



Big Data Analysis of Global Literature and Patents in Pharmaceutics and Drug Delivery Area

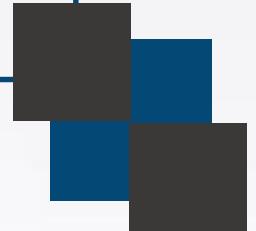


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Outline of Presentation

01



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Conclusions

Part 1

Background

01 Background

1.1 Development of Pharmaceutics/Drug Delivery



- **1st generation (before 1960's):**
Conventional dosage forms
e.g. tablets, capsules and injections
- **2nd generation (1960's – 1980's):**
Sustained-release preparations/Solubilization of water-insoluble drugs;
e.g. Osmotically controlled release tablets, solid dispersion and cyclodextrin formulations;
- **3rd generation (1980's – 2000's)**
Novel pharmaceutical dosage forms/Drug delivery systems
e.g. liposome, nanoparticle, molecular imaging

Specific technologies or approaches applied
in pharmaceutics and drug delivery systems



Global research advances and development
from macro-perspectives

01 Background

1.2 Research Progress on Scientific Knowledge Mapping

Scientometric or Bibliometric reviews ? → *Alternative approaches* → *Scientific knowledge mapping*

Conventional literature review:

considerable time for researchers;
subjective opinions;
poor efficiency;
difficulty to replicate.

Novel approaches:

massive amount of literatures;
dynamics;
macro-perspective;
visualization/intelligentization.



➤ To investigate the scientific knowledge to reveal the knowledge structure of the science and capture the evolution of the research frontiers shift over time in a visual way.

➤ Recent progress on scientific knowledge mapping applied in pharmaceutics

- *Nanoparticle drug delivery technologies*----identified thematic concentrations and emerging trends;
- *Global liposome research*----characterize the development of this science domain;
- *Nanobiopharmaceuticals*----present the dynamic evolution of the intellectual bases and research frontiers

1.3 Common Visualization Tools for Knowledge Mapping

Citespace

To investigate the knowledge structure, evolution and the future trends of the science

01

VOSviewer

to construct the collaboration networks and identify the active research fields in the domain

02

GPSvisualizer

To visualize geographic collaboration patterns.

03

Science of Science (SCI²)

To perform the study of the science and identify the nature of the development of the science

04

Gephi

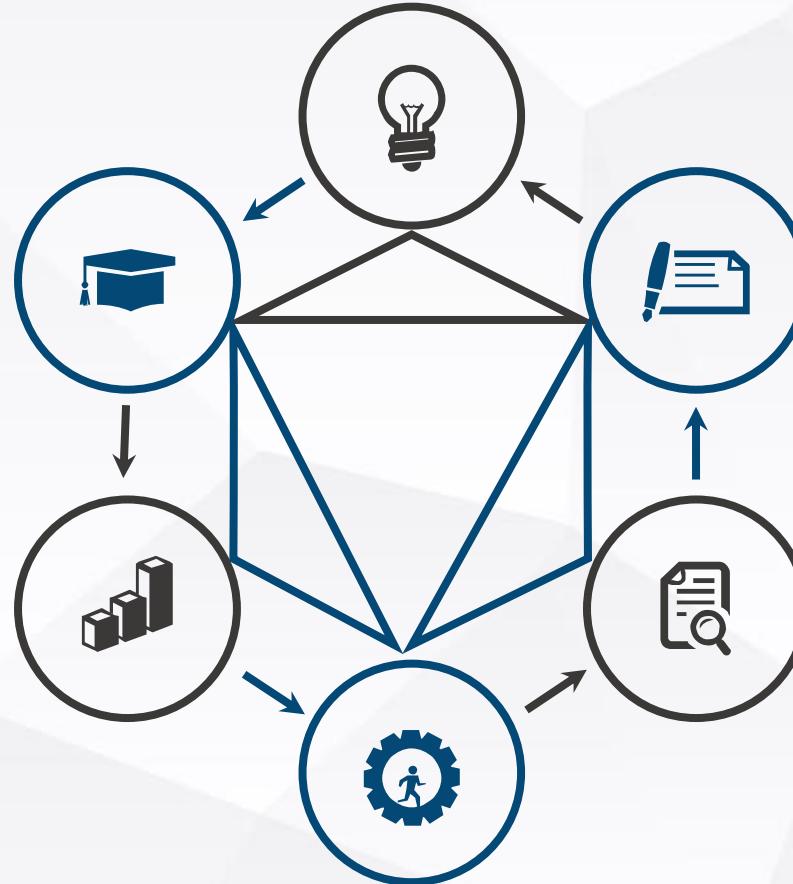
To explore the intellectual collaboration in a visual way

05

Others

SPSS, Ucient, Pajek etc

06



Part 2

Aim and Objectives

02 Aim and Objectives

Aim and objective of current study

➤ AIM

To evaluate the research outputs (literature and patent) in pharmaceuticals and drug delivery and summarize the global research advances from multi-perspectives.

➤ Objectives

01

To investigate the **intellectual landscape** of literature from multiple perspectives including years, countries and institutions

02

To investigate the **intellectual landscape** of patent from multiple perspectives including global application trend, main active institutions and hot technology domain



Part 3

Methodology

3.1 Data Collection and Analysis

• Literature

Database: Science Citation Index Expanded (SCI-E) database via Web of Science ;

Journals: All pharmaceutics periodicals with **IF >1.0** from the subject category of “**Pharmacology & Pharmacy**”;

Data: January 1980 to December 2014

- Original Data: full records and cited references which provided articles' title, authors, source title, affiliations, abstracts, publication date and number of cited times (Total: **111,461** records);

Table 1. Bibliometric analysis and visualization tools in current study

<i>Purpose</i>	<i>Unit of analysis</i>	<i>Visualization tool</i>
To investigate bibliographic landscape and scientific production	Country	Excel
	Institution	
	Published year	
To evaluate the intellectual collaboration	Country	GPSvisualizer
	Institution	VOSviewer
To identify the knowledge structure and capture the evolution of research frontiers and emerging trends	Keywords	Citespace
	Reference	

