Nano Bibliometrics

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Outline

- Spotlights
  - Nano Bibliometrics, 1995
  - Nano Bibliometrics, 2015
- Exploring large search datasets further – a case example:
  - Nano-Enabled Drug Delivery (NEDD), for
  - Cancers

Nano Bibliometrics, 1995

- Porter, A.L., and Cunningham, S., "Whither Nanotechnology? A Bibliometric Study," *Foresight Update*, No. 21, p. 12-15, 1995.

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

- 1986-1995

	SCI	*INSPEC*
Nano-Related:	912	3208
Nanotechnology:	82	584
Scanning Probe Nano:	150	122
Bottom-Up Nano:	32	42

Nano Bibliometrics, 1995

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

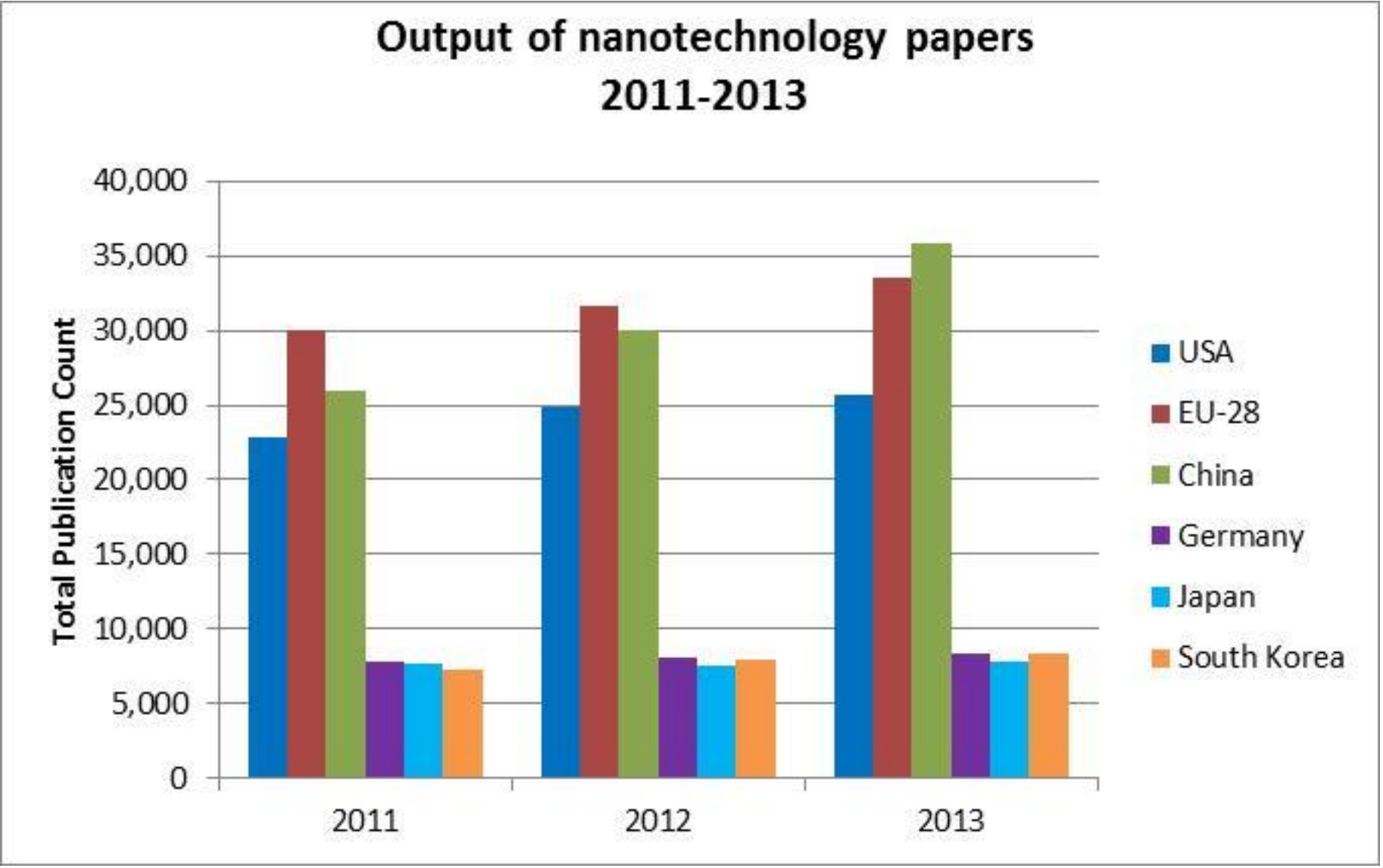
Observations:

- 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"

