document not available through the McGill Libraries system.

Publications from 2003 - 2006

1. Hood, L., Heath, J. R., Phelps, M. E., & Lin, B. (2004). Systems biology and new technologies enable predictive and preventative medicine. *Science, 306*(5696), 640-643. doi: 10.1126/science.1104635 (cited by 529).
   - Molecular therapeutics, 640
   - Personalized medicine, 643
   - Predictive medicine, 643
   - Preventive medicine, 643
   - Molecular diagnostics, 643

2. Weston, A. D., & Hood, L. (2004). Systems biology, proteomics, and the future of health care: toward predictive, preventative, and personalized medicine. *Journal of Proteome Research,* 3(2), 179-196. doi: 10.1021/pr0499693 (cited 315 times).
   - Proteomics, 179
   - Predictive medicine, 179
   - Genomics, 180
   - Metabolomics, 180
   - Diagnostic biomarkers, 180
   - Protein biomarkers, 186
   - Single molecule biomarkers, 186
   - Multiparameter analysis, 186
   - Proteomic pattern diagnostics, 186
   - Pattern diagnostics, 186
   - Genomic profile, 194
   - Proteomic profile, 194

3. Ntziachristos, V., Schellenberger, E. A., Ripoll, J., Yessayan, D., Graves, E., Bogdanov, A., Josephson, L., & Weissleider, R. (2004). Visualization of antitumor treatment by means of fluorescence molecular tomography with an annexin V-Cy5.5 conjugate. *Proceedings of the National Academy of Sciences of the United*

States of America, 101(33), 12294-12299. doi: 10.1073/pnas.0401137101 (cited 251 times).
- Molecular imaging, 12294
- Biomarker, 12294
- Pharmacodynamics, 12299

4. Collins, I., & Workman, P. (2006). New approaches to molecular cancer therapeutics. *Nature Chemical Biology,* 2(12), 689-700. doi:10.1038/nchembio840 (cited 205 times).
   - Molecular biological, 689
   - Genomics, 689
   - Genetics, 689
   - Biomarker, 689
   - Protein target, 689
   - Molecular oncology, 690
   - Targeted molecular therapeutics, 690
   - Oncogenic targets, 690
   - Targeted molecular cancer therapeutics, 691
   - Human genetics, 691
   - Genomics, 691
   - Phenotypic screening, 692
   - Molecule target, 692
   - Targeted therapeutics, 693
   - Multiparameter profiling, 694
   - Phenotypic screen, 695
   - Molecular cancer therapeutics, 695
   - Molecular-targetted agents, 696
   - Molecular biomarkers, 697
   - Small-molecule cancer therapeutics, 697
   - Molecular technologies, 698
   - Biochemical technologies, 698
   - Molecular detection, 698
   - Targeted therapy, 698
   - Targeted agents, 698
   - Molecular therapeutics, 698
   - Pharmacokinetic, 699
   - Pharmacodynamic, 699
   - Personalized molecular cancer therapeutics, 699
   - Genomic analysis, 699

5. Katoh, M. (2005). WNT/PCP signaling pathway and human cancer (Review). *Oncology Reports,* 14(6), 1583-1588. doi: 10.3892/or.14.6.1583 (cited 201 times).

Publications from 2007 - 2010

1. Ingelman-Sundberg, M., Sim, S.C., Gomez, A., & Rodriguez-Antona, C. (2007). Influence of cytochrome P450 polymorphisms on drug therapies: Pharmacogenetic, pharmacoepigenetic and clinical aspects. *Pharmacology & therapeutics,* 116(3), 496-526. doi:10.1016/j.pharmthera.2007.09.004 (cited 472 times)
    - Pharmacogenetics, 488
    - Individualized therapies, 488

2. Llovet, J. M., & Bruix, J. (2008). Molecular targeted therapies in hepatocellular carcinoma. *Hepatology,* 48(4), 1312-1327. doi: 10.1002/hep.22506 (cited 499 times)
    - Molecular targeted therapies, 1312
    - Genomic, 1312
    - Molecular therapies, 1312
    - Molecular imaging, 1312
    - Biomarkers, 1312
    - Molecular classification, 1312
    - Molecular pathogenesis, 1313
    - Single-nucleotide polymorphisms, 1314
    - Targeted therapies, 1315
    - Molecular drugs, 1318
    - Molecular targeted therapies, 1319
    - Molecular compounds, 1324
    - Gene signatures, 1325
    - Pathogenesis, 1325
    - Molecular classification, 1325
    - Biomarker approaches, 1326

3. Anderson, J. L., Horne, B. D., Stevens, S. M., Grove, A. S., Barton, S., Nicolas, Z. P., et al. (2007). Randomized trial of genotype-guided versus standard Warfarin dosing in patients initiating oral anticoagulation. *Circulation,* 116(22), 2563-2570. doi: 10.1161/CIRCULATIONAHA.107.737312 (cited 385 times)
    - Genotype-guided, 2563
    - Pharmacogenetic-guided, 2563
    - Pharmacogenetic, 2563
    - Pharmacotherapy, 2563
    - Genotype, 2564
    - Genetic makeup, 2564
    - Pharmacogenetic guidance, 2568
    - Pharmacogenetic-based algorithms, 2569
    - Genomic medicine, 2569
    - Drug target pharmacogenomics, 2569

4. Riehemann, K., Schneider, S. W., Luger, T. A., Godin, B., Ferrari, M., & Fuchs, H. (2009). Nanomedicine-challenge and perspectives. *Angewandte Chemie-International Edition 48*(5), 872-897. doi: 10.1002/anie.200802585 (cited 433 times).
    - Personalized medicine, 873
    - Theranostics, 873

5. Sotiriou, C., & Piccart, M. J. (2007). Taking gene-expression profiling to the clinic: When will molecular signatures become relevant to patient care? *Nature Reviews Cancer,* 7(7), 545-553. doi:10.1038/nrc2173 (cited 272 times).
    - Molecular signatures, 545
    - Tailored medicine, 545
    - Predictive gene signatures, 550
    - Gene expression signatures, 551

Publications from 2011 - 2013

1. Gerlinger, M., Rowan, A. J., Horswell, S., Math, M., Larkin, J., Endesfelder, D., et al. (2012). Intratumor heterogeneity and branched evolution revealed by multiregion sequencing. *New England Journal of Medicine,* 366(10), 883-892. Doi: 10.1056/NEJMoa1113205 (cited by 1606)
    - Gene-expression signature, 883
    - Genomics landscape, 883
    - Biomarker, 883
    - Phenotypic, 890
    - Genomic analysis, 891
    - Therapeutic approaches, 891
    - Single-cell sequencing, 892
    - Cell-population genetic analysis, 892
    - Molecular stratification, 892

