Nano Bibliometrics

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Thanks to Jing Ma, Doug Robinson, Ying Guo, and Xiao Zhou for underlying research. We acknowledge support from the US National Science Foundation, Science of Science & Innovation Policy (SciSIP) Program (Award #1064146 – “Revealing Innovation Pathways: Hybrid Science Maps for Technology Assessment and Foresight”). The findings and observations contained here are those of the authors and do not necessarily reflect the views of the National Science Foundation.
Spotlights
- Nano Bibliometrics, 1995
- Nano Bibliometrics, 2015

Exploring large search datasets further – a case example:
- Nano-Enabled Drug Delivery (NEDD), for Cancers

Searched in Science Citation Index (SCI) & *INSPEC*

### 1986-1995

<table>
<thead>
<tr>
<th>Category</th>
<th>SCI</th>
<th>INSPEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nano-Related</td>
<td>912</td>
<td>3208</td>
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<tr>
<td>Nanotechnology</td>
<td>82</td>
<td>584</td>
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<tr>
<td>Scanning Probe Nano</td>
<td>150</td>
<td>122</td>
</tr>
<tr>
<td>Bottom-Up Nano</td>
<td>32</td>
<td>42</td>
</tr>
</tbody>
</table>
Nano Bibliometrics, 1995

- Nano growing rapidly
- *SCI* – frequent terms: nano* [not so much “nanotechnology”], self-assembly, supramolecular

Observations:

- Diverging research areas
  - *INSPEC* rich on: semiconductors, lithography, materials science
  - *SCI* rich on: microscopy, biophysics, films, surface sciences

- Distinct citation patterns
  - E.g., 246 articles cite K. Eric Drexler (*Engines of Creation*, 1986 + more)

- USA leads; Japan 2d
  - “China active in nano-related”
Georgia Tech Program in Science, Technology & Innovation Policy (STIP) has been generating nano datasets for a decade, with support from NSF via the Center for Nano in Society at Arizona State University.

Searches in various databases, but particularly:
- SCI ~\textit{850,000} publication abstract records from 1991
- PatStat ~\textit{116,000} patent records
- The search algorithm is publicly shared and well-cited

Next slides share some highlights prepared for the President’s Council of Advisors on Science and Technology (PCAST) 2014 report – The Fifth Assessment of the National Nanotechnology Initiative

http://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/pcast_fifth_nni_review_oct2014_final.pdf
Li, Y., Arora, S., Youtie, J., Shapira, P., and Carley, S. (2014), Nanotechnology Publication Counts and Citations: 2011–2013 – for PCAST Report. This material is based upon work supported by the National Science Foundation (NSF) through the Center for Nanotechnology in Society (CNS–ASU) under NSF Grant Number 0937591. Any opinions, findings and conclusions expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the authors’ institution.
Li, Y., Arora, S., Youtie, J., Shapira, P., and Carley, S. (2014), Nanotechnology Publication Counts and Citations: 2011–2013 – for PCAST Report. This material is based upon work supported by the National Science Foundation (NSF) through the Center for Nanotechnology in Society (CNS–ASU) under NSF Grant Number 0937591. Any opinions, findings and conclusions expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the authors’ institution.
Nanotechnology-Enabled Drug Delivery (NEDD) – which A) nano components are helping deliver which B) drugs to treat which C) cancers?

Pointing toward further questions:
- How to facilitate discovery of such research opportunities?
- How might R&D policy/management better “connect” research in adjacent arenas?

But first, some background on our “tech mining” on NEDD
Simple schematic of the “NEDD dream”

Molecular imaging & therapy

Fig.3: Nanoparticles used to treat cancer
How do “nano” components work to treat diseases like cancer? [deriving mainly from analyses of the NEDD patents]

**Features**
- PH-sensitive
- Hydrophilic/Hydrophobic
- Self-assemble
- Magnetic
- Prevent aggregation

**Structures**
- Nanoconjugate/Block copolymer
- Coating/Reconstituting

**Materials**
- Liposome
- PEG
- PLA
- Iron oxide
- Gold
- Albumin
- Cyclodextrin

**Agents**
- Nucleic acid/siRNA
- Protein/Polypeptide/Antibody
- Molecule of anticancer drug or inhibitor
Data & Analyses