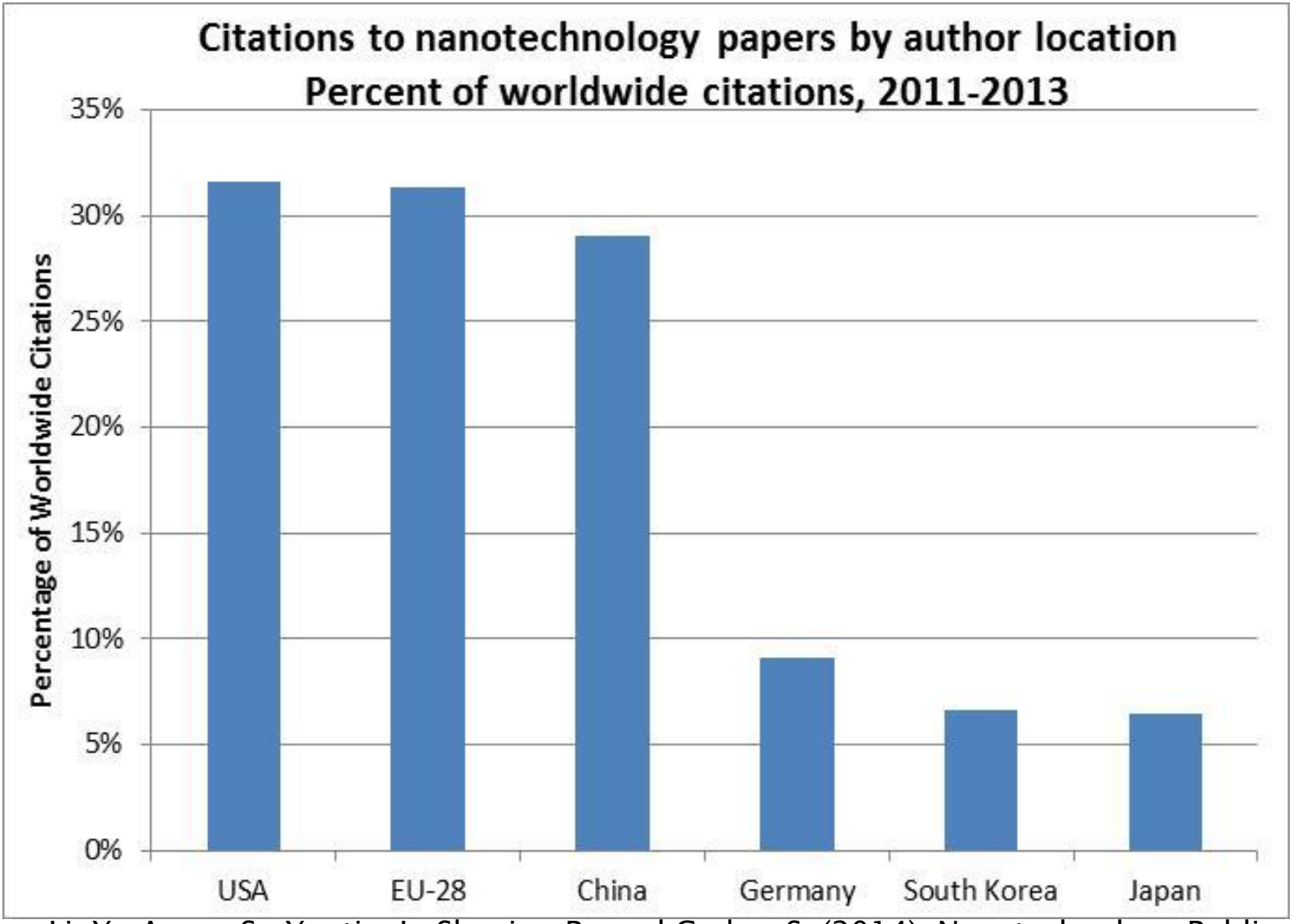
Nano Bibliometrics, 2015

- 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* ~**850,000 publication abstract records** from 1991
  - *PatStat* ~**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.



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NEDD: Research Question(s)

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”