Table 2. 27 pharmaceutics related journals

No.	Journal Title	Abbreviated Journal Title	Impact Factor	Journal Country	Publisher
1	Advanced Drug Delivery Reviews	Adv. Drug Deliv. Rev.	15.038	Netherlands	Elsevier Science BV
2	Journal of Controlled Release	J. Control. Release	7.705	Netherlands	Elsevier Science BV
3	Clinical Pharmacokinetics	Clin.Pharmacokinet.	5.053	New Zealand	Adis International Limited
4	Expert Opinion on Drug Delivery	Expert Opin. Drug Deliv.	4.840	England	Informa Healthcare
5	Molecular Pharmaceutics	Mol. Pharm.	4.384	United States	American Chemical Society
6	International Journal of Nanomedicine	Int. J. Nanomedicine	4.383	New Zealand	Dove Medical Press Ltd
7	Critical Reviews in Therapeutic Drug Carrier Systems	Crit. Rev. Ther. Drug Carr. Syst.	4.259	United States	Begell House Inc.
8	European Journal of Pharmaceutics and Biopharmaceutics	Eur. J. Pharm. Biopharm.	3.850	Netherlands	Elsevier Science BV
9	AAPS Journal	AAPS J.	3.799	United States	Springer
10	International Journal of Pharmaceutics	Int. J. Pharm.	3.650	Netherlands	Elsevier Science BV
11	Pharmaceutical Research	Pharm. Res.	3.420	Germany	Springer/Plenum Publishers
12	European Journal of Pharmaceutical Sciences	Eur. J. Pharm. Sci.	3.350	Netherlands	Elsevier Science BV
13	Journal of Drug Targeting	J. Drug Target.	2.741	England	Informa Healthcare
14	Journal of Pharmaceutical Sciences	J. Pharm. Sci.	2.590	United States	Wiley-Blackwell
15	Drug Delivery	Drug Deliv.	2.558	United States	Informa Healthcare
16	Biopharmaceutics & Drug Disposition	Biopharm. Drug Dispos.	2.340	Denmark	Wiley-Blackwell
17	Journal of Pharmacy and Pharmacology	J. Pharm. Pharmacol.	2.264	England	Wiley-Blackwell
18	Drug Development and Industrial Pharmacy	Drug Dev. Ind. Pharm.	2.101	United States	Informa Healthcare
19	Journal of Pharmacy and Pharmaceutical Sciences	J. Pharm. Pharm. Sci.	1.856	Canada	Canadian SOC Pharmaceutical Sciences
20	Journal of Pharmacokinetics and Pharmacodynamics	J. Pharmacokinet. Pharmacodyn.	1.856	United States	Springer/Plenum Publishers
21	Biological & Pharmaceutical Bulletin	Biol. Pharm. Bull.	1.828	Japan	Pharmaceutical SOC Japan
22	Journal of Liposome Research	J. Liposome Res.	1.822	United States	Informa Healthcare
23	AAPS Pharmscitech	AAPS PharmSciTech	1.641	United States	Springer
24	Journal of Microencapsulation	J. Microencapsul.	1.585	England	Informa Healthcare
25	Current Drug Delivery	Curr. Drug Deliv.	1.478	United Arab Emirates	Bentham Science Publication Ltd
26	Pharmaceutical Development and Technology	Pharm. Dev. Technol.	1.202	United States	Informa Healthcare
27	Chemical & Pharmaceutical Bulletin	Chem. Pharm. Bull.	1.164	Japan	Pharmaceutical SOC Japan

- **Patent**

➤ *Derwent World Patents Index: data collection from 1960 to 2014*

Table 3. Search query for pharmaceutical technologies

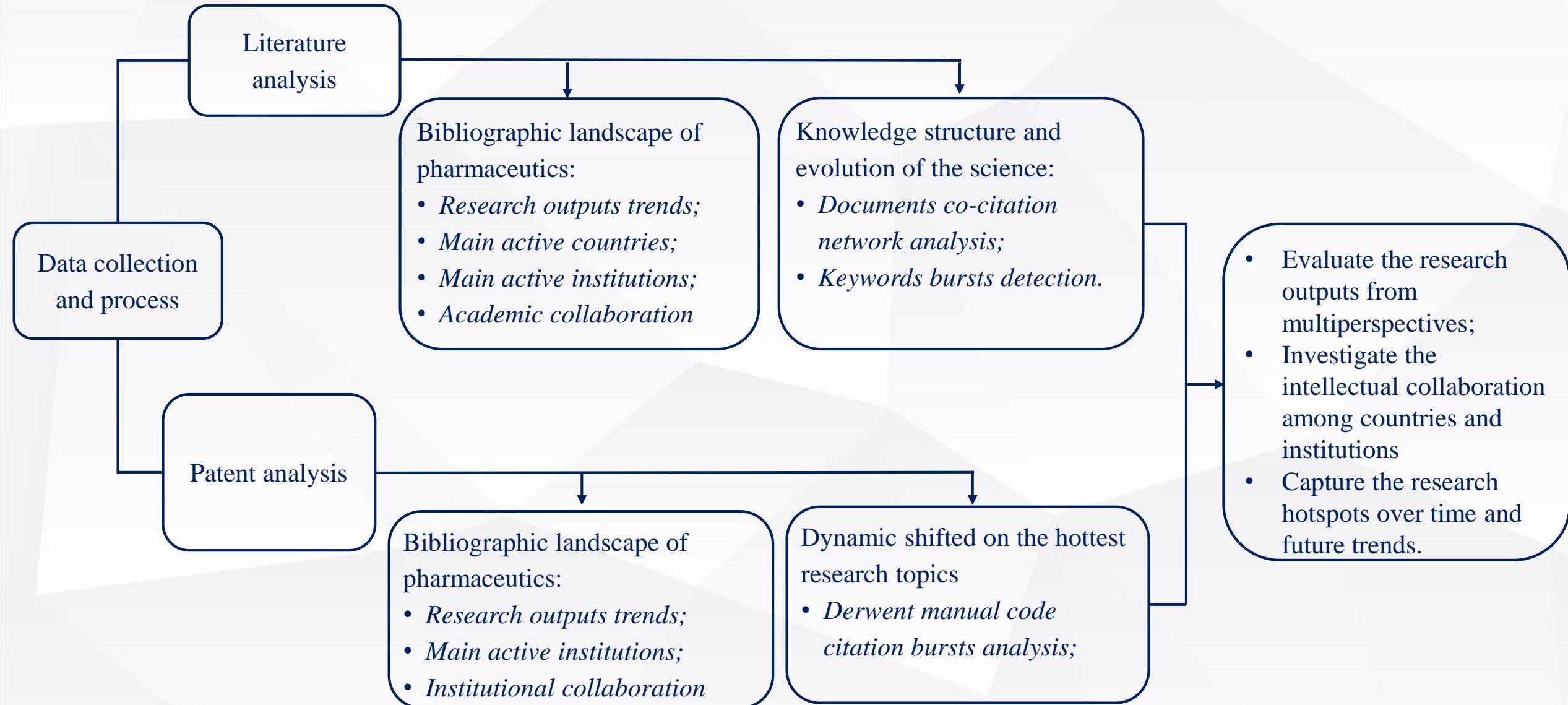
Tittle	Records	Total
“Cyclodextrin”	11,000	39,294
“Gene Therapy” AND “Drug”	2,499	
“Gene Therapy” AND “Medicine”	643	
“Liposome”	6,500	
“Nanoparticle” AND “Drug”	1,405	
“Nanoparticle” AND “Medicine”	747	
“Solid Dispersion”	16,500	