2. Itzhaki, I., Maizels, N., Huber, I., Zwi-Dantsis, L., Caspi, O., Winterstern, A., et al. (2011). Modelling the long QT syndrome with induced pluripotent stem cells. *Nature,* 471(7337), 225-U113. doi:10.1038/nature09747 (cited by 318)
    - Individualized drug testing, 225
    - Patient-specific pluripotent stem cell, 229
    - Small-molecule compounds, 229

3. Ashley, C. E., Carnes, E. C., Phillips, G. K., Padilla, D., Durfee, P. N., Hanna, T. N., et al. (2011). The targeted delivery of multicomponent cargos to cancer cells by nanoporous particle-supported lipid bilayers. *Nature Materials, 10*(5), 389-97. doi: 10.1038/nmat2992 (cited by 396).
    - Targeted delivery, 389
    - Targeted nanocarriers, 389

- Macromolecular theraputics, 396
- Gene transfer, 397

4. Chen, R., Mias, G., Li-Pook-Than, J., Jiang, L., Lam, H. Y., Chen, R. et al. (2012). Personal 'omics profiling reveals dynamic molecular and medical phenotypes. *Cell,* 148(6),1293-307. doi:10.1016/j.cell.2012.02.009 (cited by 330)
   - Integrated personal omics profiling (iPOP), 1293
   - Personalized medicine, 1293
   - Whole genome sequencing, 1294

5. Villanueva, A., & Llovet, J.M. (2011). Targeted therapies for hepatocellular carcinoma. *Gastroenterology, 140*(5), 1410-26. doi: 10.1053/j.gastro.2011.03.006 (cited by 179).
   - Personalized therapy, 1410
   - Targeted therapy, 1410
   - Personalized medicine, 1410

Search strategy 4: collection from websites and associated policy documents

We then focussed on collecting PM keywords from the websites and associated policy documents of organizations relevant to the regulation, funding, funding and integration of PM into healthcare systems in Australia, Canada, the EU, UK and the US. The list of organizations included in this search was developed SA-K, TB, RG and Prof. Christopher McCabe. We visited each site and used the site-specific search engine to search using the PM keywords listed below. If the search engine did not yield results we manually searched the website beginning with the site map. We recorded both terminology and definitions of PM found on the sites and within associated documents available on the website.

Australia

Department of Health and Ageing

Accessed site http://www.health.gov.au/internet/main/publishing.nsf/Content/Home
→ Publications, Statistics and Resources tab
→Publications
→Search Health by topic
→Health Technology
→read: "Review of Health Technology assessment in Australia"
→Pdf link: http://www.health.gov.au/internet/main/publishing.nsf/Content/AF68234CE9EB8A78CA257BF00018CBEB/$File/hta-review-report.pdf (accessed Oct 2015)

Definitions and keywords found in report:

- **Co-Dependant Health Technology** Health technologies are co-dependent if their use needs to be combined (either sequentially or simultaneously) to achieve or enhance the intended clinical effect of either technology. For example, a drug/test combination where a new medicine seeking listing on the PBS may have a related pathology test that helps to determine the population group for that medicine. (p.39)
- **Hybrid Technology** combine the characteristics of different health technologies (e.g. a medicine or a medical device or a biologic) in one intervention (e.g. drug eluting stents for treating cardiovascular disease or photodynamic therapy for treating skin disease). (p.39)

National Health and Medical Research Council
Accessed site http://www.nhmrc.gov.au/
→Guidelines and publications
→View by subject area
→Genetics and Gene Technology
→Clinical Utility of Personalised Medicine
→read: "Clinical Utility of Personalised Medicine"
→pdf link:
https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/ps0001_clinical_utility_personalised_medicine_feb_2011.pdf (accessed Oct 2015)

Note: Hybrid Technologies are very different from Hybrid Medicines (as defined by UK organizations). Hybrid Medicine is a medicine that is similar to an authorised medicine containing the same active substance, but where there are certain differences between the two medicines such as in their strength, indication or pharmaceutical form.
http://www.ema.europa.eu/ema/index.jsp?curl=pages/document_library/landing/glossary.jsp&mid=&startLetter=H

- **Personalised Medicine:** Personalised medicine is the application of genetic information to predict disease development, influence decisions about lifestyle choices, and tailor preventative interventions or medical treatment to the individual needs of each patient. Personalised medicine can allow screening, early intervention and treatment to be concentrated on those who will benefit, reducing expense and side effects for those who are not likely to benefit.
- **Predictive medicine**
- **Pharmacogenomics**
- It is important to note that the application of personalised medicine goes beyond genetic disease, and can optimise treatment for many diseases including HIV and epilepsy.
  Note: this definition is cited from the US definition from President's Council of Advisors on Science and Technology, Subcommittee on Personalized Medicine, Priorities for Personalized Medicine: Report of the President's Council of Advisors on Science and Technology, September 2008. Available at:
  http://www.whitehouse.gov/files/documents/ostp/PCAST/pcast_report_v2.pdf (accessed Oct 2015)
  - **Genomics-based molecular diagnostics**
  - **Personal genome**
  - **Genetic profile**
  - **Pharmacogenomics-based patient management**
  - **Genomics-based diagnostic test**

Medical Services Advisory Committee

Accessed site http://www.msac.gov.au/internet/msac/publishing.nsf/Content/home-1
→publications

- →read: Draft Technical Guidelines – Therapeutic – Aug 2013 (PDF 1539 KB)

→pdf link:
http://www.msac.gov.au/internet/msac/publishing.nsf/Content/BF8A5BDEAA1AA2CCCA2575AD0082FCD5/$File/Technical-Guidelines-Therapeutic-August-Consultation.pdf
(accessed Oct 2015)

Note: MSAC refers to co-dependent technology throughout the website but does not define it. It asks that you access the health technology assessment website for further info on co-dependent and hybrid technologies (www.health.gov.au/hta)

- Also searched "personalised medicine" and "individualised medicine" which rendered hits but refered to mental health or hospital operations.
- **Co-dependent technology** is the most recent and consistent term for what we call personalized medicine.

Pharmaceutical Benefits Advisory Committee
Accessed site http://www.pbs.gov.au/info/industry/listing/participants/pbac
→searched "co-dependent," "individualised medicine," "individualised," "personalised medicine," "personalised," and "stratified" all keywords rendered publication hits but none of the documents actually had any information on these terms.
Therapeutic Goods Administration
Accessed site http://www.tga.gov.au/
→in search bar entered "co-dependent technologies"
→ "Changes to the medical device application form for inclusions"

Australian Medical Association
Accessed site https://ama.com.au/
→policy
→position statements
→Genetic Testing 2012

- **Pharmacogenomic testing:** Pharmacogenomics involves determining how an individual's genetic makeup affects their response to a particular medication. Because many of the enzymes involved in drug metabolism have multiple genetic variants (alleles), pharmacogenomic testing can guide the prescription of drugs. It can allow selection of individuals who will benefit from a particular treatment and exclude individuals who will not benefit from that treatment or who are at high risk of adverse side effects. This allows individuals to receive the correct treatment sooner and reduces the chance of adverse side effects.