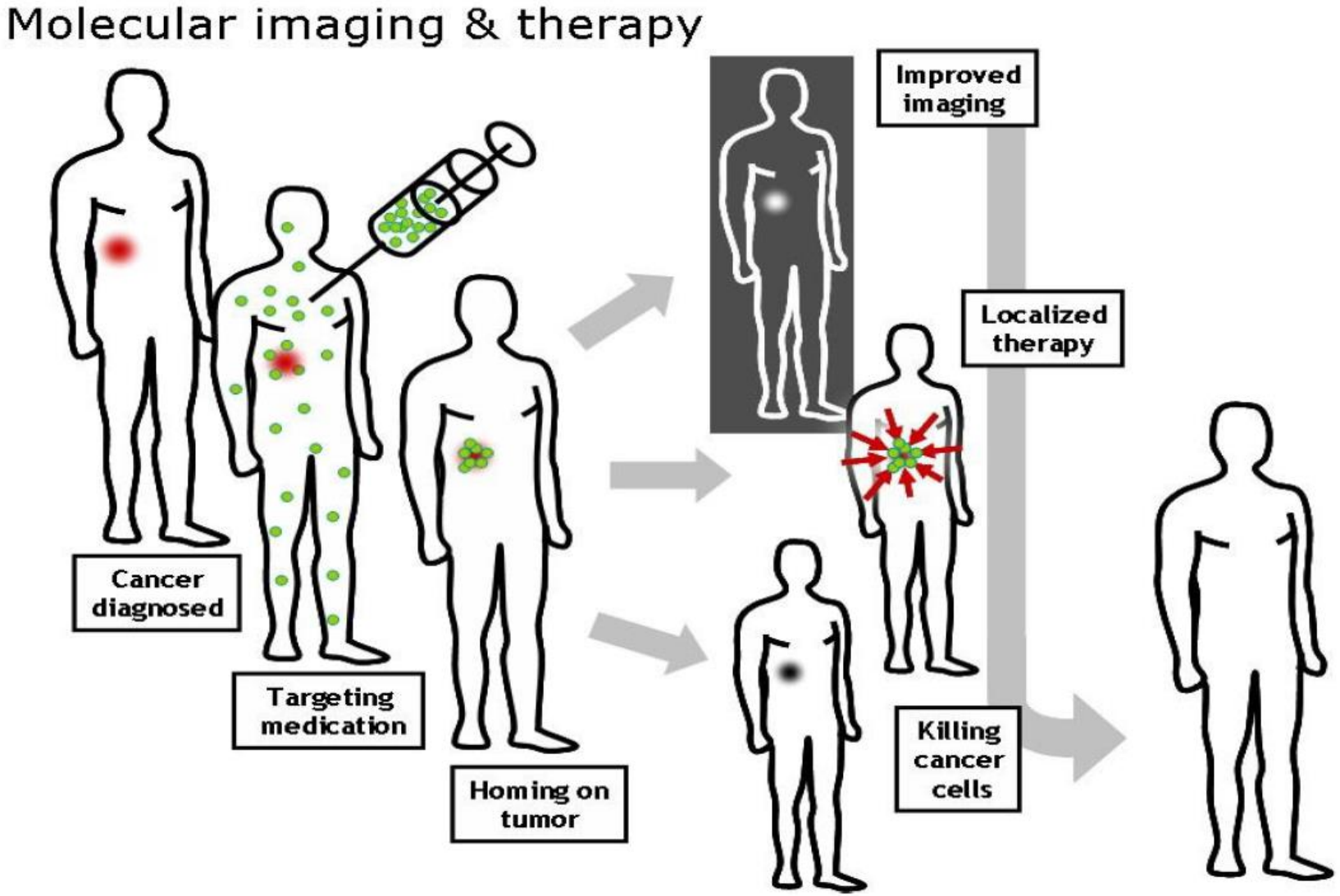
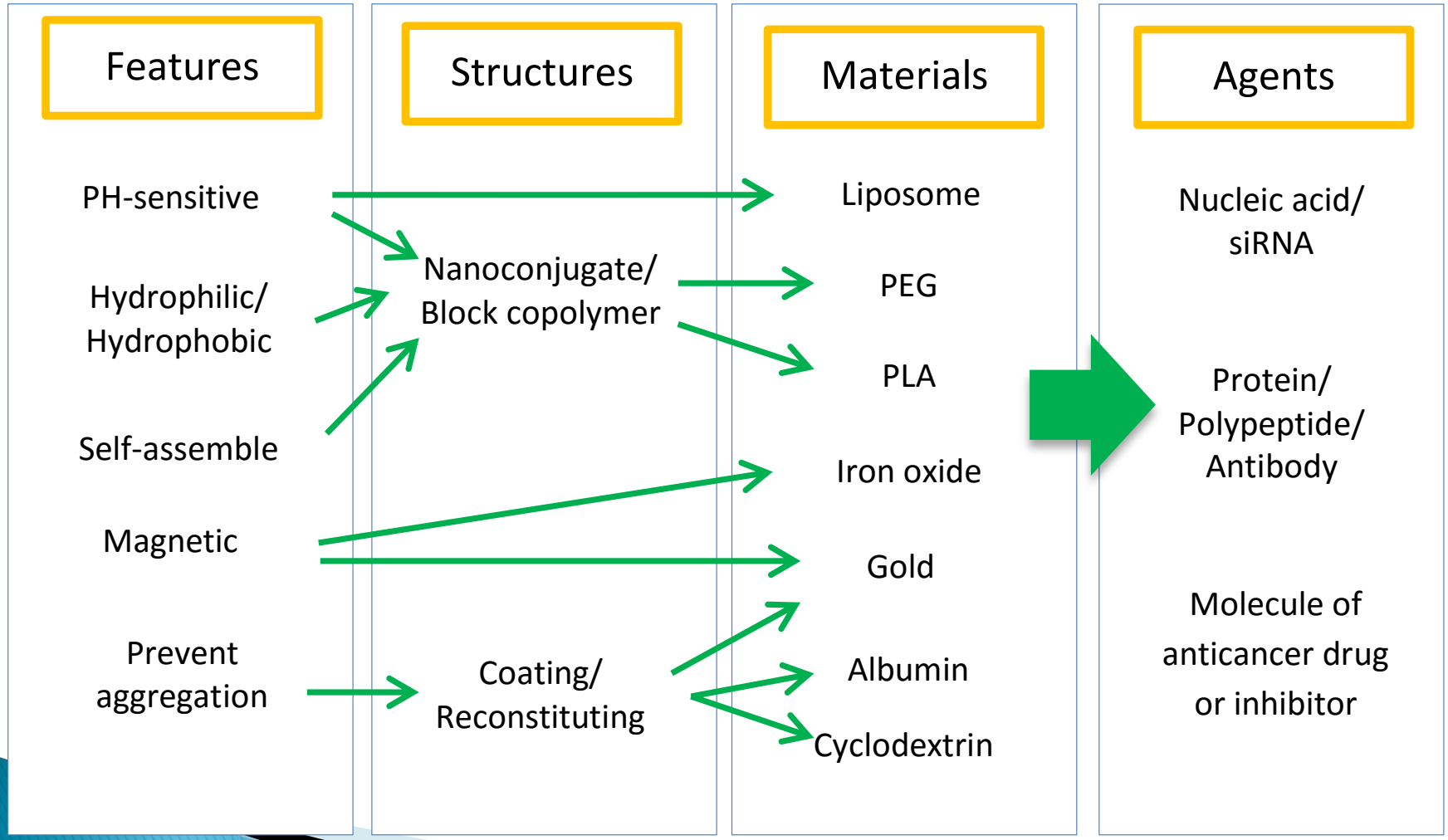


Fig.3: Nanoparticles used to treat cancer

How do "nano" components work to treat diseases like cancer?
[deriving mainly from analyses of the NEDD patents]