➤ *Data Process*

Table 4. Data extraction from patent text

Patent text fields	Patent information	Data Analysis
“AU”	Inventors	Co-inventorship network
“MC”	Derwent Manual Code	Item burst detection
“AE”	Patent Holders	Co-patents holders network
“CP”	Citing Patents	Patent co-citation network
“AD”	Application Date	Time zone view

3.2 Roadmap of the study



Part 4

Results and Discussion

04 Results and Discussion

4.1 Bibliographic Landscape of Pharmaceutics and Drug Delivery

- Global Trends of the Research Outputs
 - Literature analysis

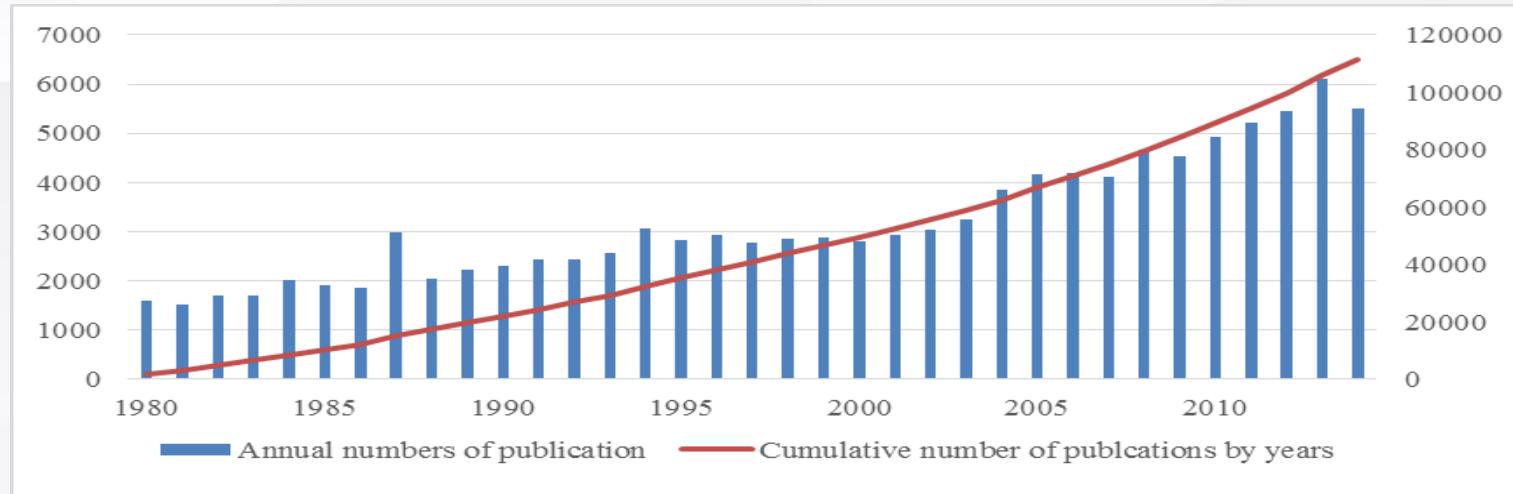


Fig. 1. Annual publication number in pharmaceutics from 1980 to 2014

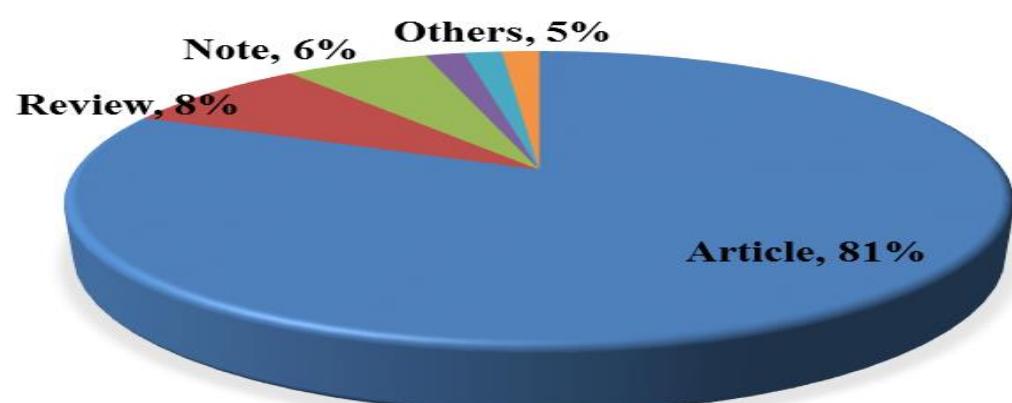


Fig. 2. Document Types of Publications