Accessed site https://ama.com.au/
Searched "personalized medicine"
→policy
→position statements
→Pathology 2011

- **Personalised Medicine:** Treatment and management of disease is tailored to the individual and avoids the trial and error of a treatment designed for a broad population. This concept has been proven over many decades in microbiology where antibiotic sensitivity is routinely reported when bacterial infections are identified, and is now being extended, by means of genomic testing, to other diseases, such as cancer and autoimmune diseases. As well as saving patients from undergoing therapy that will not be effective, it also allows targeting of expenditure so that expensive new therapies are directed to those who are most likely to benefit.

Further synonym searches rendered nothing (searched co-dependent, "individualised medicine," "individualised therapy", "stratified", "targeted therapy," "targeted medicine," and "precision medicine")

Canada

Canadian Institute of Health Research
Accessed site http://www.cihr-irsc.gc.ca/e/193.html
➔ Used search bar to search "personalized medicine"
→read: Meeting summary: CIHR Personalized Medicine Planning Meeting, May 2-3, 2011

- **Personalized Medicine:** as defined by the Personalized Medicine Working Group (Health Canada) refers to the tailoring of preventative, diagnostic or therapeutic interventions to the characteristics of an individual or population. It does not mean the creation of health interventions targeted directly to an individual, but rather that the scientific advancements that underpin personalized medicine provide the ability to classify individuals into sub-populations based on their susceptibility to a disease, or response to a specific treatment. This can allow for prevention/intervention strategies and earlier and/or targeted interventions to improve health outcomes.

Also searched "stratified medicine" which rendered results not related or that were bracketed as a synonym to personalized medicine. "Individualized medicine" gave one hit from 2007 saying, "Eventually the hope is to be able to obtain an individual signature or footprint of a patient's cancer and tailor a therapy that is specific to that individual's unique set of molecular targets, i.e. individualized medicine," but not yet defining what

individualized medicine is or speaking of it as if we are serious about it's potential. "Precision medicine" gave results of interview quotes or in passing reference but no definitions in no CIHR official documents.

Stem Cell Network
Accessed site http://www.stemcellnetwork.ca/
→searched stratified, personalized, and individualized and they all came to the same page

→Synovial Mesenchymal Stem Cells: A Diagnostic Tool for the Stratification of Osteoarthritis Severity

- **Personalized/Precision Medicine:** This phenotype has been examined by gene expression analyses, and a preliminary **gene signature** of Osteroarthritis (OA) stem cells has been generated based on differentially expressed genes (DEGs) between normal and OA samples. We believe that developing this platform will identify potential **diagnostic/prognostic biomarkers** and lead to an evidence informed methodology to **personalized/precision medicine**: the effective treatment of individuals who are appropriately stratified into subsets of OA. **(not formal definition of personalized, precision, stratified, targeted medicine).**

British Columbia Ministry of Health
Site accessed www.health.gov.bc.ca
→search "personalized medicine"

→ Report of the Pharmaceutical Task Force
Pdf link
http://www.health.gov.bc.ca/library/publications/year/2008/PharmaceuticalTaskForceReport.pdf (accessed Oct 2015)

- **Personalized Medicine:** where professionals will be more able to select the most appropriate drug for particular genotypes of patients. This trend towards use of "the right drug, at the right time for the right patient" could, if managed properly, have a very significant impact on levels of hospitalization, the reduction of adverse drug reactions and improved quality of life for patients suffering from chronic illnesses.

Searched genomic AND diagnosis AND treatment without any relevant hits

Also searched "stratified medicine" "individualized medicine" and pharmacogenomics without any hits.

Alberta Health Services
AHS documents referred to **personalized medicine** primarily but only in passing. They never defined the term. **Stratified** or **targeted medicine** would occur in interviews or other grey lit.

Searching this site for various synonyms as well as “genetic diagnosis and treatment” rendered no definitions but sent user to the Alberta Health Research Innovation Strategy that is run by Genome Alberta.

CADTH
Accessed site: http://cadth.ca/

When I searched various keywords (**personalized, individualized, stratified, genes, genomics, targeted**) articles that mentioned “**personalized medicine**” would come up but were left undefined.

Ontario Health Technology Advisory Committee
Accessed site http://www.hqontario.ca/evidence/evidence-process/about-the-ontario-health-technology-advisory-committee

The website search bar was non-functional. I searched “Ontario Health Technology Advisory Committee” AND “genomics” in google.ca and it led to the Ontario Institute of Cancer Research’s *Genomics Pathway Strategy*

Ontario Institute of Health Research
Accessed website http://oicr.on.ca/
→about
→read annual report
→pdf address:
http://oicr.on.ca//files/public/OICR_Annual_Report_2011_12.pdf (accessed Oct 2015)

- **Personalized Medicine:** using genetic information to develop strategies for the prevention and treatment of diseases like cancer is at the heart of a concept called **personalized medicine**. Its use in treatment is often described as being "the right dose, for the right person, at the right time."

Ontario Genomics Institute
Accessed website: http://www.ontariogenomics.ca/
→Personalized Medicine (OPMN) (**note:** acronym for Ontario Personalized Medicine Network)
→Learn more about the promise of personalized medicine

- **Personalized medicine** is an emerging practice of medicine that tailors health care decisions to the individual using genetic information. Personalized medicine will result in more effective health care through improved:

  - **Prevention** – assessing disease risk and taking action to prevent or delay onset/symptoms
  - **Diagnosis** – identifying illness accurately and detecting at an earlier

stage

- **Treatment** – targeting therapies to genetic traits, reducing side-effects and decreasing delays in finding the correct treatment and dose
- **Patient engagement** – allowing patients to monitor health and take action, and improving compliance

Health Canada
Accessed site http://www.hc-sc.gc.ca/index-eng.php
→search "personalized medicine"

→ **Science Advisory Board Meeting, November 2-3, 2010 - Health ...**

→**interesting note;** the agenda minutes state**, "**With respect to the advice given on the appropriateness of the term "**Personalized Medicine**" to describe this file in a Canadian context, the Personalized Medicine Working Group Secretariat undertook a terminology analysis based on public literature as well as discussions at various national and international meetings and conferences. While recognizing "**personalized medicine**" might not be the most accurate term, the Working Group expressed strong opinions to maintain this title as it has been used by stakeholders in Canada, is recognizable, and is harmonized with current international terminology (e.g., at the International Conference on Harmonization)."