Data & Analyses

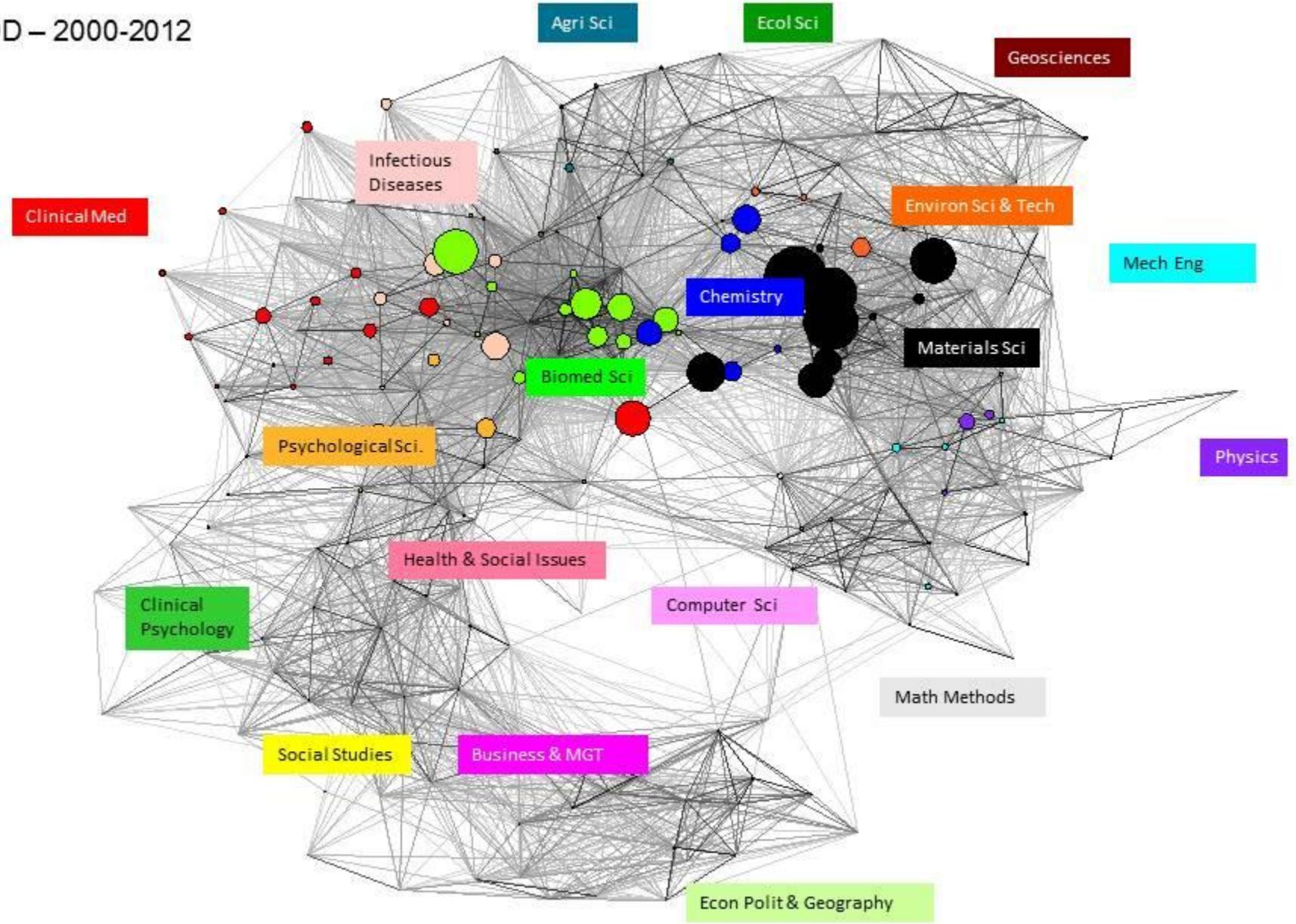
Multi-part Boolean search to retrieve NEDD data

