Italian Trade Commission

Market Report on China Biotechnology and Nanotechnology Industries

June 18, 2009

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INTRODUCTION

Objectives

This market research was conducted with two key objectives in mind:

1. Provide an overview of the nanotechnology and biotechnology industries in China, with focus on current state and key players.

2. Based on the above research and analysis, to identify potential opportunities and barriers for Italian nanotechnology and biotechnology companies and to illustrate possible market entry approaches.

Doing market research in China and our methodology

- Generally speaking, conducting market research in China is different and significantly more challenging than it is in developed countries because of 1) the size and diversity of the country; 2) lack of fully reliable centralized/official information databases; 3) constant and extremely rapid change – the whole Chinese economic system is far from being in equilibrium.

- Therefore solid market research work must be based on multiple resources and activities.

- Our methodology leverages a combination of resources/activities such as:
  - All relevant background information (client data, existing available information, etc.).
  - Secondary research (in Chinese and English), which include several different resources, from proprietary databases to access to associations or magazines, etc.
  - Extensive primary research, which include access to external business network, interviews with experts and key insiders, possible visits to trade show or selected companies, etc.
  - Collective China knowledge/sector expertise/market research expertise with hundreds of research projects executed in and outside China.

This survey

- Although the nanotechnology and biotechnology (here thereafter "*nanotech*" and "*biotech*") industries are still at a developing stage in China, they already have applications in dozens of related industries.

- Because the nanotech and biotech "industries" in China are actually comprised of dozens of sub-sectors of other industries, for the sake of this Market Report, the definitions of nanotech and biotech are as per Appendix A1.

- In addition, definitions of key biotech and nanotech-specific terminology can be found in Appendix A2.

- While biotech is recognized as an "official" industry in China and is defined explicitly by the Chinese *Ministry of Science and Technology*, nanotech is not recognized as such.

- Unlike in other countries, there is no one *overall national* industry association for either industry (though there is a national biomedicine association, a subset of biotechnology), and no official definition of the nanotech industry in China.

- Any market size estimate of these industries will depend heavily on the definition used; therefore, estimates of their market size vary greatly due to differences in definition.

Database of key players

- An excel database with contact information of ~100 key players (50 in each industry) including *companies, universities, research centers*, and *industrial parks* are provided in a separate appendix – all contacts have been verified one by one and are valid as of June 2009.

Format of this report

- The report is organized in such a way to provide different level of details in different places – executive summary, overviews, and paragraphs in the body of the report, summaries, and appendices; we have also used bullet points throughout the entire report to make reading easier.

Information Sources

- Key sources of information for this report include various secondary sources (including the *Chinese Ministry of Science and Technology, Shanghai Nanotechnology Association*, and the *National Engineering Research Center for Nanotechnology,* and others*);* primary research with several interviews carried out with industry players, industry experts, government bureaus, research centers, industrial parks, our ongoing analysis of all key facts and data collected.

- In the report, sources are mentioned for charts, tables and key data; secondary sources include dozens of Chinese sources (news reports, magazines, publications, government statistics, etc.) as well as several English sources such as *Nature*, *Forbes*, Interfax-China, *UCSB Center for Nanotechnology in Society*, OECD, and the *World Intellectual Property Organization*, as well as all companies' web sites, press releases from various magazines, etc.

- Ongoing analysis and re-elaboration of all data collected is key to cross-check data and information and identify key trends and industry dynamics.

EXECUTIVE SUMMARY

China biotechnology industry

- China's biotech market is expected to reach a value[1] of US$85 billion by 2010.
- Growth of the biotechnology industry in China has long been seen as strategic by the central government and is included in China's core economic development plans, e.g. *11th Five-Year Plan* (2006-2010)
- Biotechnology applications can be divided into five categories (which are all targeted sectors for growth under the *11th Five-Year Plan)*: *biomedicine, bioagriculture, industrial biotechnology, bioenergy,* and *bioenvironment*.
- Of these five categories, *biomedicine* is one of the most important and fastest growing.
- Currently, biotech products are mainly used by the *pharmaceutical* industry, followed by the *food*, *chemicals*, *plastics*, *textiles*, and *paper* industries.
- The following table provides an overview of the key players in the biotechnology industry in China:

Table: Overview of key players in biotechnology industry in China

Type	Description	Level of technology	Examples
Universities / Research Institutes	• Over 200 research centers • Mainly centered around Beijing and Shanghai	• Most primarily focus on biomedicine, followed by bioagriculture and industrial biotech	• *Shanghai Research and Development Center of Industrial Biotechnology* • *SINOPHARM*
Foreign Companies	• ~200 foreign-invested companies • Mainly large MNCs • Increasing number of SMEs	• High internal R&D & innovation ability • Generally bring advanced / high-end technologies • Range of products / tech	• *Novozymes* • *MicroPort Medical* • *Genzyme* • *Monsanto*
Chinese Companies	• Over 1800 companies • Leading companies are SOEs • Most are small SMEs	• Generally low internal R&D and innovation ability • Produce more low and mid-value products • Range of products / tech	• *China National Biotec Group* • *Hualan Biological Engineering Inc* • *Shanghai Kehua Bio-engineering (KHB)*
Industrial Parks	• Over 24 national bases • Most biotech companies located in industrial park • Aim to attract and incubate biotech companies	• Range of specialization	• *Shanghai Zhangjiang Hi-Tech Park* • *Suzhou New & Hi-tech Industrial Development Zone* • *Zhengzhou Biomedicine Industrial Park*

Source: JLJ analysis based on multiple sources, including relevant industry associations, Ministry of Science & Technology

[1] "Value" for the biotech industry in this report is defined as sales of biotech products, as sales are recorded in government statistical data

- The various players have different roles along the biotech value chain.
  - *Research centers* (both in universities and government-sponsored research institutes): generally focus on basic research, and do not produce products
  - *Biotech companies*: commercialize basic research into marketable applications / products
  - *Industrial parks*: attract investment according to government incentives and policies; also act as incubators for SMEs
- F*oreign companies* are generally bringing more advanced technologies and applications and are increasingly partnering with key domestic players in both the public and private sectors.
- Examples of cooperation include *joint ventures* with publicly-funded research centers and *biomedicine distribution* agreements with Chinese distributors.
- China's overall level of biotechnology research, particularly innovation, is still behind that of advanced countries like the US, Japan, and Western Europe.
- However, the *India, China & America Institute* forecasts that China will surpass the US as the world's leading biotech nation within the next 20 years.
- Industry development is mainly driven by government support for basic[2] research in research centers, though marketable applied research has also become increasingly important.
- However, biotech companies that commercialize innovations have been the focus of recent government initiatives such as the establishment of the *Growth Enterprise Board* to create a strong environment for innovation.
- Biotech industry development will be influenced by growing demand for biotech products, increasing government support, and trends toward globalized R&D (Research & Development)

China nanotechnology industry

- China has one of the fastest growing nanotechnology markets in the world, estimated to reach a value[3] of US$ 31 billion by 2010.
- Although China is a leading nanotech researcher and producer of *nanomaterials*, the Chinese nanotech industry is relatively weak in commercializing basic research and in production of *nanodevices*[4].

[2] Basic research is undertaken simply to expand knowledge; there is no obvious or immediate commercial value to the resulting discoveries, as opposed to applied research.
[3] "Value" here refers to industry output value, as government statistical data does not cover product sales
[4] *"Nanomaterial"* and *"nanodevice"* defined in Appendix A1 and A2

- Nanotech products (*nanomaterials*) are primarily used in the *microelectronics*, *textile*, *cosmetic*, *pharmaceutical*, *construction* material, and *food* industries.