04 Results and Discussion

- Patent analysis

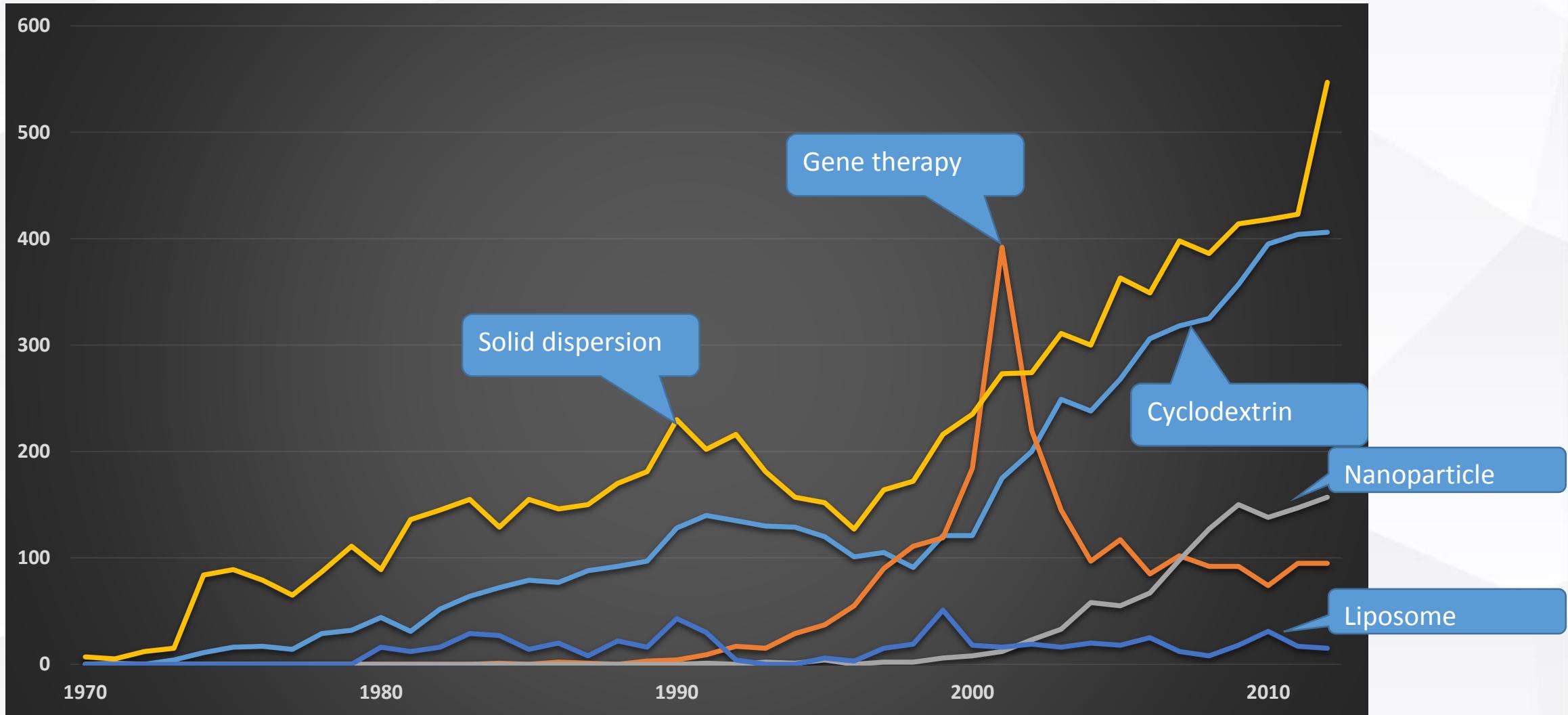


Fig. 3. The number of patent application in pharmaceutical field

04 Results and Discussion

➤ Main Active Research Countries (Literatures)

Table 5. Global publication share of top 10 productive countries

Rank	Countries	Total Publications	Average Citation Per Paper
1	Japan	29,066	16.3
2	USA	27,609	28.1
3	UK	8276	22.5
4	China	6795	15.1
5	Germany	4533	30.0
6	India	4134	18.4
7	France	4071	25.5
8	South Korea	3456	21.6
9	Italy	3283	21.2
10	Canada	2679	27.5

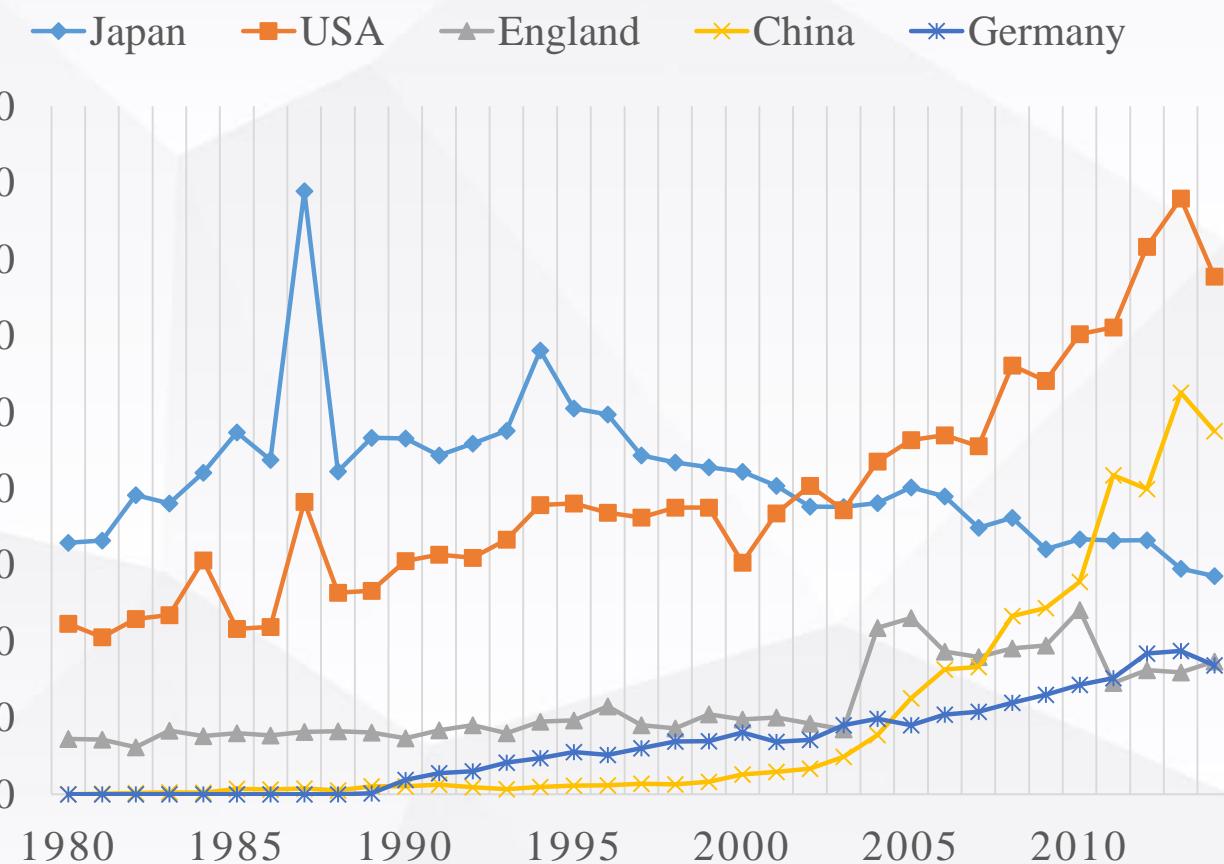


Fig. 4. Changes in the number of publications by years of top 5 productive countries

04 Results and Discussion

➤ Main Active Research Institutions (Literatures)