- ~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**

Global Map of Science, 2010 update
224 Web of Science Categories

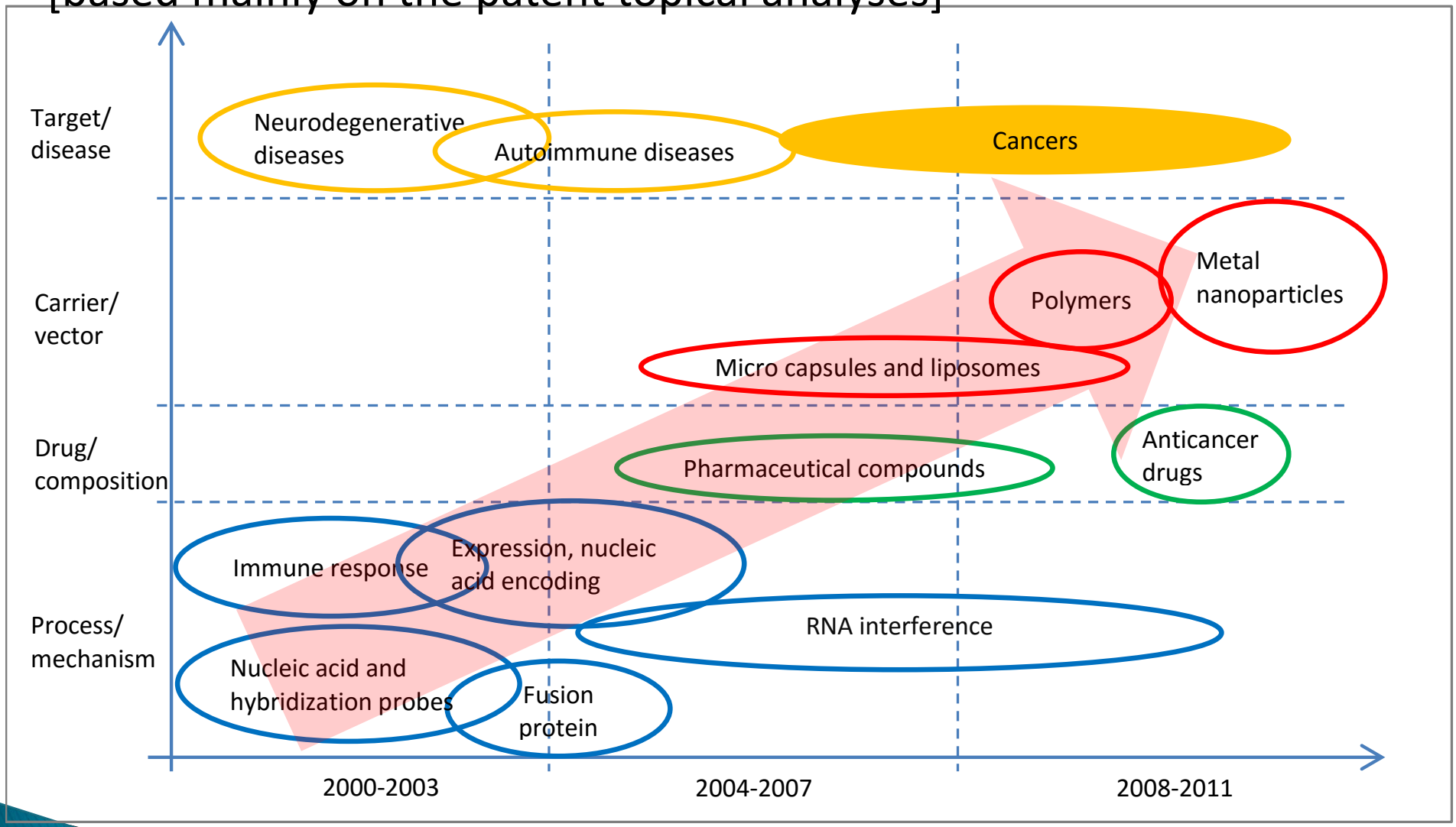
NEDD – 2000-2012



Method from Rafols, Porter and Leydesdorff (2009)

Developmental Pathways, Locating the 13 NEDD Topics of NEDD

[based mainly on the patent topical analyses]