- In recent years, China has focused on the application of nanotechnology in *advanced materials*, *IT & communications*, *energy*, *environmental protection*, *medical & health care*, and *agriculture*.

- The following table gives an overview of the key players in the nanotechnology industry in China:

Table: Overview of key players in nanotechnology industry in China

Type	Description	Level of technology	Examples
Universities / Research Institutes	• Over 70 major centers • Conduct 90% of research • Mainly centered around Beijing and Shanghai	• Range of research, but most emphasis on nanomaterials • Regional variations in type of research	• *National Center for Nanoscience and Technology (NCNST)* • *China National Academy of Nanotechnology & Engineering (CNANE)*
Foreign Companies	• 80-100 foreign-invested companies • Mainly large MNCs • Increasing number of SMEs	• High internal R&D & innovation ability • Generally bring advanced / high-end technologies • Stronger emphasis on nanodevices	• *Applied Materials* • *Anson Nanotechnology Group* • *Physik Instrumente (PI Shanghai) Co.*
Chinese Companies	• 700-900 companies • Most are SMEs • A few are members of large groups	• Generally low internal R&D and innovation ability • Strong in nanomaterials, but weaker in nanoelectronics, nanodevices, and nano-biomedical	• *Shenzhen Nanotech Port Company, Ltd.* • *Shanghai Huaming Hi-Tech (Group) Co., Ltd.* • *Advapowder Nanotechnology Co*
Industrial Parks	• 5-10 national industrial parks • Mainly located in Shanghai and Jiangsu province • Aim to attract and incubate nanotech companies	• Range of specialization	• I*nternational Nanotech Innovation Park (SIP BioBay)* • *Nanotechnology Industrialization Base of China*

Source: JLJ analysis based on multiple sources, including relevant industry associations, Ministry of Science & Technology

- Key players in nanotech generally have the same roles as their counterparts in the biotech industry, with *research centers* conducting basic research, *nanotech companies* commercializing research and producing marketable applications, and *industrial parks* seeking to attract investment and SME growth.

- *Foreign nanotech companies* tend to bring more advanced technologies and are comparatively stronger than their Chinese competitors in *nanodevices*.

- Development of the industry is primarily driven by government support for basic research done in research centers.

- However, emphasis is shifting from basic research to marketable applications and increasing cooperation between Chinese and foreign nanotech players

- Nanotechnology research centers often partner with foreign and domestic nanotech companies to commercialize their innovations.

- Overall, the nanotech industry in China is less developed and less organized than the biotech industry, due to its later start in government-sponsored basic research and in commercialization.

- As biotech and nanotech can be combined in a variety of industries, it is quite common for industrial parks and research centers to focus on both.

Regulatory environment

- China's government has targeted biotech as a strategic industry for growth and has issued several regulations to guide industry development.

- These regulations mainly concern genetic-engineering applied to *agriculture*, *animals*, and *people*.

- There are comparatively fewer regulations related to the nanotech industry, which are mainly standards by which to gauge whether a product is truly a nanotech product or not.

- China generally welcomes foreign investment in both biotech and nanotech, though policies can differ for specific products, e.g. development of human stem cells is prohibited.

- China has a large body of general IPR[5]-related legislation and is party to several international IPR agreements; however, historically, enforcement has been the weak link

- Although enforcement remains inconsistent, China's IPR situation has been steadily improving in recent years, also due to international pressure

- Several biotech-specific IPR laws have been passed, covering biotech applications in *food*, *medicine*, *energy*, and *environment*.

- While China currently lacks nanotech-specific IPR legislation, nanotech-related IPR issues are still covered under a large body of general IPR laws and the government has become more aware of IPR issues in this industry.

[5] IPR: Intellectual Property Rights

- While IPR may be a key concern for foreign entrants, it can be mitigated through several methods, including early registration of IP, proper due diligence, etc.

Considerations for Italian players

Key opportunities

- Advanced biotech and nanotech technology and applications from players US, Japan, and Western Europe players are in great demand.

- To encourage biotech and nanotech development, the central government has instituted preferential policies for high-tech foreign firms entering these fields.

- Key domestic players are quite willing to form partnership agreements with new entrants, especially ones with strong ability to innovate.

- China's US$ 586 billion economic stimulus package announced in 2008 allocated US$ 19 billion for nanotech R&D.

- Additionally, the government announced in June 2009 that it will spend US$ 9.2 billion over 2 years to accelerate the development of the biotech industry in 2009-2010.

Key challenges

- As nanotech and biotech firms rely heavily on intellectual property, China's still-developing IPR enforcement is a point of attention for new entrants.

- Although finding a local partner can be crucial in some project-based sectors (e.g. *bioenvironment*), new entrants must be careful to select the right company or organization.

- Both biotech and nanotech lack overall national industry associations, presenting a challenge to new entrants looking for both industry information and partnerships.

Practical options for market entry

- Foreign biotech and nanotech companies have several possible market entry options, each offering different level of risk/returns.

- Entry mode would depend on the company's business objectives, and it is often the case that there is no perfect solution to a specific company's objective.

- The are four (plus one) main entry methods into the China market include:

1. *Use of distributors/Agents* – simplest of all methods and used only for those players looking to distribute/sell products in China without setting up a direct presence.

2. *Representative Office* – the simplest legal setup format; it requires no capital investment but a limited in business scope.

3. *Joint Venture* – cooperative or equity Joint Ventures with a local company.

4. *Wholly Foreign Owned Enterprise* (WOFE) – multiple types exist and is determined by business scope (e.g. manufacture biotech or nanotech products, distribute/sell, or conduct R&D operations).

5. *[Acquisition of Local Company* – an option often only for larger players and with experience in M&A; needless to say, conducting proper due diligence is a must and presents significant challenges].

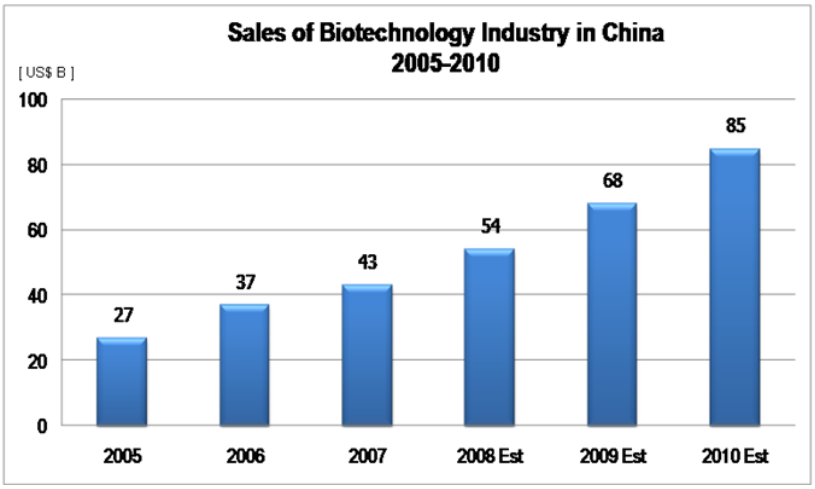
- It is essential that Italian players wishing to approach the market seek advice from a professional service provider when considering establishing a presence in China as the regulatory environment and registration process can be complex.

CHINA BIOTECHNOLOGY INDUSTRY

Market overview

- China is one of the leading biotech nations in the world, with value[6] estimated to reach US$ 85 billion by 2010 (2% of China's GDP).

  - Sales reached US$ 43 billion in 2007[7], growing at CAGR[8] of 26% since 2005.