Google Searched "Personalized Medicine Working Group" and "Health Canada"

→ Meeting Summary: CIHR Personalized Medicine Planning Meeting - May 2-3, 2011

- **Personalized Medicine** Personalized Medicine, as defined by the Personalized Medicine Working Group (Health Canada) refers to the tailoring of preventative, diagnostic or therapeutic interventions to the characteristics of an individual or population. It does not mean the creation of health interventions targeted directly to an individual, but rather that the scientific advancements that underpin personalized medicine provide the ability to classify individuals into sub-populations based on their susceptibility to a disease, or response to a specific treatment. This can allow for prevention/intervention strategies and earlier and/or targeted interventions to improve health outcomes. Personalized medicine aims to transform the delivery of healthcare to patients such that it will evolve from a "one-size-fits-all" system towards a custom tailored system delivering more predictive, preventive, and precision care. Personalized medicine will also enhance awareness about lifestyle and preventive lifestyle changes based on individual risk factors. A **personalized molecular medicine** approach is expected to

lead to better health outcomes, improved treatments, and a reduction in unnecessary treatment with its associated costs and adverse events.

Accessed site http://www.hc-sc.gc.ca/index-eng.php

→science and research
→biotechnology
→about biotechnology
→glossary

- **Pharmacogenetics and Pharmacogenomics:** these two terms, which relate to the role of genetics in pharmaceutical research, are often used interchangeably. Pharmacogenetics is the study of genetic differences among individuals that relate to drug response. Pharmacogenomics is the study of variability in the expression of individual genes that relate to disease susceptibility and drug response at the cellular, tissue, individual and population level.
  A major objective of pharmacogenomics is the development of innovative classes of targeted drugs and vaccines designed to affect highly specific processes in the body while minimizing side effects. A related area is biopharmaceuticals, whereby transgenic techniques are used to insert therapeutic properties, including vaccines, into foods, potentially replacing pills and syringe injections.

Canadian Society for Pharmaceutical Sciences
Accessed site http://www.cspscanada.org/default.aspx

Scanned site manually because there was neither a site map nor a search bar. The term "**personalized medicine**" was used exclusively throughout the site but never discussed in depth or defined.

International Society for Pharmaceutical Engineering
Accessed site http://www.ispe.org/home

Searched keywords "personalized medicine" "individualized medicine" "targeted therapy" "molecular medicine" "pharmacogenomics" "stratified medicine"

Personalized medicine was the only term that prompted search results. The associated documents were for ISPE members only. Therefore, I could not access any PM definitions.

BIOTECanada
Searched keywords "personalized medicine" "individualized medicine" "targeted therapy" "molecular medicine" "pharmacogenomics" "stratified medicine"

Personalized medicine was the only term that prompted search results. The associated results held no definitions or discussions of PM.

Life Sciences BC
Accessed site http://www.lifesciencesbc.ca/
→publications
→LSBC Publications
→LifeSciences British Columbia 2012 (pg 18)
→pdf link:
http://issuu.com/bivmediagroup/docs/lifesciences12_ebook?e=1187657/1320581
(accessed Oct 2015)

- **Personalized medicine:** the customization of health care on the basis of genetic variations.

→search "pharmacogenomics"
→Life Sciences Glossary (p.65)
→pdf link: http://www.lifesciencesbc.ca/files/PDF/other/Glossary.pdf

- **Pharmacogenomics:** The study of genetically determined responses to drugs. Pharmacogenomics is the use of genetic information to predict the safety, toxicity and/or efficacy of drugs in individual patients or groups of patients.

Also used the site search engine to search keywords "personalized medicine" "individualized medicine" "targeted therapy" "molecular medicine" "stratified medicine"
Note: No definitions were found but all keywords created media release hits that related to media releases aggregated from other news sources.

Centre for Excellence in Personalized Medicine
Site accessed http://www.cepmed.com/
→About Personalized Medicine

- **Personalized medicine:** the tailoring of medical treatment to the individual characteristics of each patient." This report stated that: "personalized medicine does not literally mean the creation of drugs or medical devices that are unique to a patient but rather the ability to classify individuals into sub-populations that differ in their susceptibility to a particular disease or their response to a specific treatment. Preventative and therapeutic interventions can then be concentrated on those who will benefit, sparing expense and side effects for those who will not."

Note: definition cited from The President's Council of Advisors on Science and Technology
(PCAST) "http://www.whitehouse.gov/files/documents/ostp/PCAST/pcast_report_v2.pdf

- **P4 Medicine**
  - P4 Medicine is **personalized**, taking into account a person's genetic or protein profile.
  - P4 Medicine is **preventative**, anticipating health problems and focusing on wellness, not disease.
  - P4 Medicine is **predictive**, directing appropriate treatment, and avoiding drug reactions.
  - P4 Medicine is **participatory**, empowering patients to take more responsibility for their health and care.

Note: definition cited from a healthcare paradigm proposed by Dr. Leroy Hood of the Institute for Systems Biology

Canadian organization for Rare Disorders
Accessed site http://www.raredisorders.ca/index.html
No search bar or site map. Manually browsed CORD publications but no keywords were defined.

European Union

PHGEN II
Site Accessed http://www.phgen.eu/typo3/index.php
→ **PHGEN II as a Success Story, Biobanks and Personalized Medicine**
→**here**
→**pdf link**
http://www.phgen.eu/typo3/fileadmin/downloads/success_stories_full_en.pdf (Accessed Oct 2015)

- **Personalised Medicine:** tailor-made individualised diagnostics and therapy that take into account the genetic differences among humans

European Alliance for Personalised Medicine
Site Accessed http://euapm.eu/#
→Home

- **Personalised Medicine:** a targeted approach to the prevention, diagnosis and treatment of disease based on an individual's specific profile.

Note: they have a full report on the EAPM and what personalized medicine means to them
→pdf link, European Alliance for Personalised Medicine (2012). Personalised Medicine: new perspectives for patients in Europe. Manifesto. http://euapm.eu/pdf/EAPM_Manifesto.pdf (accessed Oct 2015)

- Biomarkers
- Individualised medicine

- Predictive, personalised, pre-emptive approach
- Companion diagnostics
- Drug-diagnostic pairings
- 'Omics
- Targeted therapy

EURORDIS
Site Accessed http://www.eurordis.org/content/national-alliances-rare-diseases
→Search "personalised medicine"
➔ EURORDIS'
→pdf link:
http://www.eurordis.org/sites/default/files/EURORDIS_Rapport_Research_2012.pdf
(accessed Oct 2015)
No mention of personalised medicine.
Also searched "individualized medicine," "targeted medicine," co-dependent, pharmacogenomics, and stratified in their search function which rendered no relevant results.

European Medicines Agency
Agency Accessed
http://www.ema.europa.eu/ema/index.jsp?curl=pages/home/Home_Page.jsp&mid=
→document search
→glossary
→

- **Personalised medicine:** a medicine that is targeted to individual patients, based on their genetic characteristics.
- **Pharmacogenomics:** the study of how the variability of the expression of genes between people leads to differences in susceptibility to disease and responses to medicines.