Multi-part Boolean search to retrieve NEDD data

- ~60,000 Web of Science publication abstracts
- ~8,000 Derwent Innovation Index abstracts
- ~50,000 MEDLINE publication abstracts
- ~10,000 MEDLINE—NEDD for cancer abstracts
Developmental Pathways, Locating the 13 NEDD Topics of NEDD [based mainly on the patent topical analyses]

Target/disease
- Neurodegenerative diseases
- Autoimmune diseases
- Cancers

Carrier/vector
- Metal nanoparticles
- Polymers
- Micro capsules and liposomes

Drug/composition
- Pharmaceutical compounds
- Anticancer drugs

Process/mechanism
- Nucleic acid and hybridization probes
- Fusion protein
- Expression, nucleic acid encoding

RNA interference

Immune response

Process/mechanism
- 2000-2003
- 2004-2007
- 2008-2011
Feedback on the Empirical Research Profiling

Workshop with bio-medical & science policy colleagues at Georgia Tech (and 2d workshop at a Novel Drug Delivery Systems conference) – payoff will come from focusing on particular nano components and/or targets

- One path: comparing NEDD for brain applications – Alzheimer’s Disease and brain cancer
- Second path (today’s focus) – NEDD for cancer treatments
<table>
<thead>
<tr>
<th>COMMERCIALISATION</th>
<th>Approved on Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doxil/Caelyx (Breast cancer / leukemia)</td>
<td></td>
</tr>
<tr>
<td>Abraxane (Breast cancer)</td>
<td></td>
</tr>
<tr>
<td>Myocet (Ovarian cancer)</td>
<td></td>
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<tr>
<td>DaunoXome (Kaposi’s sarcoma)</td>
<td></td>
</tr>
<tr>
<td>Genexol-PM (lung and breast cancer (KOREA))</td>
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<tr>
<td>Depocyte (neoplasm meningitis)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>EFFICACY &amp; TOXICITY TESTS</th>
<th>Clinical Trials</th>
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</thead>
<tbody>
<tr>
<td>S-CKD602 / PEGyl. Liposome – Alza Corp.</td>
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<tr>
<td>CRLX101 / Cyclodextrin – Cerulean Pharma</td>
<td></td>
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<tr>
<td>CPX-1 / Liposomal irinotecan – Celator Pharma</td>
<td></td>
</tr>
<tr>
<td>LE-SN28 Liposoma SN38 – Neopharm</td>
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</tr>
<tr>
<td>NC-6004 / Cisplatin – NanoCarrier Co.</td>
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<tr>
<td>ALN-VSP / lipid nanoparticle of siRNA – Alnylam</td>
<td></td>
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<tr>
<td>OSI-211 / Liposomal irinotecan / OSI Pharma</td>
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</tr>
<tr>
<td>BIND-014 / polymeric NP docetaxel – BIND Bioscience</td>
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<tr>
<td>MBP-426 / Transferrin targetd oxaliplatin – Mebiopharm</td>
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<tr>
<td>CALAA-01 / cyclodextrin and siRNA – Calando Pharma</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>RESEARCH &amp; DEVELOPMENT</th>
<th>Nano-vector research</th>
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</thead>
<tbody>
<tr>
<td>Liposomes</td>
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<tr>
<td>Phospholipids</td>
<td></td>
</tr>
<tr>
<td>PluronicR</td>
<td></td>
</tr>
<tr>
<td>Poly (L-aminoacid) with oligonucleotides</td>
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</tr>
<tr>
<td>Polyester micelles</td>
<td></td>
</tr>
<tr>
<td>Nanoemulsions</td>
<td></td>
</tr>
<tr>
<td>Drug nanocrystals</td>
<td></td>
</tr>
<tr>
<td>Polymer-based nanoparticles</td>
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<tr>
<td>Lipid-based nanoparticles</td>
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<tr>
<td>Ceramic-based nanoparticles</td>
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<tr>
<td>Albumin nanoparticles</td>
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<tr>
<td>Nanogels</td>
<td></td>
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<tr>
<td>Dendrimers</td>
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</table>

Applications of approved nano-cancer therapies to other cancers

Co-delivery of multiple drugs in one therapy?