Source: JLJ Analysis based on Ministry of Science and Technology data

  - According to forecasts from the *India, China, America Institute*[9], China will surpass the US to become the leading biotech nation within the next 20 years.

- *Biomedicine* is one of the fastest growing components of biotech product sales, with sales of US$ 10 billion in 2008, an increase of 31% year-on-year.

- The Chinese government's *11th Five-Year Plan*[10] for economic development (2006-2010) lists biotech a targeted industry for development:

  - sales of *biomedicine* are targeted to reach US$ 15 billion by 2010;

  - by 2020, the value of *industrial biotechnology* (including *bioenergy*) and related applications is predicted to reach US$ 323 billion;

  - *bioenvironmental* technologies (e.g. *bioconversion*) are targeted to add US$ 320 billion in savings by 2020 through reducing materials, water, and energy inputs used in the chemicals industry by 30% (and reduce pollution).

[6] "Value" here is equivalent to sales of biotech products, as this is recorded in government statistical data
[7] Note: 2007 was the last year statistics were released by the Chinese Ministry of Science and Technology
[8] CAGR: Compound Annual Growth Rate
[9] The India, China, America Institute is a non-profit research institute studying the rise of India and China and their impact on global markets, global resources, and geopolitics
[10] Five-Year Plan: Chinese government's core economic development plan, listing priorities for 5 year intervals

Development of the China biotechnology industry

- Modern biotechnology in China started developing in the 1980s with the introduction of government plans targeting it as a development priority.

- The biotech industry's development has since been primarily fueled by government initiatives and funding for basic research[11]totaling ~US$ 90 billion, primarily in 3 key sectors: *bioagriculture*, *biomedicine*, and *industrial biotech*.

- *Bioagriculture* development was emphasized with the *National High Technology Research and Development Plan* (also known as the "863 Plan") in March 1986.

    - Research focused on *genetic engineering, enzyme engineering*, and *molecular genetics*, especially for *agriculture* and *pharmaceuticals*.

    - Bio-agriculture research produced several key successes, including genetically modified plants such as *bollworm[12]-resistant cotton*.

- With the start of the *National Basic Research Program* in March 1997 ("973 Plan"), *biomedicine* became an increasingly important sector for research.

    - Targeted areas of research include: prevention and control of *infectious diseases*, *cardiovascular* and *cerebrovascular disease* (CCVD), *malignancy*, *stem cells*, and *protein engineering*.

    - *Biomedicine* has since become a key high-tech industry and has grown rapidly in both scale and intensification in the last 10 years.

- The latest phase of development has centered on *industrial biotechnology*; one prominent example was the introduction of polylactic acid[13] to the market in 2000.

- Biotech is seen as a strategic industry for future development, highlighted in the *National Medium and Long Term Layout of the Development of Science and Technology Program* (2006-2020) and in the *Eleventh 5-year Plan* (2006-2010).

- From 2001 to 2005, annual government spending on biotech research increased significantly from US$ 100 million to US$ 1.2 billion

- With the global economic downturn, the Chinese government announced in June 2009 that it will spend US$ 9.2 billion over 2 years to accelerate the development of biotech in 2009-2010.

[11] Note: Basic research is undertaken simply to expand knowledge. There is no obvious commercial value to the resulting discoveries, as opposed to applied research.
[12] Bollworms: moth caterpillars that destroy cotton bolls
[13] Note: Polylactic Acid is a biodegradable, thermoplastic, aliphatic polyester derived from renewable resources, such as corn starch or sugarcanes.

Key application sectors of biotechnology

- Biotech applications can be divided into 5 key sectors: *biomedicine*, *bioagriculture*, *industrial biotechnology*, *bioenergy*, and *bioenvironment*.

- The development of the biotechnology industry is a key component of the *11th Five-Year Plan*, and focus is placed on developing each of these five sectors.

- Currently, biotechnology and derivative products are mainly used by the *pharmaceutical* industry, followed by the *food*, *chemicals*, *plastics*, *textiles*, and *paper* industries.

- The following sections discuss each of the 5 key sectors and their applications.

Biomedicine

- Biotechnology is applied in the manufacture of medicines and in the diagnosis and treatment of diseases in the *pharmaceutical* and *health care* industries.

- Biomedicine began in China with the establishment of the *China National Center for Biotechnology Development* in 1983; it accelerated with the *973 Plan* in 1997.

- It is now the most organized sector of biotechnology (the only one with a national association and is also one of the fastest-growing biotech sectors:

    - biomedicine contributed an estimated US $11 billion to the biotech industry in 2008 – ~20% of total biotech value;

    - over 150 kinds of pharmaceuticals are currently being researched, and more than 20 kinds of drugs have been produced (e.g. *Interferon*);

    - additionally, 7 genetic diagnostic & therapy programs and 6 tissue engineering products are in the clinical trial phase.

- China has introduced few patented drugs to the world market – currently 90% of drugs produced in China are generic.

- As a result, the central government is pushing for increased biotechnology investment in healthcare and in pharmaceuticals.

- Additionally, the recent appearance of major infectious diseases (e.g. SARS, birdflue, etc.) has provided more reasons for the government to push for the development of new types of *vaccines*, *diagnostic reagents*, *innovative drugs* and *medical devices*.

Bioagriculture

- Bioagricutlure is mainly used by the *plant/animal feed* and *livestock* industries.
- Under the *11th Five-Year Plan*, bioagriculture development has focused on the commercialization of new *hybrid / genetically-modified crops*, and on production of *bio-fertilizers*, *feed additives*, *veterinary vaccines*, and *diagnostic reagents*.
- In July 2008, the Chinese State Council announced plans to spend US$ 3.5 billion over the next 12 years to promote the commercialized planting of three genetically modified crops – wheat, barley, and corn.
- China is already an international leader in hybrid rice and insect-resistant cotton, and has successfully genetically modified and cloned animals (e.g. ox, sheep);
- In addition to genetically modified plants and animals, China has also commercialized five new veterinary vaccines and drugs.

Industrial biotechnology

- Industrial biotechnology is used in a variety of industries, including *food, animal feed, chemicals, plastic, textiles,* and *paper* industries.
- China has focused on *enzyme* and *fermentation engineering*, *bioproduct manufacturing*.
- China is also focusing on the development of “green” processing techniques to control waste/pollution from chemical products, food, plastics, textiles, and paper.
- Traditional chemical synthesis methods have been replaced with microorganism fermentation to produce chemicals such as *polyacrylamide* and *lactic acid*.
- Citric acid is the main category of fermented organic acid produced, and China already accounts for 1/3 of world output and is the #1 exporter of *citric acid*.

Bioenergy

- Bioenergy mainly involves the production of alcohol fuel and bio-diesel, which is used in the *automotive*, *fuel*, and *chemicals* industries.
- The Chinese government has emphasized production of non-food energy crops, increasing ethanol fuel production and speeding up bio-diesel commercialization.
    - Over US$ 70 million has been invested in ethanol enterprises in *Jilin*, *Henan*, *Anhui* and *Guangxi* provinces.
    - *Guangxi* province in the south is currently being developed as the largest bio-energy production base in China.

- Production of bio-diesel leads ethanol production, with the former exceeding 3 million metric tons in 2007, compared to 1.7 million metric tons of ethanol.

- While production has been growing rapidly, ethanol production will most likely not reach the *11th Five-year Plan*'s stated target of 2 million metric tons by 2010.

- The shortfall in production is primarily due to a shortage of raw material and new government restrictions on ethanol produced through grain and other food crops.

Bioenvironment

- Bioenvironmental technology is used in the *sewage* / *waste treatment* and *environmental protection* / *preservation* industries.