Note: manually searched through entire glossary for synonyms for personalized medicine, none of which appeared.

International Pharmaceutical Federation
Site Accessed: http://www.fip.org/news_publications
→Annual Reports and Publications
→Impact of Pharmaceutical Sciences on Healthcare
→pdf link:
http://www.fip.org/files/fip/publications/2FIP_Impact_Pharm_Sci_20122.pdf (accessed Oct 2015)

- **Personalized medicine:** At the present time, based on the considerable knowledge gained in the pharmacogenetics and pharmacogenomics areas, we now know that an individual's genetic make-up may determine in part how specific drugs are

handled within the body. Additionally we have learned that many disease states are a heterogeneous mix of disease sub-types that may be ameliorated best through highly targeted "personalized medicine" approaches (p.22-23)

→Search bar "personalized medicine"
→SIG on Translational Research and Individualized Medicines
- **Individualized Medicines**: not defined, but this link comes up regardless of which synonym is entered in the search bar.

European Federation of Pharmaceutical Sciences
Accessed site: http://www.eufeps.org/
→Mission and strategy
→Strategic plan 2006-2010
- **Personalised Medicines:** (used but not defined)

International Society for Pharmacoeconomics and Outcomes Research
Accessed site http://www.ispor.org/Default.asp
→Search "personalized medicine"
→Getting our Methods Right
- **Personalised Medicine** new technologies, including genetic testing which offers the possibility of establishing which intervention is most suitable for a given patient.

→ISPOR 17th Annual International Meeting: Workshop Presentations
- **Personalized Medicine:** in which medical interventions are targeted to patients based on their individual characteristics, including their genetic profile

European Federation of Biotechnology
Accessed site: http://www.efb-central.org
→ no search engine so examined site. No mention of personalized medicine or any synonyms.

United Kingdom

UK Department of Health

Site Accessed: https://www.gov.uk/government/organisations/department-of-health
→Search Stratified Medicine

→ **Government launches new programme to make UK global partner of choice for R&D collaboration**

- **Stratified approach to disease:** (targeting the right treatments to the right people), enabling effective clinical trials as well as identifying novel biomarkers, mechanisms and targets.

→Search Personalised Medicine

→DNA tests to revolutionise fight against cancer and help 100,000 NHS patients

- **Personalised Care:** the **genome profile** will give doctors a new, advanced understanding of a patient's genetic make-up, condition and treatment needs, ensuring they have access to the right drugs and **personalised care** far quicker than ever before.

Also searched "individualised medicine," "individualized medicine", "precision medicine," and pharmacogenomics which rendered no relevant pages.

National Institute for health and Care Excellence

Site accessedhttp://www.nice.org.uk/

→search "genomics"

→NICE to have 'key role' in adoption of genetic tests by NHS

→link to UK Human Genomics Strategy Group (url: https://www.gov.uk/government/news/genomic-innovation-will-better-target-treatment-in-the-nhs)

→link to Building Our Inheritance: Genomic Technology in Healthcare

→research analysis

Pdf link https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213705/dh_132382.pdf (accessed Oct 2015)

- **Stratified medicine:** essentially selecting a highly specific treatment pathway based on a greater understanding of the exact pathology of disease (p21).

Cancer Research UK

Site accessed http://www.cancerresearchuk.org/home/

→funding and research

→research

→research topic: personalised medicine

→link to stratified medicine program

→Press release: Multi million pound project launched to improve genetic testing for cancer drugs

→link to stratified medicine

- → **Stratified medicine** means looking at large groups of cancer patients to try and find ways of predicting which treatments cancers are likely to respond to…This is one step towards something called **ersonalised medicine**.
- **Personalised medicine** uses genetic and other information to diagnose and treat disease. Once we have carried out research with large groups of cancer patients, we may be able to predict response to treatments. Then we hope we will be able to tailor cancer treatment very precisely to an individual person's cancer.

Wellcome Trust
Site accessed http://www.wellcome.ac.uk/
➔ Search "personalised medicine"
→Personalised medicine facts
- **Personalised medicine:** therapy tailored to a patient's genetic makeup

Searched "stratified medicine," pharmacogenomics, "targeted therapy," "precision medicine" all of which rendered hits but no definitions

Nuffield Council
Site accessed http://www.nuffieldbioethics.org/
→view all projects
→pharmacogenetics
→pharmacogenetics full report
Pdf: http://nuffieldbioethics.org/project/pharmacogenetics/
(accessed Oct 2015)
Personalised medicines: the option of using genetic information to predict response to medicines…to target or tailor-make medicine (p3, p21)
Pdf: Medical profiling and online medicine: the ethics of 'personalised healthcare' in a consumer age.
http://nuffieldbioethics.org/project/personalised-healthcare-0/
(accessed Oct 2015)

- **Personalised healthcare:** it can mean healthcare that is tailored to a person's specific characteristics, or healthcare where more responsibility is given to individuals rather than medical professionals (p2)
- **Personal genetic profiling**

searched "stratified medicine," "individualised medicine," "genomic medicine," "targeted therapy," all with no hits.

MHRA (Regulating Medicines and Medical Devises)
Site accessed http://www.mhra.gov.uk/index.htm
→search "personalised medicine"
→personalised medicine
Pdf link: http://www.mhra.gov.uk/home/groups/es-policy/documents/websiteresources/con2030481.pdf

- **Personalised medicine:** is concerned with the individualisation of drug dose and of drug choice...Personalised medicine can occur on the basis of dose adjustment for side effects, dose adjustment for efficacy, dose adjustment for concomitant medication, metabolising rate and renal excretion, drug choice due to allergic potential, drug choice due to resistance profile of the infecting organism, drug choice due to biological target, and drug choice according to the personal wishes of a patient.

→Forum on Personalized medicines
pdf link: http://www.mhra.gov.uk/home/groups/es-policy/documents/websiteresources/con065593.pdf

- **Personalised medicine:** is the application of genomic and molecular data to better target the delivery of health care, facilitate the discovery and clinical testing of new products, and help determine a person's predisposition to a particular disease or condition.

Note: as used in the Genomics and Personalised Medicines Act 2007 in the US

Also searched "individualized medicine," "stratified medicine," "targeted therapy," and "precision medicine" without getting any hits.

Royal Society
Site accessed http://royalsociety.org/
→search "stratified medicine"
→Medicine gets personal

- **Stratified Medicine** the strategy to shift away from a one-size-fits-all approach to medicine and towards grouping patients based on treatment efficacy.