Table 6. Productivity and impact of top 10 active institutions

Institutes	Publications	Rank	Institutes	Average Citation	Rank
University Of London	1891	1	University Of Utah	40.2	1
Pfizer	1741	2	University Of Michigan System	38.2	2
Kyoto University	1470	3	University of Paris-Sud (Paris Xi)	38.0	3
French National Center for Scientific Research (CNRS)	1183	4	University Of California System	36.1	4
University Of Tokyo	1176	5	Uppsala University	36.0	5
University Of California System	1143	6	University Of Texas Austin	34.7	6
Toyama University	1076	7	Purdue University System	34.6	7
Osaka University	1020	8	Leiden University	34.5	8
GlaxoSmithKline	1007	9	French National Center for Scientific Research (CNRS)	32.2	9
Kyoto Pharmaceutical University	992	10	University Of Utrecht	30.9	10

➤ Main Patents Holders (Patents)

Table 7. Top 20 patent holders

Rank	Patent Holder	Number	Country
1	DU PONT DE NEMOURS & CO EI	1259	USA
2	DOW CHEM CO	1253	USA
3	ICI LTD	992	UK
4	EASTMAN KODAK CO	755	USA
5	SUN OIL CO	717	JAPAN
6	FARBENFAB BAYER AG	497	GERMANY
7	FUJI PHOTO FILM CO LTD	434	JAPAN
8	UNION CARBIDE CORP	400	USA
9	IMPERIAL CHEM IND LTD	357	UK
10	HERCULES INC	346	USA
11	AMERICAN CYANAMID CO	339	USA
12	CPC INT INC	333	USA
13	TOYO RAYON CO LTD	330	JAPAN
14	MONSANTO CO	282	USA
15	GRACE & CO W R	281	USA
16	PHILLIPS PETROLEUM CO	277	USA
17	SHELL INT RES MIJ NV	277	NETHERLANDS
18	BADISCHE ANILIN & SODA FAB AG	276	GERMANY
19	DAINIPPON INK & CHEM KK	244	JAPAN
20	TEXACO INC	227	USA

04 Results and Discussion

4.2 Intellectual Collaboration

- Academic Collaboration (Literatures)
- Collaboration cross countries



Fig. 5. Global intellectual collaboration of high-quality publication by affiliation of authors

- Major research institutions with high-quality publications are mainly located in Europe, North America and Asian.
- Collaborations between North America and Europe are much stronger than that Asia

- Collaboration cross institutions

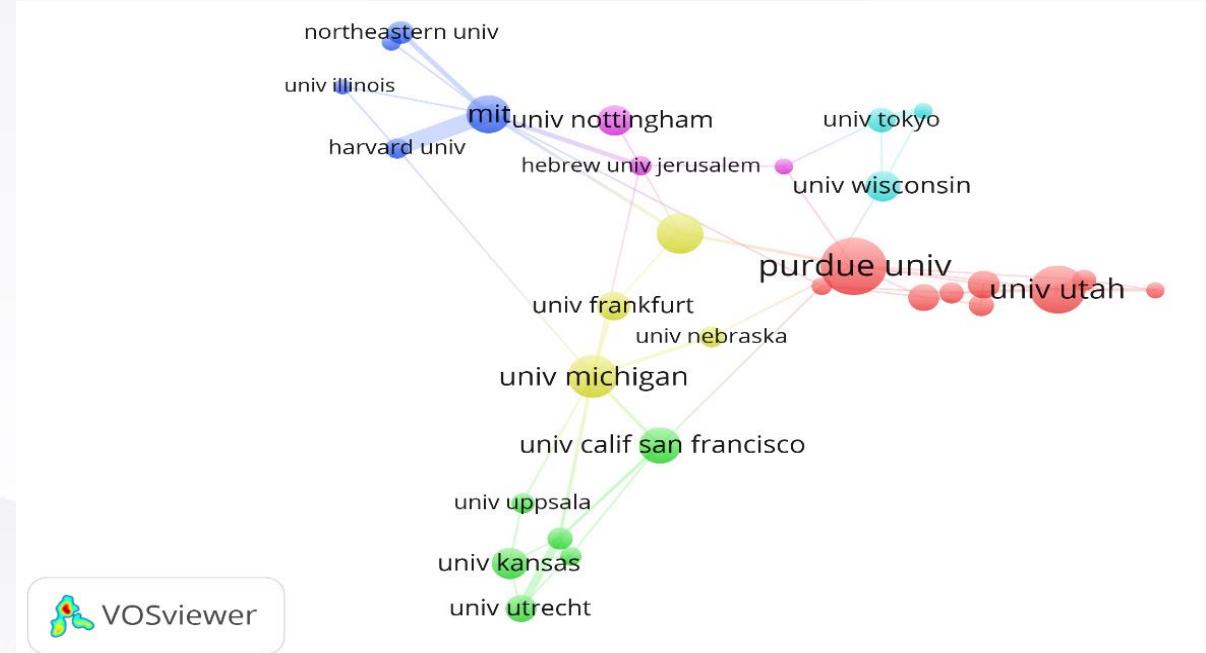


Fig. 6. Institutional collaboration network of top 30 most productive institutions with high-quality publication

- Purdue University hold the largest number of high-quality publications and played a bridging role in collaboration network.
- MIT and Harvard University are the most frequency cooperation partners.

- Patent Holders Collaboration (Patents)