- China is promoting the use of biotechnology to deal with environmental issues such as treatment of *wastewater and air pollution* as well as *decontamination* and *rehabilitation* of *industrial sites*; however application is still limited.

- Several cities in China (e.g. Wuxi and Ningbo) have adopted biotechnology to treat the recurrent water hyacinth[14] problem on waterways.

- Biotechnology has also been used to reduce industrial waste, e.g. *Shengli Oil Field* used biotech to decrease the amount of oily sludge by 70%.

Competitive landscape of biotechnology industry

Overview

- Key players in the biotech industry include *publicly-funded research institutions*, *biotech companies*, and *industrial parks*.

- *Research institutions* mainly focus on basic research and applications, while *biotech companies* are the main channels for commercialization.

- *Industrial parks* are often sponsored by local governments to create a positive environment for regional biotech development.

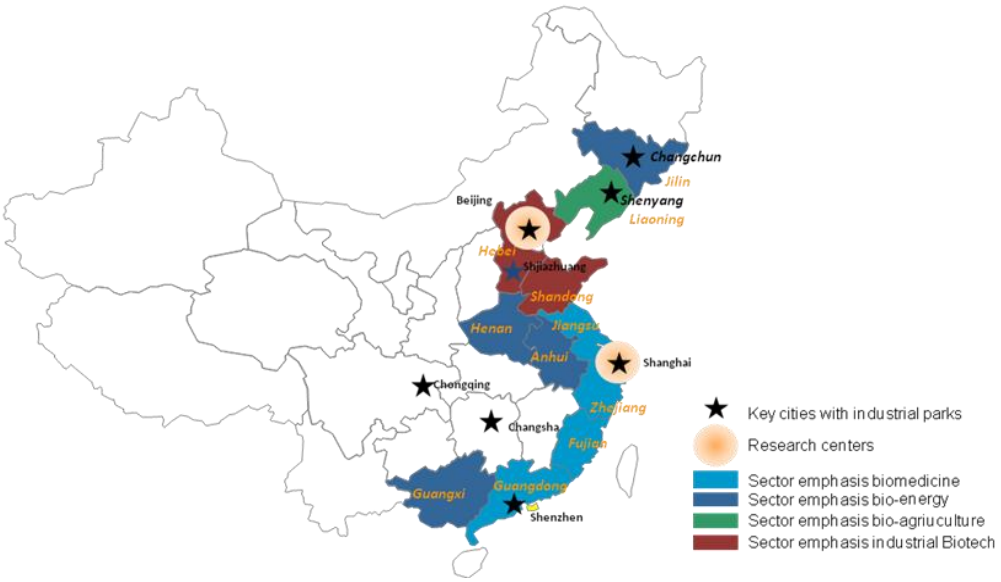
- Traditionally, China's biotech industry has been dominated and driven by publicly-funded research conducted in universities or state-sponsored institutes.

- *Biomedicine*, the most prominent biotech sector, is dominated by foreign and state-owned companies.

[14] Water hyacinth: free-floating perennial aquatic plant that reproduces rapidly, and can destroy natural ecosystems by depleting oxygen in water

- Development is mainly concentrated in the coastal regions; the following map shows the distribution of key players by geography:

China Key Biotech Players Distribution by Geography



Source: JLJ analysis based on multiple sources

Key players within biotechnology industry

Universities and Research Institutes

- Excluding private research centers, there are over 200 publicly-funded research centers in China, including universities and state-sponsored research institutes.

- 80% of research centers cooperate with companies (SOE and non-SOE) under a range of agreements, e.g. *sharing facilities, contract research, corporate sponsorship*.

- Beijing and Shanghai are the 2 key hubs of research activity.

- While each center concentrates on different research areas, most focus on *biomedicine*, followed by *bioagriculture* and *industrial biotechnology*.

- The following table shows key research centers in China, covering various areas of research and established by different organizations:

Table: Key biotech research centers in China

Name of Research Center	Location	Year Established	Established by	Key Research Areas
Shanghai Research and Development Center of Industrial Biotechnology	Shanghai	2008	*China Academy of Science (Shanghai Branch)* and *Shanghai Institutes for Biological Sciences*	Bioenergy, biomaterials, biomedicine, industrial biotech (amino acids, organic acids, enzymes)
Beijing Kaituo DNA Biotech Research Center Co., Ltd (KTDNA)	Beijing	2007	*Beijing University* and *DuPoint*	Bio-agriculture technology
SINOPHARM	Sichuan province	1965	*China Medicine(Group) General Company*	Bio-medicine
Shanghai Center for Cassava Biotechnology	Shanghai	2007	*Shanghai Institutes for Biological Sciences*, *Chinese Academy of Sciences* (SIBS, CAS), and *Swiss Federal Institute of Technology Zurich* (ETH Zurich)	Cassava and sweet potato biotechnology and applications

Source: JLJ Analysis from multiple sources

Biotechnology companies

- There are an estimated 2,000-2,500 biotech companies in China in 2009[15], having grown quickly from roughly 900 companies in 2005; most are domestic companies.

- Biotech companies are distributed across a variety of sectors, most commonly focusing on research, production, and sales in:

  - *biomedicine* (most companies): pharmaceuticals, health products;
  - *bioagriculture*: feeds and additives, veterinary vaccines;
  - *bioenergy:* fuel ethanol;
  - *industrial biotechnology*: enzyme preparation, amino acids.

[15] Estimate depends on definition of biotech industry

- Geography also tends to affect the types of biotech companies that setup there, with certain provinces attracting companies in the following sectors:
  - *biomedicine*: Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong provinces
  - *bioagriculture*: Liaoning province
  - *bioenergy*: Jilin, Henan, Anhui, Guangxi provinces
  - *industrial biotechnology*: Hebei, Shandong provinces
- Biotech companies engage in a range of activities along different parts of the value chain, with 2 primary types.
  - Some companies produce end-use products through R&D (either outsourced or proprietary).
  - Others companies provide contract services along the product development chain (e.g. early-stage research, preclinical development, clinical services, and/or manufacturing).
- While domestic biotech companies commonly cooperate with research institutes and universities in China, some have partnerships with foreign players.
  - These foreign players can be foreign-invested companies inside China or companies and universities outside of China.
  - Arrangements include joint-development of a bioproduct, licensing agreements for key technologies, or joint research centers.
- Divisions of large domestic (especially state-owned) and foreign-invested companies are more likely to have their own internal research centers.

- The following table highlights the key differences between Chinese and foreign biotech companies:

Table: Overview of Chinese and foreign biotech companies

Type	Description	Level of Technology	Key Products / Technology
Foreign	• ~ 10% of total market • Mainly large MNCs • Increasing number of SMEs • Key players: *Novozymes, MicroPort Medical, Monsanto, Genzyme*, etc.	• High internal R&D • High innovation ability • Generally bring high-end / advanced technologies	• Bio-medicine & medical device • Fermentation technology • Gene engineering • Industrial products (e.g. enzymes) • Agricultural products
Chinese	• ~ 90% of total market • Most are SMEs but a few becoming large players • Leading companies are SOE's • Key Players: *China National Biotec Group, Hualan Biological Engineering, Shanghai Kehua Bio-engineering (KHB), Anhui BBCA Biochemical*, etc	• Low R&D ability • Low innovation ability, though improving rapidly	• Vaccines, chemical drugs, generics • Traditional Chinese Medicine • Industrial products (enzyme, amino acid) • Agricultural products (e.g. fodder, pesticide)

Source: JLJ Analysis from multiple sources

- Foreign companies have a range of level of commitment to the China market, and often vary according to their sector focus.