→Personalised Medicines: hopes and realities

→pdf link: http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2005/9631.pdf (accessed Oct 2015)

- **Personalised Medicine:** it was soon clear that post-genomic technology might make it possible to obtain detailed profiles of the genes involved in drug action, and that this would ultimately lead to an understanding of individual variation in response to a wide range of therapeutic agents, or to the promise of '**personalised medicine'**. (p6).
- **Pharmacogenetics**
- **Pharmacogenomics**

→search "personalized medicine"

→pharmacogenetics dialogue report

→pdf link https://royalsociety.org/topics-policy/publications/2005/pharmacogenetics/ (accessed Oct 2015)

- **Personalised medicine** on the basis of information about their genetic make-up, one medicine rather than another may be prescribed, or the dosage of a particular medicine changed. (p.13)
- **Pharmacogenetics**

Biotechnology and Biological Research Council

Site Accessed http://www.bbsrc.ac.uk/home/home.aspx

→search personalized medicine

→ Solexa Sequencing – Innovator 2010 overall winner - BBSRC

- **Personalised medicine:** drug treatments and nutritional regimes tailored to an individual's genetic makeup

→ 5 March 2013 - Study maps human metabolism in health and disease - BBSRC

- **Personalised Medicine** treatments are tailored according to the patient's genetic information

Also searched "stratified medicine," "precision medicine"

United States

Federal Drug Administration

- **Personalized Medicine**: when a biomarker for target status is used to define a subgroup of patients who have a different benefit/risk ratio than an unselected population Most biomarkers are mechanistic and not merely associations which increases their credibility. Personalized medicine is not new, and it doesn't matter if the test is DNA-based or not. Personalized medicine relies on targeted therapies.

Note: this definition was found on the *International Society for Pharmacoeconomics and Outcomes Research* website as part of an FDA presentation given in Europe**.**
http://www.ispor.org/meetings/atlanta0510/presentations/Lawrence-Lesko-Presentation.pdf (accessed Oct 2015)

→ Drug-Diagnostic Co-Development Concept Paper
http://www.fda.gov/downloads/drugs/scienceresearch/researchareas/pharmacogenetics/ucm116689.pdf (accessed Oct 2015)

- Targeted therapy
- Pharmacogenetics
- Biomarkers
- Multi-analyte diagnostic test
- Gene expression array
- Pharmacogenetic tests
- Pharmacogenomics tests

National Research Council – Institute of Medicine
Site accessed www.iom.edu
→search "personalized medicine"
→By type: Report
→Policy Issues in the Development of Personalized Medicine
→Read report online for free url:
http://books.nap.edu/openbook.php?record_id=12779&page=1
(accessed Oct 2015)

- **Personalized cancer medicine:** is defined as medical care based on the particular biological characteristics of the disease process in individual patients. By using genomics and proteomics, individuals can be classified into subpopulations based on their susceptibility to a particular disease or response to a specific treatment. They may then be given preventive or therapeutic interventions that will be most effective given their particular characteristics. (p.1)

→Extending the spectrum of precompetitive collaboration on oncology research – workshop summary
→Read report free online url:
http://books.nap.edu/booksearch.php?booksearch=1&term=personalized+medicine&record_id=12930

- **Personalized medicine –** in this report, leveraging scientific advances in fields such as genomics, proteomics, molecular biology, and metabolomics to improve the extent to which medical care is personalized to an individual. (p.89)\ (accessed Oct 2015)

Also searched "precision medicine," pharmacogenetics, and "targeted therapy." These keywords render hits, but no definitions. Searched "stratified medicine" but no hits emerged.

President's Council on Science and Technology
Site accessed: http://www.whitehouse.gov/champions/open-science/kathy-giusti

Searched "precision medicine," "targeted therapy," "individualized medicine," and pharmacogenomics with hits but no definitions.

Searched "stratified medicine" with no hits.

Centre for Medicare and Medicaid Services
Site accessed http://www.cms.gov/

Searched "personalized medicine," "targeted therapy," "precision medicine" and pharmacogenomics with hits but no definitions.

Searched " individualized medicine, " "stratified medicine" with no hits.

US Dept. of Health and Human Services
Site accessed *http://www.hhs.gov*
→*Searched "personalized medicine" – many hits, but prioritized reports:*

→ HHS Secretary's Advisory Committee on Genetics Health Society (SACGHS) Report: Personalized Health Care: Pioneers, Partnerships Progress. https://www3.marshfieldclinic.org/proxy///mcrf-visitors-wgi-phcreport.1.pdf (accessed Oct 2015)

- **Personalized health care:**

- help us achieve the right diagnosis and prescribe the right medication for the particular individual and exact condition, steadily improving on traditional trial-and-error approaches;
- enable us to spot the onset of disease even before symptoms appear, and take action to preempt or delay onset of the condition; and
- help us identify our own predisposition to disease, so that we can take more effective steps to prevent it.

- **Molecular-based diagnostics**
- **Direct-to-consumer genetic information services**
- **Gene/protein expression diagnostics**
- **Multi-biomarker panels**
- **Gene sequencing test**
- **Genomics-guided medicine**

National Institute of Standards in Technology
Site Accessed www.nist.gov
→search personalized medicine
→Publicly Submitted White Papers
→ Developing Strategies, Infrastructure & Knowledge for Equitable, Personalized Medicine
Pdf link:
http://www.nist.gov/tip/wp/pswp/upload/36_developing_strategies_infrastructure_knowledge.pdf

- **Personalized Medicine:** the sequencing of the human genome, subsequent analyses of human genetic variation, and studies that associate gene variants with disease markers or other phenotypic alterations provides the knowledge for personalizing medical practice... The goal of personalized nutrition and medicine, which form the basis of personalized healthcare, is to get the right nutrient or therapeutic to the right individual at the right time for the right outcome. (p.1)

Searched " individualized medicine, " "targeted therapy," "precision medicine" and pharmacogenomics with hits but no definitions.

Searched "stratified medicine" with no hits.

BIO
Site Accessed www.bio.org
→areas of work
→personalized medicine
→ Personalized Medicine and Diagnostics (PMDx) Working Group Mission Statement
→Bio's Principles on Personalized Medicine

- **Personalized Medicine** Scientific advances in our understanding of the molecular and genetic causes of disease offer opportunities to advance a new approach to healthcare. This new approach, personalized medicine, will allow healthcare providers to identify the most appropriate therapeutic intervention and/or dosage for an individual based on his or her personal bio-molecular characteristics, thereby maximizing clinical benefit and reducing the risk of side effects.

Searched "targeted therapy," and pharmacogenomics with hits but no definitions.
Searched " individualized medicine, " "stratified medicine," and "precision medicine" with no hits.

Note: Based on personal observation, BIO took the hardest line on which keywords were used in their site. Personalized medicine was very consistently used. Even if other terms slipped into the site, they were put in relation to, or clarified as, personalized medicine in the same sentence or paragraph.

PhARMA
Site accessed http://www.phrma.org/
→search personalized medicine
→Personalized Cancer Medicines Helping Patients Live Longer, Healthier Lives
- **Personalized medicine:** is an emerging field that uses diagnostic tools to identify specific biological markers, typically genetic, and assess which medical treatments will be best for each patient.