Multi-functional nano-enabled drug delivery systems with active targeting?

TODAY | TOMORROW?
# NEDD + Cancers

<table>
<thead>
<tr>
<th>#</th>
<th>Search Strategy (Web of Knowledge’s MEDLINE -- 2000–2013, performed 7/24/14)</th>
<th>NO. of records</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>MeSH HEADING:exp: (Neoplasms OR Antineoplastic Agents) AND (Drug carriers OR Micelles)</td>
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<td>#2</td>
<td>((MeSH HEADING:exp: (Neoplasms OR Antineoplastic Agents) AND Nanostructures) NOT #1) AND MeSH HEADING: (Drug Delivery Systems OR RNA Small Interfering OR Gene Transfer Techniques OR Delayed–Action Preparations OR RNA Interference OR Pharmaceutical Vehicles OR Genetic Vectors OR Transfection OR Polyglycolic Acid)</td>
<td>1517</td>
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<tr>
<td>#3</td>
<td>(((MeSH HEADING:exp: (Neoplasms OR Antineoplastic Agents) AND Nanostructures) NOT #1) AND MeSH HEADING: (Doxorubicin OR Polyethylene Glycols OR Paclitaxel)) NOT #2) AND ABSTRACT/TITLE: deliver*</td>
<td>122</td>
</tr>
<tr>
<td>#4</td>
<td>Total</td>
<td>10354</td>
</tr>
</tbody>
</table>
Use VantagePoint desktop software (www.theVantagePoint.com) to separate ~3334 primary MeSH terms and 73 Qualifiers in those 10,354 abstract records

Focus on top **200 primary MeSH terms** and **73 Qualifiers** = matrix

SPSS Hierarchical Clustering to consolidate those 200 MeSH terms into 7 clusters

- **Drug** – drugs and formulas
- **Component** – nanoparticles and accompanied materials
- **Cancer** – different cancer types
- **Method** – techniques, procedures, and programs
- **Effect** – effects of treatment
- **Interface** – receptors and metabolism
- **Antibody** – antibodies and antigens
Explore co-occurrences

3 key relationships to explore:
- Cancers (20) by Drugs (50)
- Cancers (20) by Nano components (62)
- Drugs (50) by Nano components (62)

But really more than 2-D – additional dimensions to explore – e.g.:
- Nano Components – which are getting specialized use vs. broad use?
- When [which topics are hot]?
Agent profiling: DOX -- Used for all 20; sarcoma & bone neoplasm most: Paclitaxel used for all but one (lymphoma) – why not?

Cancer profiling: Leukemia – 5 drugs overwhelmingly used to treat this – see earlier matrix

Agent for Cancer: Explore the zeroes with biomedical scientists
Examine **groups** of agents or cancers: genetic treatments [RNAi & DNA] – notably widely used.

**Crosswalk:** explore why RNAi is not showing for peritoneal neoplasms, but DNA is? Also, DNA is prominent for uterine cervical, why less so RNAi?

Look at **narrowly targeted** agents; might they hold potential for others?
Hot!

Using which nano components?

+ other cancers?

+ other drugs (multi-drug delivery?)
50 Agents (Drugs) by 62 Nano Components

Address 4958 of the 10,354 articles; spotlighted a row (one agent) – 430 articles on “RNA, small interfering”

Using which nano components?
For which cancers?
Only 10 also entail DNA?
Select References


Can we “discover” opportunities via such tech mining?

- Research gap analyses – could nano component X also facilitate delivery of treatment Y, for disease Z?
- Could such R&D profiling/parsing help in your studies?
- How do you learn about “one step removed” research findings, methods, applications, etc.?
Information Resources

➢ Contact me: Alan Porter: 404-384-6295; aporter@searchtech.com

• Lots of our papers: www.researchgate.net/profile/Alan_Porter4

• Providing a paper on this soon

➢ Software -- www.theVantagePoint.com

• NIH Library has 5-seat license server – for information: Lu, Ya-Ling (NIH/OD/ORS) [E] ya-ling.lu@nih.gov

• We are glad to provide webex support to learn how to use it (and/or visit as mutually scheduling works)