  - Firms with lower commitment and offering products that can be easily exported often choose an export-only model, depending on a local distributor to distribute their products in China.

  - E.g. *AnaSpec* (USA) and *Carna Biosciences* (Japan) have distribution agreements with *Shanghai Universal Biotech* for their biopharmaceuticals.

  - Larger foreign-invested companies and firms specializing in technologies that cannot easily be exported have established more committed presences in China, setting up production in China and even R&D centers.

  - E.g. *Novozymes* (Denmark), has its own research center in China, and produces more sophisticated *biomedicines*, *gene chips*, *veterinary biodrugs*, and *enzymes*.

- The following table gives further details on some key biotech companies in China:

Table: Key biotech companies in China

Company	Ownership	Year Established	Location	Revenue (US$ /year)	Products
China National Biotec Group	State-owned	1989	Beijing	7 billion (2008)	• Largest producer of vaccines in China • Serum, antitoxin, Prevention drugs & preparations
Novozymes	WFOE	1994	Tianjin	7.7 billion worldwide (2006)	Enzyme preparation (food & industrial grade)
Shanghai Kehua Bio-engineering Co., Ltd (KHB)	Holding Company	1981	Shanghai	487 million (2008)	In-vitro diagnostic products (One of largest developers / manufacturers in China)
Hualan Biological Engineering Inc.	State-owned	1992	Henan province	475 million (2008)	Blood products (Research & produce)
Anhui BBCA Biochemical Co., Ltd.	State-owned	1998	Anhui province	4.8 billion (2008)	Bioenergy and biochemical products (R&D, produce)

Source: JLJ Analysis from company websites

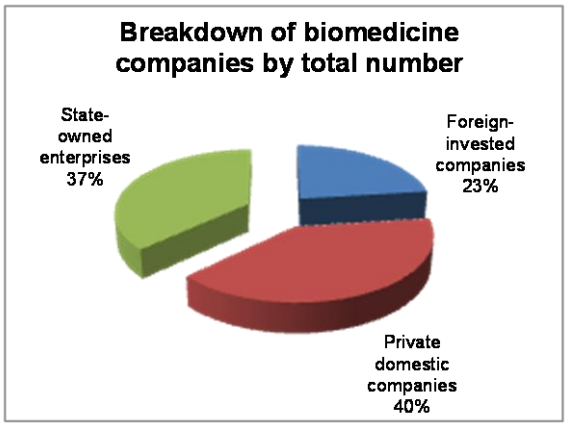
- Biomedicine producers constitute the largest and most organized group of biotech companies (the only biotech segment to have a national association).

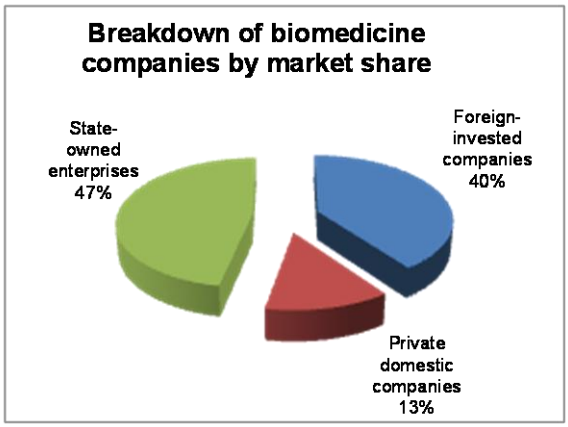
  - China has over 700 bio-medicine companies, with *foreign-invested companies* comprising 23%, *state-owned enterprises* 37%, and *private domestic companies* 40%.

  - While *private domestic companies* are the bulk of bio-medicine producers (40%), they tend to be small SME's with limited output, specializing in lower-value products, and capturing only 13% of the total market share.

  - *Foreign-invested companies* tend to be larger in scale and specialize in higher-value products; capturing a disproportionately larger share of total market share (40%).

- The following charts show a breakdown of biomedicine companies by number and by market share:





Source: JLJ analysis on multiple sources, including China Industrial Research Institute

Industrial parks

- Over 24 national biotech industry bases have been created to concentrate biotech companies and create an environment for regional biotech development.

- Most biotech companies are located in industrial parks sponsored by local governments; multiple parks can often be found in one city

- Key industrial parks can be found in major cities such as *Beijing, Shanghai, Chongqing, Shenzhen* and *Guangzhou* (Guangdong province), *Shijiazhuang* (Hebei province), *Changsha* (Hunan province), and *Changchun* (Jilin province).

- Industrial parks try to attract and concentrate biotech companies by providing benefits including: *tax/government incentives, bonded warehouse facilities, efficient government services,* and *logistics support*.

- The parks also serve as incubators for small and medium-sized biotech companies, gathering talent and resources in close proximity to research centers.

- The following table shows some of the most well-known industrial parks, encompassing a range of specialties and locations:

Table: Well-known biotech industrial parks in China

Industrial Park	Location	Year Established	Specialized Areas	Key Players
Shanghai Zhangjiang Hi-Tech Park	Shanghai	1992	• IC industry • Software industry • Biomedicine	*Kirin Kunpeng, Pfizer, Roche*
Suzhou New & Hi-tech Industrial Development Zone	Jiangsu province	1992	• Hi-tech industries • Education • Biomedicine	65 companies, e.g. *Upjohn-Suzhou Pharmaceuticals*
Wuxi (Huishan) Life Science & Technology Industrial Park	Jiangsu province	2001	• Biomedicine • Clean energy • High-tech manufacturing	*AstraZeneca, China Worldbest Group*
Zhengzhou Biomedicine Industrial Park	Zhengzhou (Henan province)	2000	• Genetically engineered drugs • Medical devices • Health products	80 companies, e.g. *Henan Puxin Bio-engineering Co*
Changsha National Biomedicine Industrial Park	Changsha (Hunan province)	2006	• Biomedicine • Traditional Chinese medicine • Health products	60 companies, e.g. *ConAgra Foods, Welman*

Source: JLJ analysis based on websites and government postings

Public-private sector interaction

- The Chinese government's dominant role in promoting the biotech industry has resulted in the development of many state-owned domestic biotech enterprises.

- Additionally, the government’s role has strengthened ties between enterprises and universities.

- Biotech companies utilize a variety of methods to cooperate with research institutes and universities, each with different levels of investment and commitment, e.g. joint R&D, outsourcing R&D, licensing technologies.

- The table below shows three common public-private cooperation schemes:

Table: Three common types of public-private sector cooperation

Format	Example
Joint Research **(Local company + Local research center)**	• *CapitalBio* with the *National Engineering Center* (Beijing) • *SinoGenoMax* with the *National Human Genomics Center* (Beijing) • Share campuses, equipment and human resources
Licensing **(Local company + Local research center)**	• *HD Biosciences* licensed core technology from the *Chinese National Genome Center* (Beijing) • *Shenzhen Chipscreen* licensed core technology from *National Engineering Research Center for Beijing Biochip Technology*
Commercial Spinoff **(Foreign company + Local research center)**	• *United Pharmaceutical* (Philippines) setup joint venture with *Institute for Life Sciences* (Shanghai) • Joint venture is now a subsidiary of *United Pharmaceuticals*

Source: *Nature Biotechnology* journal, JLJ analysis

- In cases of joint research and commercial spinoffs, the national research institute owns a share of the spin-off project.

- Through university partnerships, students have an opportunity to train in advanced research techniques applied in an industrial setting, while allowing companies to train a highly qualified workforce.