Also searched "stratified medicine," "individualized medicine, " pharmacogenomics and "precision medicine" which rendered no relevant hits.

Regulatory Affairs Professionals Society
Site accessed www.raps.com

Searched "targeted therapy," "stratified medicine," "personalized medicine," and pharmacogenomics with hits but no definitions.

Searched "individualized medicine, " and "precision medicine" with no hits.

Analytical, Life Science and Diagnostics Association
Site Accessed http://thealda.org/index.php

Searched "personalized medicine." This term is used consistently throughout ALDA website in documents talking about themselves. Press releases etc. rendered hits for "targeted therapy" too. Neither term was defined in the site.

Searched pharmacogenomics, "individualized medicine, " and "precision medicine" with no hits.

Parenteral Drug Association
Site Accessed www.pda.org

Searched "personalized medicine," "stratified medicine," pharmacogenomics, and "individualized medicine" which rendered hits but no definitions

Searched "precision medicine" with no hits.

The Hastings Centre

Accessed site www.thehastingscenter.org

The way this sight was set up, public users could not access full reports and essays. **Personalized medicine** seemed to be predominant, but I could not see any definitions. Other keywords such as **stratified, precision,** and **individualized medicine** rendered hits, but I could not tell if these terms were used synonymously with personalized medicine.

Food and Drug Law Institute
Site Accessed
→search personalized medicine
→ Personalized Medicine: A Challenging Revolution in Healthcare
- **Personalized Medicine** uses genetic information to tailor treatments to specific individuals.

The Personalized Medicine Coalition
Site accessed: http://www.personalizedmedicinecoalition.org

→ Document said to be the PMC's signature offering: The Personalized Medicine Coalition: The Case For Personalized Medicine
pdf: http://www.personalizedmedicinecoalition.org/Userfiles/PMC-Corporate/file/pmc_case_for_personalized_medicine.pdf (accessed Oct 2015)
- **Molecular diagnosis**
- **Molecular medicine**
- **Proteome**
- **Metabolome**
- **Epigenome**
- **Genetic screening**
- **Molecular screening**
- **Tailored therapeutics**
- **Targeted therapies**
- **Genetic tests**
- **Genetic markers**
- **Biomarker**
- **Genetic diagnosis**
- **Predictive medicine**

Wikipedia "personalized medicine"
Site accessed https://en.wikipedia.org/wiki/Personalized_medicine
→ recorded keywords (July 2013)
- **Tailored treatments**
- **Customized drug products**
- **Individualized dosing**
- **Individualized medications**

- **Pharmacometabolomics**
- **Prospective medicine**
- **Toxgnostics**
- **Oncogenomics**

PM search 5: selected popular news press

Finally, we carried out a search of selected popular press that often report on economically or socially significant biomedical developments: the Wall Street Journal, the New York Times and the Economist. We accessed the publications via the McGill Libraries Proquest database web portal, and used the database specific search engines to search for publications using the terms: 'personalized medicine', 'personalized medicine' and 'individualised medicine' separated by the Boolen operator OR. We limited the search to publication between Jan 1999 and July 31 2013. We accessed the full texts, and collected keywords that were used in a generally equivalent sense to PM, as well as closely related terms, from the full text and keywords of the publications.

Wall Street Journal

The above search strategy yielded about 120 results. We examined the full-texts of the first 80 of these hits.

1. Langreth, R. & Waldholz, M. (1999). New era of personalized medicine targeting drugs for each unique genetic profile. *The Wall Street Journal,* (April 16).
    - Gene markers
    - Gene map
    - SNP – single nucleotide polymorphism
    - Genetic susceptibility

2. Hotz, R. L. Personalized Medicine Moves Closer. *Wall Street Journal*, Eastern edition [New York, N.Y] 01 Nov 2012: A.2.
    - Genome profile
    - Hereditary variation

3. Landro, L. The Healthy Reader. *Wall Street Journal*, Eastern edition [New York, N.Y] 18 Sep 2012: D.3.
    - Biomarker
    - Predictive health

4. Winslow, R. Research on Pain Medicines Seeks a Genetic-Trait Link. *Wall Street Journal,* Eastern edition [New York, N.Y] 06 Aug 2012: A.6.
    - Biological signals

- Targeted treatment
- Genetic driver
- Genetic mutation

5. Kusisto, L. New Home for the Genome Center. *Wall Street Journal,* Eastern edition [New York, N.Y] 18 June 2012: A.15.
    - Gene mapping
    - Genomic makeup
    - DNA sequence

6. Winslow, R. Corporate News: Personalized Rx for Children --- Pfizer's Xalkori, Used in Adults With Lung Cancer, Appears Effective Against Rare Childhood Tumors. *Wall Street Journal,* Eastern edition [New York, N.Y] 17 May 2012: B.3.
    - Targeted drug
    - Precision medicine

7. Winslow, R. Innovations in Health Care (A Special Report) --- The Wireless Revolution Hits Medicine: Eric Topol talks about the upheaval that's coming as the digitization of health care meets the smartphone. *Wall Street Journal,* Eastern edition [New York, N.Y] 16 Apr 2012: R.7.
    - Biosensor
    - DNA data
    - Genomic data

8. Linebaugh, K. Corporate News: GE to Buy Personalized-Medicine Company. *Wall Street Journal,* Eastern edition [New York, N.Y] 05 Apr 2012: B.6.
    - Genomic sequencing
    - Genetic profile
    - Molecular diagnostics

9. Kendall, B., Rockoff, J. D., & Weaver, C. Top Court Decision Stirs Alarm In Biotech. *Wall Street Journal,* Eastern edition [New York, N.Y] 21 Mar 2012: A.1.
    - Molecular diagnostic test

10. Winslow, R. 'Personalized Medicine' Hits a Bump. *Wall Street Journal,* Eastern edition [New York, N.Y] 08 Mar 2012: A.3.
    - Genetic signature
    - Genetic makeup
    - Genetic mutation
    - DNA sequencing
    - Customized treatment

11. Das, A. & Winslow, R. Roche Offers $5.7 Billion For Gene Company Illumina. *Wall Street Journal*, Eastern edition [New York, N.Y] 25 Jan 2012: B.1.

- Gene sequencing
- Genetic makeup
- Genetic code
- Genome sequencing
- Genetic sequencing

12. Winslow, R. & Wang, S. S. Soon, $1,000 Will Map Genes. *Wall Street Journal*, Eastern edition [New York, N.Y] 10 Jan 2012: A.2.

- Preventative medicine
- Genetic profiling
- Genetic screening
- Whole-genome sequencing
- Preventative drug
- Genetic data

13. Rockoff, J. D. Guided By Genes, Shrinking Cancer --- A Big Step for 'Personalized Medicine' With Approval of Roche Drug; Results 'Take Your Breath Away'. *Wall Street Journal*, Eastern edition [New York, N.Y] 18 Aug 2011: B.1.