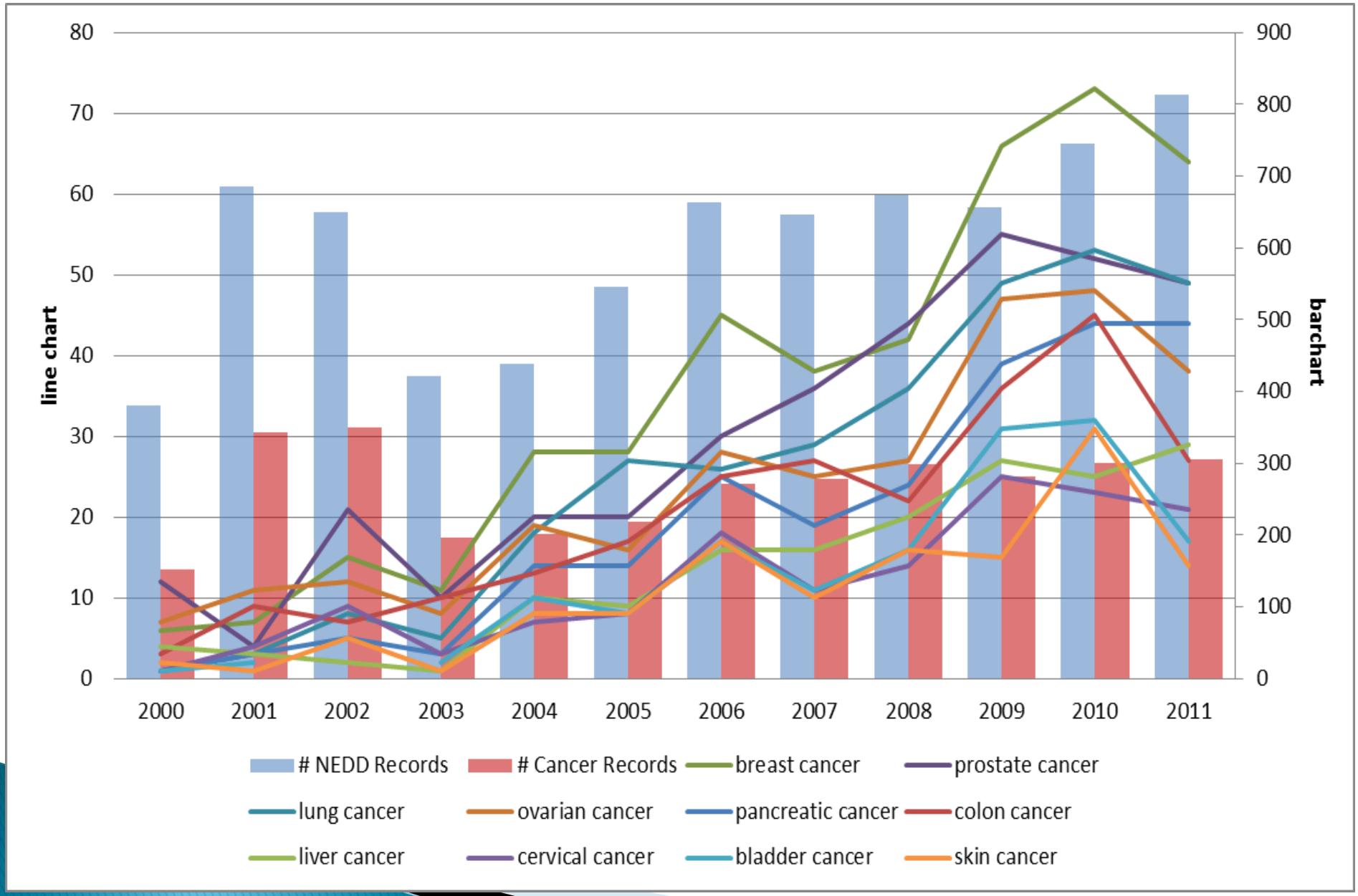


Feedback on the Empirical Research Profiling

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**

Focus on Cancers [patenting patterns]



		TODAY	TOMORROW?
COMMERCIAL-ISATION	Approved on Market	Doxil/Caelyx *(Breat cancer / leukemia)* Abraxane *(Breast cancer)* Myocet *(Ovarian cancer)* DaunoXome *(Karposi's sarcoma)* Genexol-PM (lung and breast cancer (KOREA) Depocyte (neoplast meningitis)	Applications of approved nano-cancer therapies to other cancers
EFFICACY & TOXICITY TESTS	Clincial Trials	S-CKD602 / PEGyl. Liposome – Alza Corp. CRLX101 / Cyclodextrin – Cerulean Pharma CPX-1 / Liposomal irinotecan – Celator Pharma LE-SN28 Liposoma SN38 – Neopharm NC-6004 / Cisplatin – NanoCarrier Co. ALN-VSP / lipid nanoparticle of siRNA – Alnylam OSI-211 / Liposomeal lurtotecan / OSI Pharma BIND-014 / polymeric NPdocetaxel – BIND Bioscience MBP-426 / Transferrin targetd oxaliplatin – Mebiopharm CALAA-01 / cyclodextrin and siRNA – Calando Pharma SGT53-01 / Liposome with p53 gene – SynerGene Therap.	Co-delivery of multiple drugs in one therapy?
RESEARCH & DEVELOPMENT	Vector + drug R&D	Liposomes Phospholipids PluronicR Poly (L-aminoacid) with oligonucleotides Polyester micelles Nanoemulsions Drug nanocrystals	Multi-functional nano-enabled drug delivery systems with active targeting?
	Nano-vector research	Polymer-based nanoparticles Lipid-based nanoparticles Ceramic-based nanoparticles Albumin nanoparticles Nanogels Dendrimers	

NEDD + Cancers

#	Search Strategy (Web of Knowledge's MEDLINE -- 2000-2013, performed 7/24/14)	NO. of records
#1	MeSH HEADING:exp: (Neoplasms OR Antineoplastic Agents) AND (Drug carriers OR Micelles)	8715
#2	((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)	1517
#3	((((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*	122
#4	Total	10354

Mining the Data

- 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

Happy Hunting Grounds!

- 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]?

	3879	Col Sum	704	580	248	224	89	319	238	224	23
		# Records	2697	1476	713	430	212	864	761	290	42
	# Records	CANCERS \ AGENTS	Antineopla	Doxorubici	Paclitaxel	RNA, Sma	DNA	Antibiotics,	Antineopla	Antineopla	Adjuvants, Pl
1	627	Breast Neoplasms	0.79	1.51	1.37	0.83	0.42	1.34	0.94	1.52	0.27
2	490	Brain and Nerve Neoplasms	1.02	0.78	1.12	0.85	1.16	0.77	1.00	0.53	0.69
3	397	Liver Neoplasms	0.96	1.43	0.59	1.00	1.76	1.72	0.86	0.26	0.85
4	376	Lung Neoplasms	1.10	0.80	1.33	1.70	1.16	0.81	1.30	0.88	0.90
5	356	Skin Neoplasms	1.05	0.83	0.53	0.78	1.59	0.75	0.96	0.34	3.32
6	269	Colorectal Neoplasms	1.09	0.72	0.70	0.52	0.32	0.54	1.33	0.71	1.25
7	237	Ovarian Neoplasms	1.05	1.50	2.11	1.46	0.55	1.74	1.31	2.41	0.00
8	208	Prostatic Neoplasms	0.90	0.71	0.38	2.41	1.26	0.47	0.63	0.50	0.81
9	133	Adenocarcinoma	0.91	0.75	0.82	0.65	1.31	0.82	0.74	1.82	1.27
10	131	Leukemia	0.72	0.36	0.12	0.13	0.33	1.58	1.00	2.51	0.00
11	122	Pancreatic Neoplasms	1.45	0.22	0.77	0.71	2.14	0.20	0.94	1.28	0.00
12	114	Carcinoma, Squamous Cell	0.77	0.47	0.69	0.61	0.76	0.43	0.71	1.37	0.00
13	79	Stomach Neoplasms	0.91	0.25	1.78	1.10	0.55	0.62	1.86	1.10	0.00
14	67	Bone Neoplasms	1.40	1.90	0.47	1.29	0.65	0.73	0.00	1.29	0.00
15	59	Head and Neck Neoplasms	1.21	1.13	0.27	0.88	0.00	1.03	0.00	1.17	0.00
16	53	Urinary Bladder Neoplasms	1.04	0.76	2.95	1.63	0.00	1.38	1.85	0.00	3.18
17	51	Peritoneal Neoplasms	1.94	0.92	1.23	0.00	0.85	0.72	1.60	0.34	0.00
18	38	Uterine Cervical Neoplasms	0.87	0.70	1.65	1.37	3.44	0.64	0.86	0.91	8.88
19	37	Lymphoma	0.74	0.90	0.00	0.47	0.00	0.66	0.88	0.00	4.56
20	35	Sarcoma	1.57	2.87	0.45	0.00	1.25	1.39	0.47	1.98	4.82