- Examples of these partnerships include:

  - employees at *Shanghai Genomics* can work toward a PhD from *Shanghai Jiao Tong University;*

  - employees at *Shanghai Genon Bio-Engineering* may earn credit toward a degree from *Tongji University* (Shanghai) and *Shanghai Jiao Tong University.*

- Players in the public sector often cooperate, e.g. universities will cooperate with local governments to set up joint research centers placed in industrial parks.

Key technologies and assessment of domestic technologies

- China's leading biotech technologies are genomics[16]-related, including *genetic manipulation, protein engineering, genetically-engineered drugs & vaccines, genetic diagnostic and therapy, functional genomics, and metabolic engineering*.

- The following table shows some of the key Chinese achievements in biotech:

Table: Key technologies and level of domestic technologies compared to international level

Technology	Application Industry	Achievements	Assessment of Technology
Genomics	Health care and agriculture	• In 1999, China joined the human genome project and was the only developing country in the group. • Many microorganism gene sequencings (e.g. vaccines, viruses, rice genome)	Close to international level
Genetic Modification	Agriculture	• Super hybrid rice yields 15%-20% more than ordinary hybrid rice • Anti-bollworm cotton and sheep cloning have reached advanced level	Advanced international level
Genetically Engineered Drugs and Vaccines	Pharmaceuticals	• 20+ drugs & vaccines on the market, more than 100 are in clinical research	Slow to innovate (90% generics)
Genetic Diagnostic & Therapy	Pharmaceuticals and health care	• Breakthroughs in anti-angiogenesis therapy and cancer immunotherapy • Clinical trials of malignancy and B-hemophilia therapies	Still in clinical trial phase
Functional Genomics & Metabolic Engineering	Industrial biotechnology	• Most research is still at the primary single-gene operation phase • Current industrial biotechnologies mainly use fermentation for production	Currently in preclinical development
Protein Engineering	Pharmaceuticals	• Achieved a series of breakthroughs and patents (e.g. Sifuvirtide for AIDS treatment, reformed TNF for rheumarthritis therapy).	Still in clinical trial phase

Source: JLJ analysis based on multiple sources

- China's biotechnology level exceeds other developing countries, but it still trails advanced countries such as the *US*, *Wetern European* countries, and *Japan*:

  - While published articles have increased every year, they currently only account for 2% of total worldwide biotech research publications.

  - However, China ranks #8 internationally for high-level articles published and patents.

  - While Chinese biomedicine manufacturing capability is quite advanced, with 8 of the top 10 biodrugs in the world manufactured in China, the country has developed few innovative biodrugs of its own.

[16] Genomics: study of an organism's genomes (full DNA sequences)

- Biomedicine market is still dominated by *biogenerics* (>90%), with novel products representing only 3-7% of this market segment.

- It is estimated that research and technology level of *bioenergy, biomaterial* and *fine chemical products* are 10 to 20 years behind developed countries.

- Many research methods and equipment employed are outdated, as the automation and testing levels of many instruments and synthesis equipment cannot meet the demanding requirements for biotech industry development.

- As a result, Chinese players are open to partnerships with foreign research centers and companies who can offer advanced biotech research and applications

Key biotechnology market dynamics and trends

The following are some of the key market dynamics and trends affecting the development of the biotech industry in China, presently as well as in the near future.

1. Growing demand for biotechnology in general, and for sub-sectors specifically

- Fueled by China's rapid development, the domestic market demand for *healthcare products* and *biomedicine* has grown rapidly in recent years.

- The government's plan to provide universal healthcare to the country's entire population by 2011, will further boost demand for biotech products.

- *Biomedicines* are increasingly in demand and are often imported, prompted by recent outbreaks of major diseases (e.g. SARS)

- However the types of drugs that can be imported into China are regulated by the State Drug Administration, which grants Import Drug Licenses (IDL) to registered foreign producers

- *Bioagriculture* is predicted to benefit from increased need for food grains, with China expected to increase grain yield by 50%–60% per hectare and introduce new genetically-modified food commodities (e.g. rice, soybeans).

2. Increasing government support for biotech research and applications

- Biotechnology development was a focus of the *11th Five-year Plan* (2006-2010) and is also expected to be a focus of the *12th Five-Year Plan* (2011-2015)

- The government has issued a series of policies to accelerate the biotech industry's development.

- One such policy is expected in late 2009, which supports clean energy sources including bio-energy and other renewable sources.

- The Chinese government is also increasing its investment in leading science and technology parks through grants and awards,

- Additionally, the government is targeting to build up comprehensive industry bases in different application industries in Beijing, Tianjin, and Hebei province, and around the Yangtze and Pearl River Deltas.

- Examples of government support include the Shanghai government offering aid to biotech companies developing new projects, as well as the establishment of China's first biotech innovation fund in 2008 by the *Bureau of Life Science & Biotechnology*, under the *Chinese Academy of Sciences.*

- Biotech SME's will benefit from the recent establishment of the *Growth Enterprise Board (GEB)* on May 1, 2009, a NASDAQ-like exchange for small high-tech companies that have low listing requirements.

3. Increased international cooperation in R&D

- With the rise of advanced information and communication networks, biotechnology research across the world has become increasingly globalized.

- As many diseases today are multifactorial disorders and differ by region and race, there is no "one medicine" that works for all cases, prompting the need for international cooperation in drug R&D.

- E.g. Shenzhen-based *Tongjitang Pharmaceutical*, *Co.* is conducting Phase 4 clinical trials of a Traditional Chinese Medicine (TCM) for osteoporosis in collaboration with *Synarc* (San Francisco, USA) and the *University of California, San Francisco*, aiming to register the product in the US.

4. Economic downturn has spurred biotech growth and innovation

- With the global economic downturn, the Chinese government announced in June 2009 an US$ 9.2 billion stimulus package (*Policies to Accelerate Biological Industry Growth*), to accelerate investment in biotech for 2009-2010.

- The policies will focus on increasing technological innovation, attracting talent, and providing fund support for key fields, and will include preferential tax policies for R&D costs for new technologies, techniques, and products

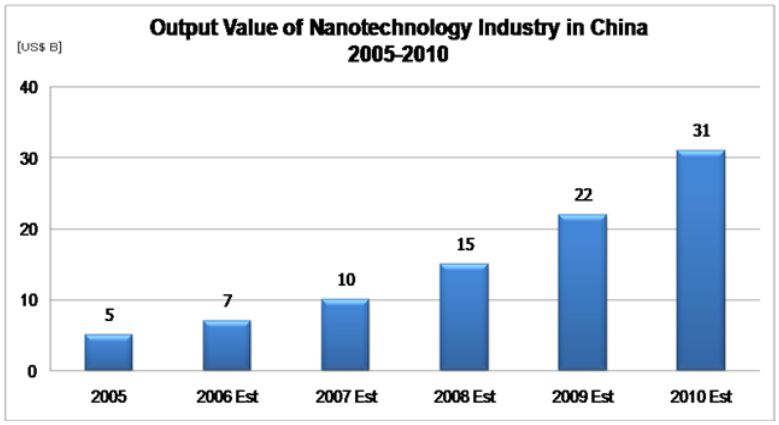
- Key sectors include *biopharmaceuticals, bioagriculture, bioenergy, industrial biotech,* and *bioenvironmental protection*.

- This plan is aimed not only aims at creating large Chinese biotech enterprises, but also focuses on promoting the growth of innovation-oriented SMEs – presenting an opportunity for innovative foreign players with advanced tech.