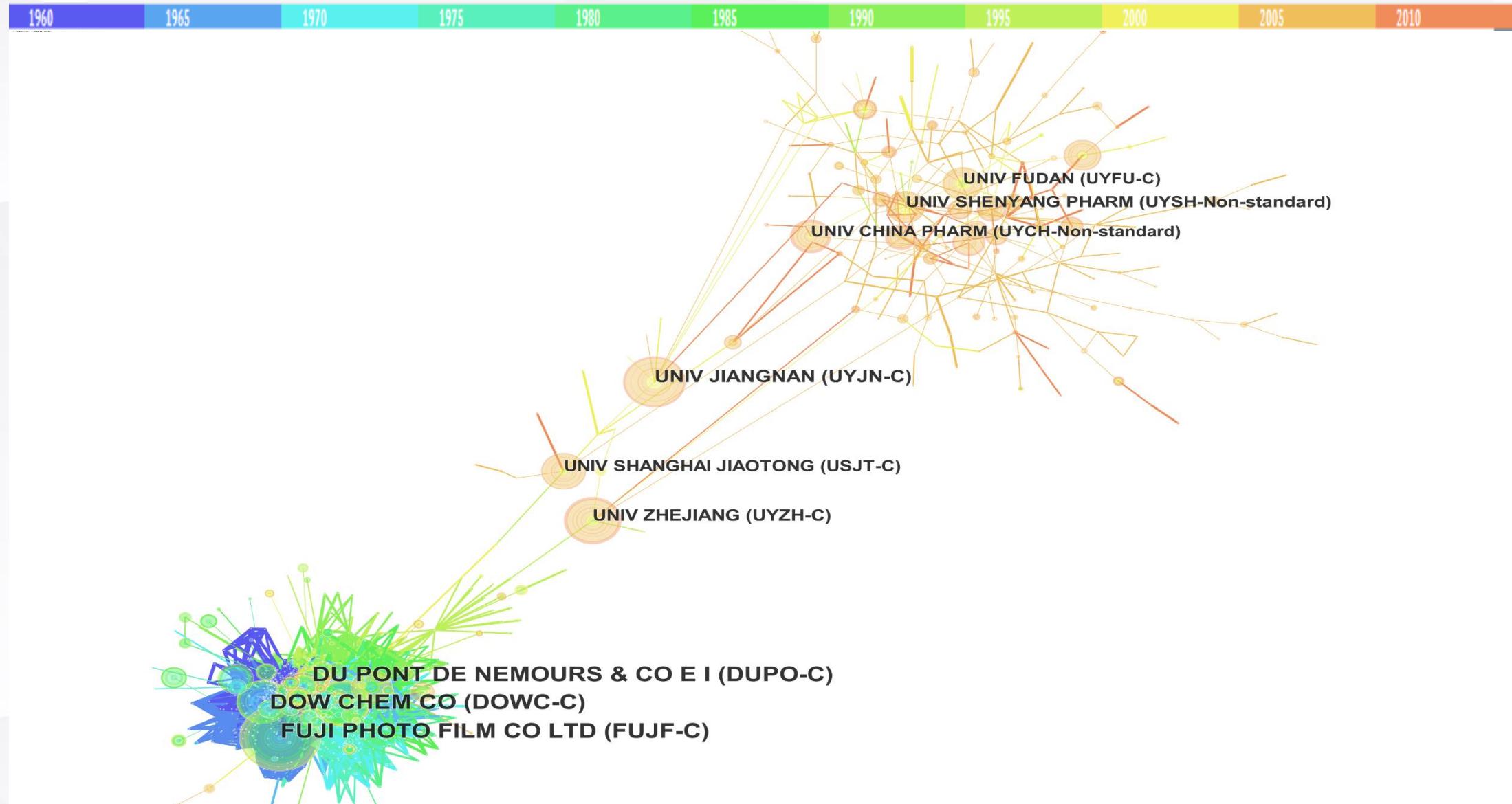
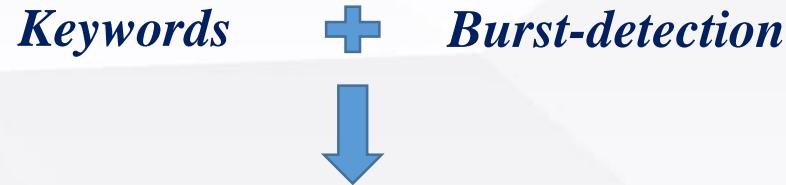


Fig. 7. Collaboration network in main patent holders

4.3 Research Frontiers Shifted Over Time

- Literatures



Development of the science domain

Before 2000:

Conventional dosage forms

("Prodrug", "Metabolism", "Metabolite" and "pharmacokinetics")

After 2000:

Advanced drug delivery systems and nanotechnologies for cancer therapy

("Insulin", "Peptide", "Liposome", "Microcapsule", "Nanoparticle", "Gene delivery" and "Cancer".)

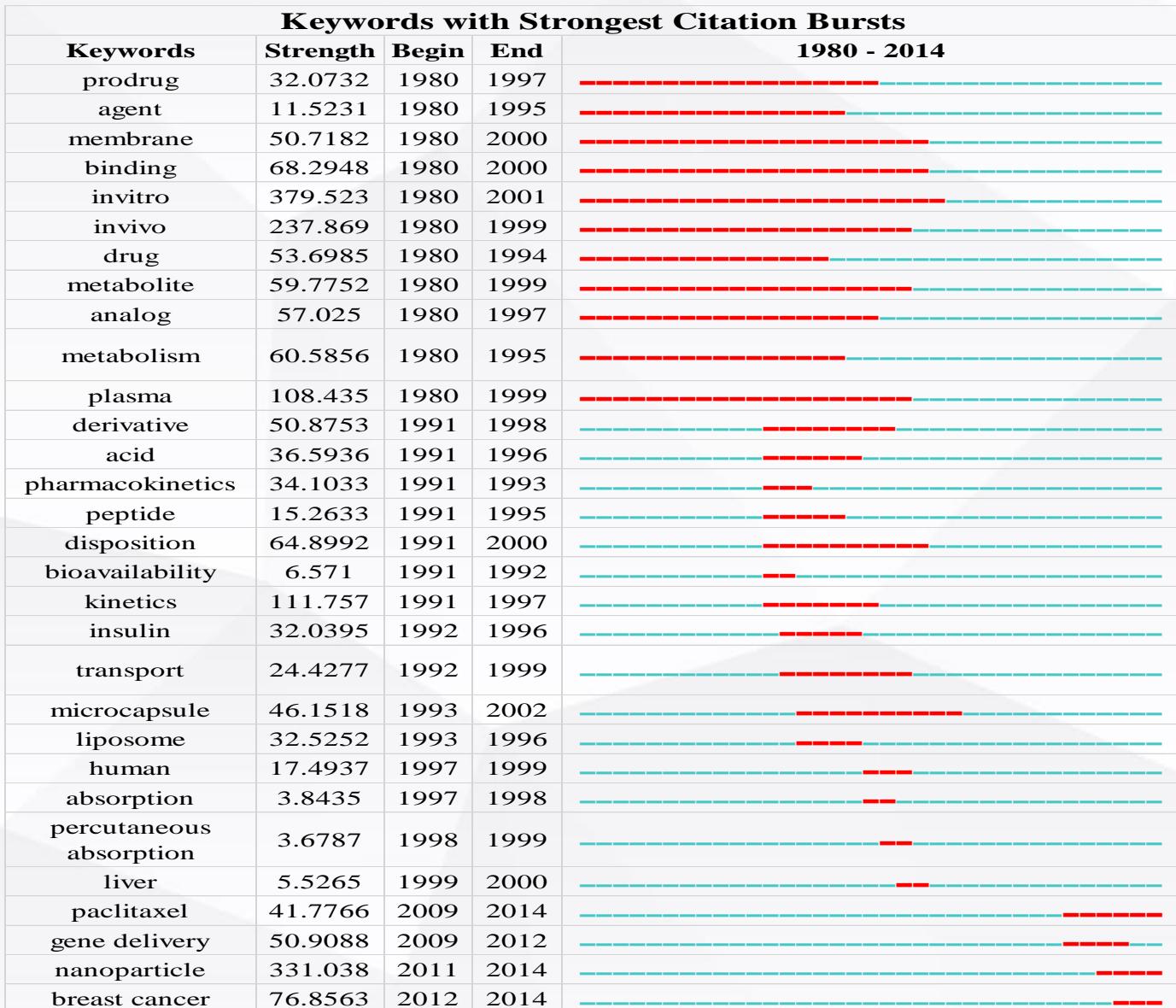


Fig. 8. The summary of keywords with citation bursts

04 Results and Discussion

Evolution of Hot Research Topics (Literatures)