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

3879	Col Sum	704	580	248	224	89	319	7
	# Records	2697	1476	713	430	212	864	45
# Records	CANCERS \ AGENTS	Antineopla	Doxorubici	Paclitaxel	RNA, Sma	DNA	Antibiotics,	Etoposide
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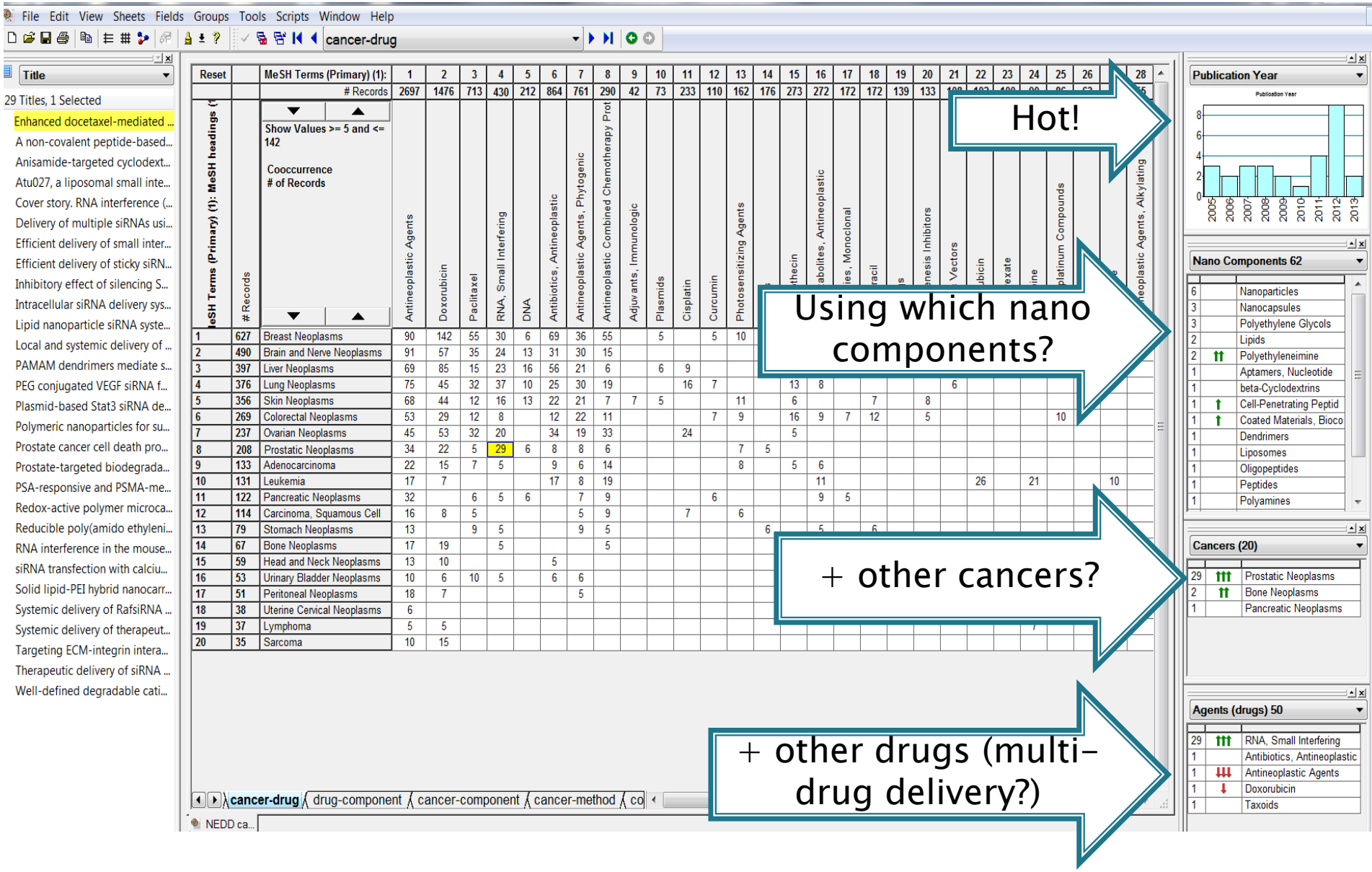
490	Brain and Nerve Neoplasms	1.02	0.78	1.12	0.85	1.16	0.77	2.26
397	Liver Neoplasms	0.96	1.43	0.59	1.00	1.76	1.72	0.00
376	Lung Neoplasms	1.10	0.80	1.33	1.70	1.16	0.81	2.95
356	Skin Neoplasms	1.05	0.83	0.53	0.78	1.59	0.75	0.00
269	Colorectal Neoplasms	1.09	0.72	0.70	0.52	0.32	0.54	0.00
237	Ovarian Neoplasms	1.05	1.50	2.11	1.46	0.55	1.74	0.00
208	Prostatic Neoplasms	0.90	0.71	0.38	2.41	1.26	0.47	0.00
133	Adenocarcinoma	0.91	0.75	0.82	0.65	1.31	0.82	0.00
131	Leukemia	0.72	0.36	0.12	0.13	0.33	1.58	0.00
122	Pancreatic Neoplasms	1.45	0.22	0.77	0.71	2.14	0.20	0.00
114	Carcinoma, Squamous Cell	0.77	0.47	0.69	0.61	0.76	0.43	0.00
79	Stomach Neoplasms	0.91	0.25	1.78	1.10	0.55	0.62	0.00
67	Bone Neoplasms	1.40	1.90	0.47	1.29	0.65	0.73	0.00
59	Head and Neck Neoplasms	1.21	1.13	0.27	0.88	0.00	1.03	0.00
53	Urinary Bladder Neoplasms	1.04	0.76	2.95	1.63	0.00	1.38	0.00
51	Peritoneal Neoplasms	1.94	0.92	1.23	0.00	0.85	0.72	0.00
38	Uterine Cervical Neoplasms	0.87	0.70	1.65	1.37	3.44	0.64	0.00
37	Lymphoma	0.74	0.90	0.00	0.47	0.00	0.66	29.95
35	Sarcoma	1.57	2.87	0.45	0.00	1.25	1.39	0.00