- Targeted therapy

14. Winslow, R. Major Shift in War on Cancer --- Drug Studies Focus on Genes of Individual Patients; Testing Obstacles Loom. *Wall Street Journal*, Eastern edition [New York, N.Y] 06 June 2011: A.1.

- Targeted treatment
- Targeted therapy

15. Plumridge, H. Pharmaceutical Sector Remains Genetically Challenged. *Wall Street Journal*, Eastern edition [New York, N.Y] 22 Jan 2011: B.18.

- Genetic trigger
- Companion test

16. Landro, L. Health & Wellness -- The Informed Patient: Wellness Reading List: Five Top Picks of 2010 --- Physicians and Others, Writing About Their Own Experiences, Offer Advice and Insights Into Maintaining Health. *Wall Street Journal,* Eastern edition [New York, N.Y] 21 Dec 2010: D.3.

- Genetic profiling
- Early disease detection
- Personalized risk profile

17. Wang, S. S. Health & Wellness -- In The Lab: Unraveling Crohn's Genetic Trail. *Wall Street Journal*, Eastern edition [New York, N.Y] 27 Apr 2010: D.4.

- DNA segment

18. Winslow, R. Gene Test for Tumors Offers Hope of Aiding Treatment. *Wall Street Journal*, Eastern edition [New York, N.Y] 19 Feb 2010: A.3.

- Biomarker

19. Winslow, R. Skin-Cancer Drug Uses Genetics. *Wall Street Journal,* Eastern edition [New York, N.Y] 03 June 2009: D.3.

- Genetic biomarker

20. Landro, L. The Informed Patient: Submitting To the Science Of Prevention. *Wall Street Journal*, Eastern edition [New York, N.Y] 26 Nov 2008: D.1.

- Predictive health assessment
- Predictive health
- Personalized risk profile

21. Winslow, R. Gene Analysis Boosts Sidelined Heart Drug. *Wall Street Journal,* Eastern edition [New York, N.Y] 23 Sep 2008: D.2.

- Genetic profile
- Genetic variation
- Genetically guided therapy
- Genetic test

22. Brin, D. W. Medco Health, FDA to Study Role Of Genetics in Prescribing Drugs. *Wall Street Journal,* Eastern edition [New York, N.Y] 19 Aug 2008: B.3.

- Pharmacogenomics testing
- Genetic predisposition
- Disease risk factor

23. Wang, S. S. Genetics May Bring New Life to Failed Drugs. *Wall Street Journal,* Eastern edition [New York, N.Y] 24 Mar 2008: B.1.

- Genetic tools

24. Winslow, R. Gene Variant Is Said to Be Linked To Heart Attack and Prevention. *Wall Street Journal*, Eastern edition [New York, N.Y] 22 Jan 2008: D.3.

- Genome scan
- Drug target
- Biology illness

New York Times

The above search strategy yielded about 180 results. We examined the first 10 publications per year selecting those with a focus on PM. We found that few articles

yielded terminology for PM; they were often written in a narrative or first person style, and included limited conceptual information or relevant terminology. Some contained the same familiar keywords as mentioned in previous searches. Duplicate terms are not recorded below.

1. Kolkata, K. Genetic Gamble: new approached to fighting cancer. A New Treatment's Tantalizing Promise Brings Heartbreaking Ups and Downs (July 9, 2012) New York Times. http://www.nytimes.com/2012/07/09/health/new-frontiers-of-cancer-treatment-bring-breathtaking-swings.html
    - Whole genome sequencing
    - Genetic sequence

2. Conventional Cancer Therapy and Whole Genome Sequencing. (July 8 2012). New York Times http://www.nytimes.com/interactive/2012/07/08/health/conventional-cancer-therapy-and-whole-genome-sequencing.html?
    - Whole genome sequencing
    - Target gene

3. Patterson, D. Computer Scientists may have what it takes to Cure Cancer (Dec 5, 2011). New York Times. http://www.nytimes.com/2011/12/06/science/david-patterson-enlist-computer-scientists-in-cancer-fight.html
    - Targeted therapy
    - Personalized therapy

4. Pollack, A. Push to Tie New Drugs to Diagnostics (Dec 26, 2011) New York Times. http://www.nytimes.com/2011/12/27/health/pressure-to-link-drugs-and-companion-diagnostics.html?pagewanted=all
    - Companion test
    - Companion diagnostic

The Economist

The above search strategy yielded about 80 results. We read through about the first 60 of these, reading a maximum of ten articles per year and selecting those whose main focus was PM.

1. Getting personal; Biotechnology. *The Economist.* 387.8585 (Apr. 6, 2009): p77(US)
    - Gene sequencing
    - Genetic tests
    - Direct-to-consumer genomics

- Personal genomics

2. Medicine's New Central Bankers. *The Economist.* 377.8456 (Dec. 8, 2005): p30(US)
    - Biobank
    - Personalised treatment
    - Personalised diagnostic test

3. An array of errors; Misconduct in science. *The Economist.* 400.8750 (Sept. 10, 2011): p91(US)
    - Gene expression
    - Gene-expression data
    - Expression data
    - Expression array

4. Taking aim sooner; Cancer therapy. *The Economist.* 399.8737 (June 11, 2011): p81(US)
    - Targeted therapy

5. Back to the lab; Roche digests Genentech. *The Economist.* 393.8661 (Dec. 12, 2009): p65(EU)
    - Molecular diagnostics

6. Getting personal. *The Economist.* 391.8627 (Apr. 18, 2009): p10(US).
    - Genetic material
    - Direct-to-consumer genomics
    - Genomic history
    - whole-genome sequencing
    - biomarker
    - SNP - single nucleotide polymorphism
    - Genetic biomarker
    - Pharmacogenetics
    - Precision medicine

7. A doctor in your pocket. *The Economist.* 391.8627 (Apr. 18, 2009): p12(US).
    - Digital medical records
    - Genetic analysis

8. Signs of a long life; Metabolomics. *The Economist.* 387.8586 (June 28, 2008):
    - Microbiome
    - Metabolome

9. Within spitting distance? Personal genetics. *The Economist.* 385.8556 (Nov. 24, 2007): p68(US)
    - Personal genetics

10. Storm in a test tube; Health care. *The Economist.* 383.8531 (June 2, 2007): p68(US)
    - Genetic screening

11. Beyond the blockbuster; Pharmaceuticals. *The Economist.* 383.8535 (June 30, 2007): p73(US)
    - High-throughput sequencing
    - Personal phenotyping

12. Billion dollar pills – Pharmaceuticals. *The Economist.* 382.8513 (Jan. 27, 2007): p70(US)
    - Proteomics
    - Specialized drug

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Note that unless stated, all PDFs were last accessed Oct 2015.

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