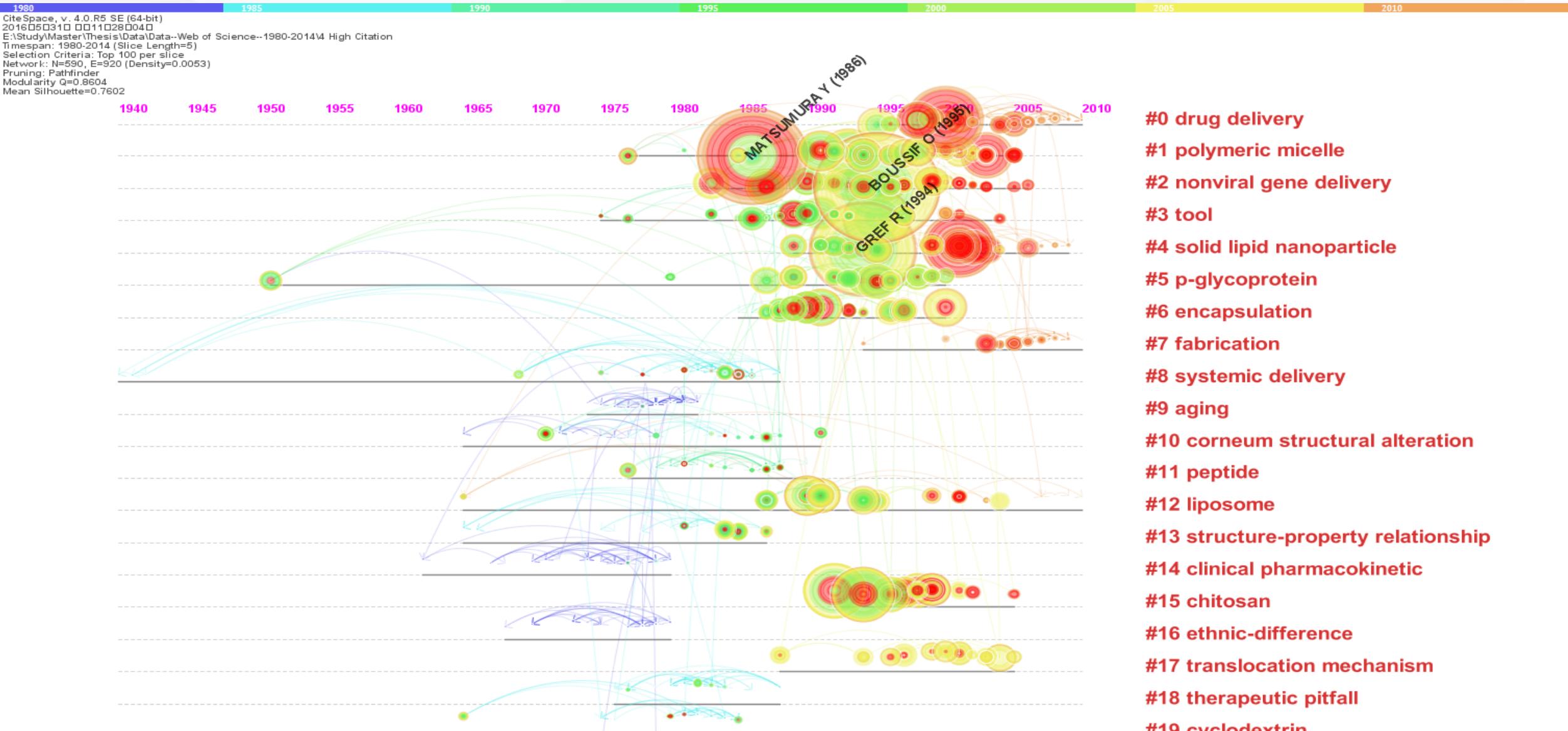
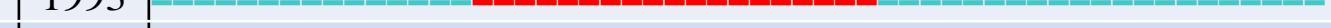
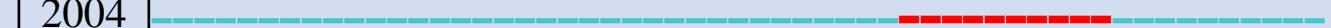
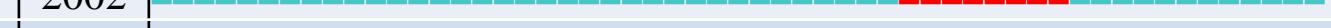
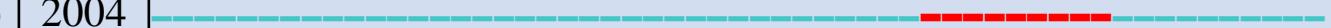
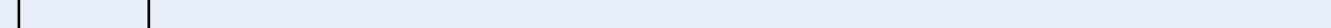
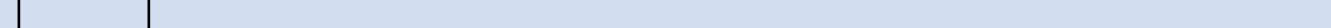
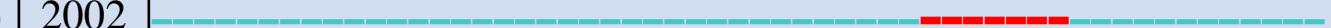
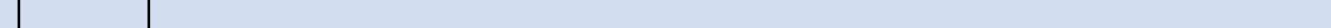
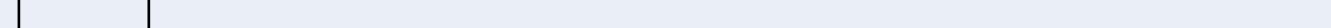
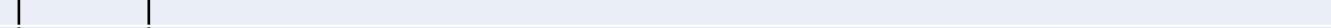
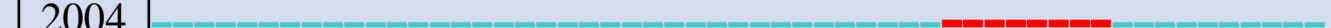