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?

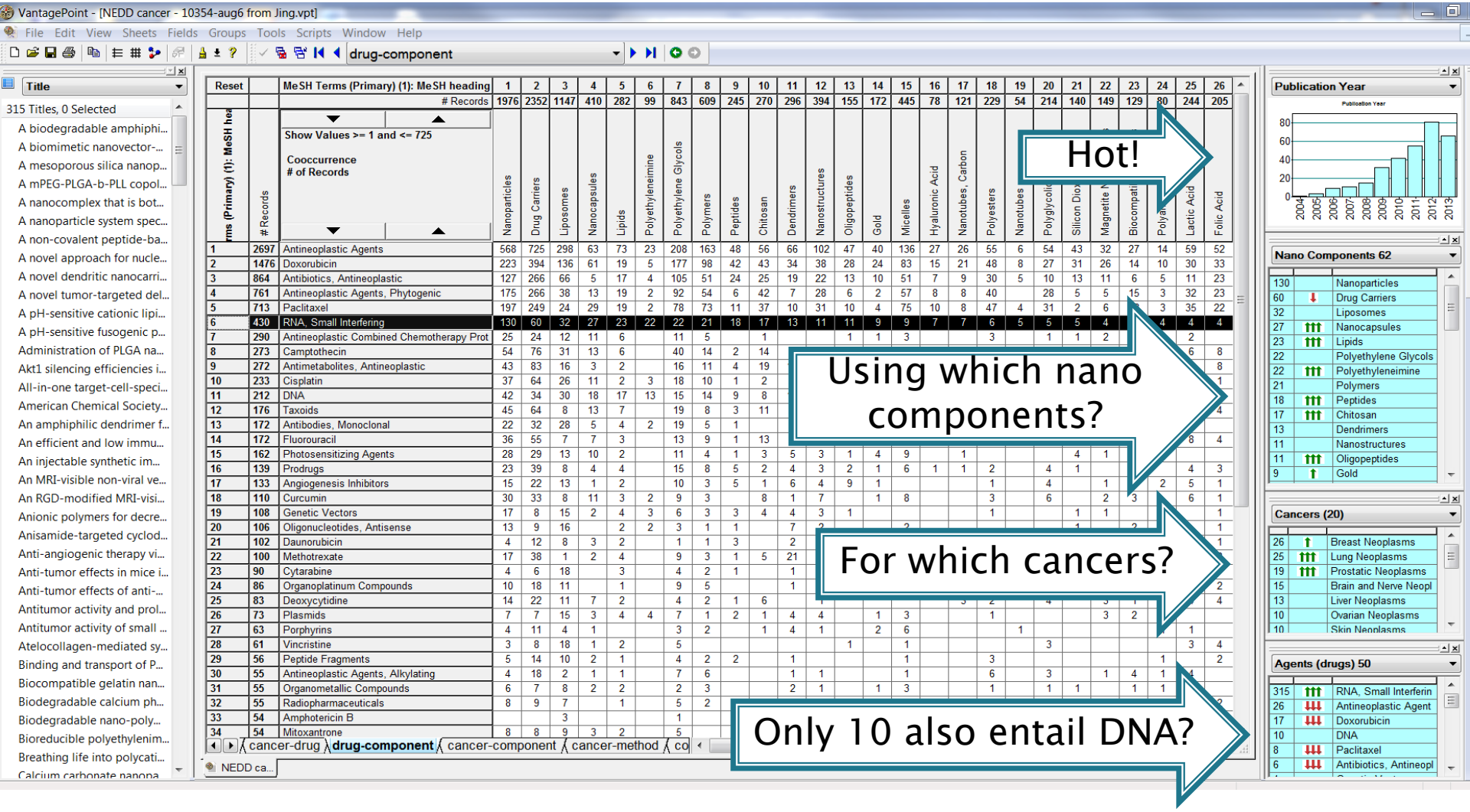
Look at **narrowly targeted** agents; might they hold potential for others?

20 Cancers by 50 Drugs: Added Dimensions Ex. 29 articles on RNAi for Prostate



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”



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Discussion??

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)