CHINA NANOTECHNOLOGY INDUSTRY

Market overview

- China is one of the fastest-growing nanotechnology markets in the world with value[17] estimated to reach US$ 31 billion by 2010 and US$ 145 billion by 2015.
  - This is a significant increase from output of US$ 5 billion in 2005, growing at an estimated CAGR[18] of 44% from 2005-2010.



Source: RNCOS, JLJ analysis

  - China nanotechnology market is mainly composed of the following segments: *nanomaterials*, *nanoelectronics*, *nanobiology*, and *nano-life sciences*, which together account for 70% of output
  - Remaining output comes from nano applications in *environment*, *energy*, *agriculture*, and *aviation* industries.
- Although China has become a strong international player in *nanomaterials*, it still lags behind other leading nations in more advanced applications.
- The nanotech industry has been designated as a key area for development by the Chinese government, which is the main driver of nanotech research.
  - Annual funding for basic research grew by 20% annually from 2000-2005 to reach US$ 600 million in 2007.
  - China is a prolific publisher of nanotech research, surpassing the United States in 2005 to become #1 in quantity of published articles.
  - However, most articles are focused on basic research and applications.
- Most domestic nanotech companies tend to focus solely on the China market.

[17] "Value" here is defined as industry output value
[18] CAGR: Compound Annual Growth Rate

- Adding the word *"nano"* to describe materials used in consumer products such as cosmetics, clothes, and cups has become something of a fad among Chinese companies to attract consumers and investors.

- However, consumers have become more careful about *"nano"* products, and investors are more carefully evaluating opportunities in this area.

- Globally, though not in China, consumers and investors are more concerned with the potential health risks of nanoproducts, rather than their authenticity.

Development of the China nanotechnology industry

- China's nanotech development has primarily been driven by government investment in basic research[19], in the areas of *nanomaterials*, *nanostructure inspection*, and *nanodevices*.

- The *8th Five-Year Plan* (1991-1995) listed the research of *nanomaterials* as one of the government's key projects, prompting the beginning of major investment in nanotechnology.

- The *National Basic Research Program* ("973 Plan") initiated in March 1997 continued the emphasis on basic research into *nanomaterials* and *nanostructures*.

  - Following the "973" plan, several new discoveries were made (e.g. *carbon nanotubes*, *gallium nitride nanorods*).

- Annual government expenditure on nanotech research reached US$ 600 million in 2007, increasing from US$ 400 million in 2005.

- R&D efforts became more coordinated in 2001 with the unveiling of the National *Nanotechnology Development Guideline (2001-2010).*

  - A "Nanotech Guidance and Coordination Commission" was established as well as the first national nanotech research center and industrialization base;

  - Development of nanotechnology applications was focused on the fields of *advanced materials, IT & communications, medical & health care, agriculture energy, and environmental protection*.

- Since 2001, the number of Chinese nanotech patents and innovations increased rapidly.

- In 2003 China held 12% of the total number of international nanotech patents, ranking third behind the US and Japan.

[19] Basic (aka fundamental or pure) research is undertaken simply to expand knowledge. There is no obvious commercial value to the resulting discoveries, as opposed to applied research

- The *Standardization Administration of the PRC (SAC)* released standards in 2005 to judge if a material truly uses nanotechnology – an important consumer protection project.

- In 2006, China surpassed the US to become #1 in quantity of publications, though the quality and depth of research still lags behind the US and Japan.

- Also in 2006, China's State Council released its *National Long Term Layout of the Development of Science and Technology Program* (2006–2020), highlighting nanotech as a major field for R&D in China's development plans.

- While most nanotech achievements came from government efforts, private nanotech companies began contributing to industry development after 2000.

Key application sectors for nanotechnology

- China's nanotechnology industry is still heavily focused on basic research with weak application and commercialization – only 5% of laboratory research is transformed into scalable products.

- Currently, nanoproducts are mainly *nanoscale powders* of diverse materials (e.g. oxides, metals, carbon nanotubes, fullerenes, etc) used in *coatings, fibers, fabrics, paper, ceramics, catalysts*, and in *nanomedicine*.

- Nanoproducts are mainly used in the *microelectronics, textile, cosmetics, pharmaceutical, construction material,* and *food* industries.

- *Nano functional powder* has been increasingly adopted for use in the textile industry, with the largest clothing manufacturers and 6 of the top 10 domestic underwear producers using it.

- Of the fields emphasized in the *National Nanotechnology Development Guideline*, China has made progress in several areas, including:

  - ***Advanced materials***: China has seen notable developments in light weight and high-strength materials applied in the *transportation* industry and functional materials applied in *IT, construction and health care* industries.

    - E.g. A type of heat insulation nanomaterial was used in the nano painting displayed at the 2008 Olympic stadium.

  - ***IT & communications***: heavy focus on nanostructures and nanodevices for use in *chips, sensors*, and *regulators*.

    - E.g. Some Chinese companies have signed contracts with international players to manufacture nano chips in China.

- ***Medical & health care***: goal is to combine nanotechnology, biotechnology, biomedicine and traditional medicine to develop nano-bio medicines that can detect, diagnose, and target diseases for treatments.

  - E.g. A new disinfectant was developed using nanotechnology to kill the SARS virus in one minute.

- ***Energy***: focus on products such as *catalysts, detergents and combustors* that can improve the energy utilization rate.

  - E.g. Nanotechnology has been used in the development of agents for diesel fuel and gasoline to improve combustion.

  - China is also actively researching nanostructured materials for energy transformation.

- ***Environmental protection***: to prioritize air cleaning and water cleaning by using *nanofiltration* technology or *nanocatalysts*.

  - E.g. the photocatalyst TiO_2 has been recognized for its effect on polluted air treatment.

  - TiO_2's treatment of hazardous compounds has been successful in laboratory tests; it is expected to be used to treat polluted rivers and wastewater.

- ***Agriculture***: goal is to improve the ability of plants to resist diseases and insects, and to adapt plants to their environment.

  - E.g. Nanofertilizer has been used since 2005 to improve crop yields while not damaging the soil or water.

Competitive landscape of the nanotechnology industry

Overview

- Around 70 major research centers (*universities* and state-sponsored *research institutes*) are engaging in nanotechnology research.

- Additionally, there are an estimated 800-1000[20] *nanotech companies* focusing on commercialization of nanotechnology.

- Over 90% of research (particularly of *nanomaterials*) is conducted in university research centers and in state-sponsored research institutes.

[20] Estimate based on multiple sources. Because nanotechnology is still a developing industry in China, no national industry association exists, and government bureaus do not track number of players (as the industry is not defined)

- Public and private companies (e.g. SOE[21] and non-SOE) only contribute less than 10% to overall research.

- *Industrial parks are* set up by local governments or jointly with foreign investors to geographically concentrate nanotech companies.

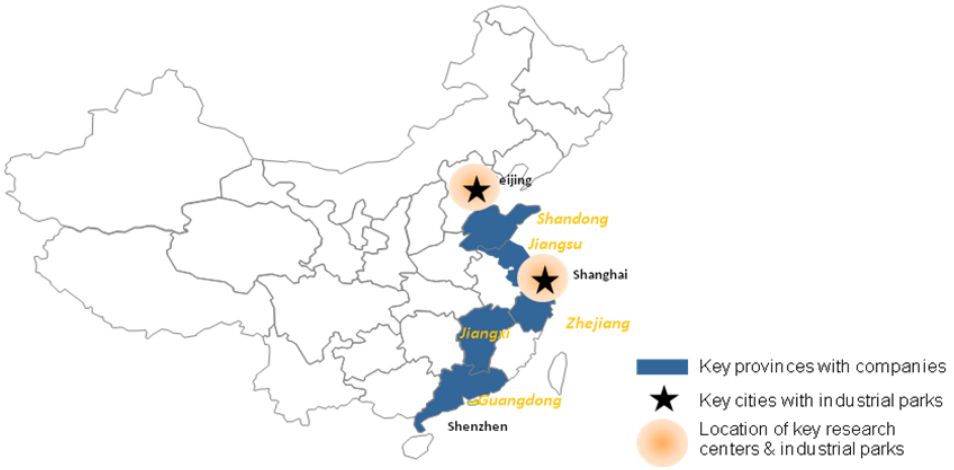
- These industrial parks are usually located near research centers, with which companies often cooperate to bring their research to market.