Fig. 9. Timeline view for dynamic shift on hot research topics

04 Results and Discussion

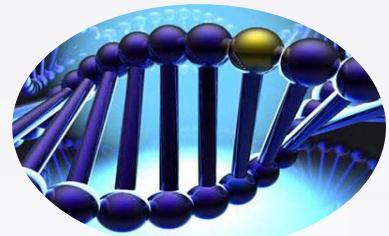
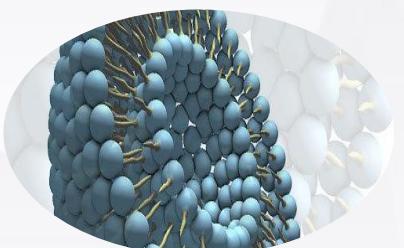
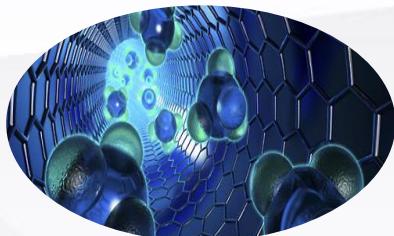
- Patents

Table 8. Top patent with strongest citation bursts

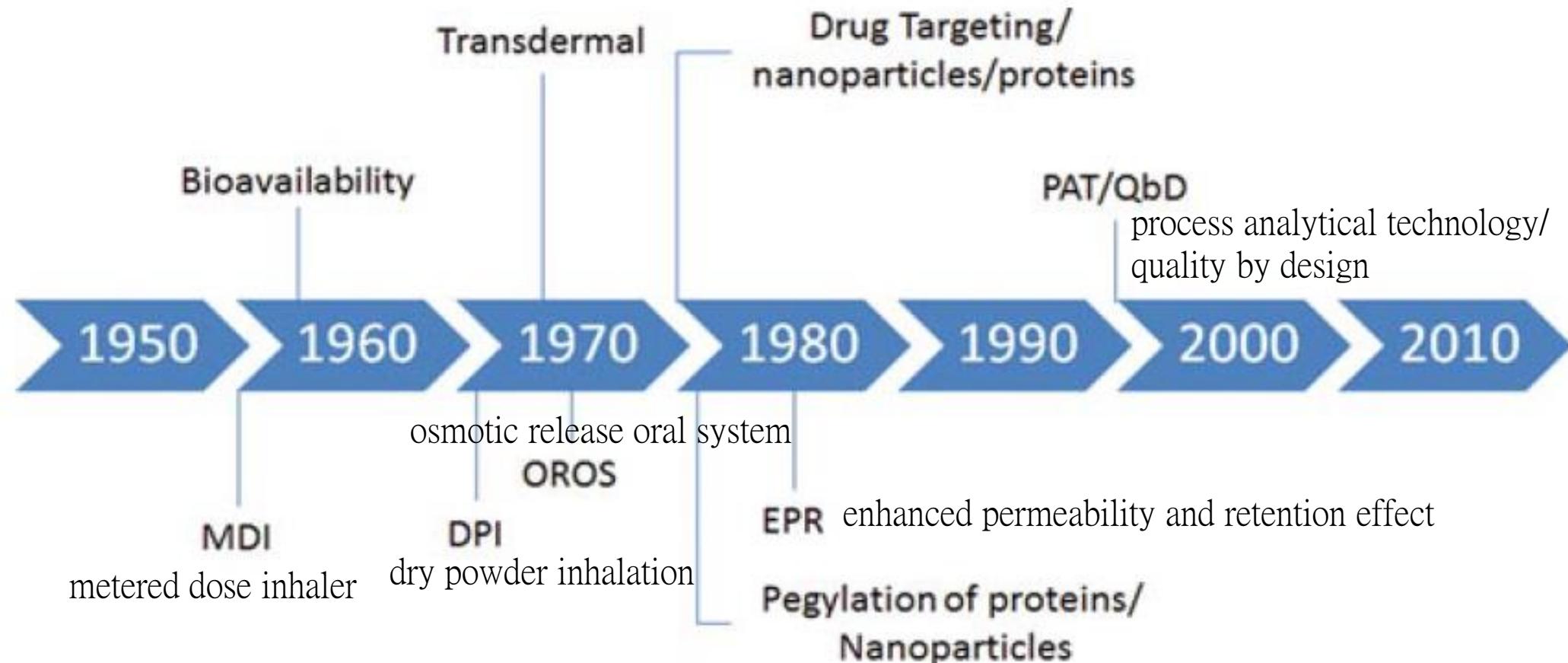
MC code and Title	Begin	End	1960 - 2014
Tablets, capsules etc (B12-M11)	1960	1987	
Tumor-inhibitor (B12-G07)	1975	1993	
Gene therapy (B14-S03)	1995	2004	
Recombinant cells (D05-H14)	1995	2002	
Antibodies (D05-H11)	1996	2004	
Cells, microorganisms, transformants, hosts, cell lines, tissue (B04-F0100E)	1996	2003	
Production of other specified wild-type protein (D05-H17A6)	1996	2002	
Tests involving nucleic acid, hybridisation probes etc. (B12-K04F)	1997	2004	
Cell or tissue culture general or unspecified (D05-H08)	1997	2004	
Biological procedures for testing (B11-C08E)	1997	2004	
Polypeptides with 31 or more alpha amino acid residues (B04-C01G)	1998	2003	
Testing for substances other than for diseases (B12-K04E)	1999	2003	
Nanoformulations (B12-M11Q)	2008	2014	
Nanotechnology (A12-W14)	2008	2014	
Drug combination (B14-S18)	2010	2014	
Controlled release (A12-W15)	2010	2014	
Patent with herbal composition (B04-A98)	2011	2014	

➤ Dynamic shift on the hot research topics

Time	1970-2000	2000-2014
Literature	<ul style="list-style-type: none"> <i>Drug absorption and metabolism;</i> <i>Physical methods;</i> <i>P-glycoprotein;</i> 	<ul style="list-style-type: none"> <i>Novel drug carriers (Polymeric micelle, and gene delivery system);</i> <i>Nanotechnology;</i> <i>Cancer therapy;</i>
Patent	<ul style="list-style-type: none"> <i>Conventional dosage forms;</i> 	<ul style="list-style-type: none"> <i>Cyclodextrin, solid dispersion</i> <i>Biopharmaceutics, such as gene, protein;</i>



Timeline of introduction of some key concepts and developments in formulation sciences



Part 5

Conclusion

05 Conclusion and Significance

➤ Conclusion

Current study provided a comprehensive and systematic insight to pharmaceutics field from global view in recent three decades.

➤ Significance



01

The **first global review** in pharmaceutics from multi-perspectives by scientific knowledge mapping tools



02

Qualitatively and quantitatively evaluate the research outputs to identify scientific knowledge structure and trace the evolution of the research frontiers with time



Big Data Analysis of Global Literature and Patents in Pharmaceutics and Drug Delivery Area

Thanks!

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