- About 80% of research centers and companies are concentrated in either North China (centered around Beijing) or in East China (centered around Shanghai).

- In addition, Shenzhen in southern Guangdong province also has major concentrations of nanotech R&D activity.

- The following map shows the geographic distribution of key nanotech hubs:

China Key Nanotech Players Distribution by Geography



Source: JLJ analysis of multiple sources, including China National Academy of Nanotechnology and Engineering (CNANE)

[21] Note: SOE = State Owned Enterprise

Key players within nanotechnology industry

Universities and Research institutes

- Prominent research centers (both university-sponsored research centers and state-sponsored research institutes) are concentrated near Beijing or Shanghai.

- Research centers in Beijing tend to focus more on the more academically-oriented basic research.

  - Top universities include: *Tsinghua University*, *Peking University*, *China University of Science & Technology*, and *Tianjin University*.

  - Prominent research institutes include: *Chinese Academy of Science* (several divisions), *China National Center for Nanoscience and Technology*, and *China National Academy of Nanotechnology & Engineering*.

  - Basic research topics include: carbon *nanotubes*, *nano-magnetic liquid material, nano semi-conductors, high-polymer nano composite material, nano functional coating, and nano functional membranes*.

- On the other hand, research centers around Shanghai tend to focus more on applied research.

  - Top universities include: *Fudan University, Shanghai Communications University, Tongji University, East China University of Science, and Zhejiang University.*

  - Prominent research institutes include: *National Engineering Research Center for Nanotechnology*, and divisions of the *Chinese Academy of Science*.

  - These research centers primarily focus on applications of nanotechnology and commercialization of research in *nanopharmaceuticals*, *nanoelectronics*, *nanomechanics*, *nanobiology* and other *nanomaterials* and *nanodevices*.

- The most prominent national research institutes are collaborations between various stakeholders.

  - The *National Center for Nanoscience and Technology* (NCNST) was established by the *Chinese Academy of Sciences*, *Tsinghua* and *Peking Universities*.

  - The NCNST focuses on basic and applied research in a wide range of *nanomaterials*, *nanodevices*, and *nanoproducts*.

  - The *China National Academy of Nanotechnology & Engineering* (CNANE) was founded by the national *Ministry of Science and Technology*, *Chinese Academy of Sciences*, and the local Tianjin government.

- The CNANE primarily serves as an industrial park, research institute, and product testing center.

- Large national universities and research institutes are well-funded and state-owned, and they often cooperate with foreign research institutes and large foreign-invested companies.

  - E.g. *CAS Suzhou Nanotech and Nanobionics Institute,* which has a research cooperation agreement with the *Finnish National Technological Resource Center.*

  - Another example is *Anson Nanotechnology Group*, an HK-invested company based in Guangdong province, which cooperated with the *Chinese Academy of Medical Sciences* to setup a nanotechnology R&D fund.

  - *Anson* also invested US$ 25 billion to set up research centers in Shanghai with the *Chinese Academy of Science.*

- While large national-level universities and research institutes have nanotech research centers that are well-funded by the government, smaller universities have to find other funding – often cooperating with private enterprises.

- Regional / less prestigious universities tend to collaborate with local nanotech enterprises or foreign multinationals based nearby, e.g. *Essilor* (France) and *Shanghai University.*

- As a result, these smaller universities have become an important source for applied research.

- The following table shows key nanotech research centers representative of the diverse funding and research models employed.

Table: Key nanotech research centers in China

Research Center	Location	Year established	Established by	Key research
National Center for Nanoscience and Technology (NCNST)	Beijing	2003	Chinese Academy of Sciences (CAS), Tsinghua & Peking Universities	• Nanoprocessing and nanodevices • Nanomaterials • Nanostructures • Nanomedicine
China National Academy of Nanotechnology & Engineering (CNANE)	Tianjin	2005	Ministry of Science & Technology, CAS, local government	• Nano-particle drug • Nano-particle precise classification • Nano-optics • Nanofilters applied in sewage processing
Shanghai Nanotechnology Promotion Center (SNPC)	Shanghai	2001	Shanghai municipal government, National Development and Reform Commission, local enterprises	• Environmental issues • Coordinates efforts across 7 university campuses & with 9 private enterprises
Suzhou Institute of Nanotech and Nanobionics (SINANO)	Suzhou (Jiangsu province)	2005	CAS, Jiangsu provincial government, Suzhou city government	• Nanodevices and related materials • Nano-biotech and nanomedicine • Nanobionics

Source: JLJ analysis from multiple sources, including research centers

Nanotechnology companies

- It is estimated that the number of nanotech companies in China has grown to about 800-1000 in 2009 – a significant increase from ~300 companies in 2001.

- Nanotech companies are mainly located in *Beijing* and *Shanghai*, but strong concentrations exist in *Jiangsu*, *Zhejiang*, *Shandong*, and *Guangdong* provinces.

- Over 90% of nanotech companies are domestic companies, of which 95% are small SMEs.

  - The majority of the companies (80%) focus on production of *nanomaterials*, primarily *nanooxide*, *nanometal powder*, and *nano compound powder*.

- The remaining domestic companies focus on nanotechnology research and applications in consumer products such as daily *cosmetics* and *paint*.

- Less than 10% are foreign-invested companies, which typically prefer Shanghai as the first place to invest.

- Foreign companies tend to focus on commercializing *nanodevices* (e.g. sensors, healthcare detectors, storage, and display devices) and *nanobiology* (e.g. DNA and protein chips, nanoscale tools for early diagnosis) – higher value items.

- The following table highlights the key differences between Chinese and foreign nanotech companies:

Table: Overview of Chinese and foreign nanotech companies

Type	Description	Level of technology	Key products
Foreign	• < 10% of total companies • Primarily in Shanghai • Mainly large MNCs, increasing SMEs • Key players : *Applied Materials*, *Physik Instrumente (PI Shanghai) Co., Anson Nanotechnology Group*	• Relatively advanced especially in nanodevice & semiconductor	• Nanomaterials: chiral drugs, nano-photocatalysis material, • Pearlescent pigment, coating material • Semiconductors • Textiles & instruments
Chinese	• > 90% of total companies • A few are members of a large group • Most are SMEs • Key players: *Shenzhen Nanotech Port*, *Shanghai Huaming Hi-Tech*, *Advapowder Nanotechnology*	• Mature in nanomaterials • Weaker in nanoelectronic, nanodevices and nano-bio medical	• Nanomaterials: metal powder, nanotubes and anti-bacterial material

Source: JLJ analysis, company websites

- Two examples of key players include:

  - *Applied Materials Inc.,* the world's largest nanotech semiconductor producer, invested US$ 255 million to set up its global R&D center in Xi'an.

  - *Shenzhen Nanotech Port Company, Ltd*. has successfully created commercial spin-offs of conductive and anti-corrosive coatings for oil tanks.

- Several foreign commitments have made larger-scale commitments to the China market, establishing production and even setting up joint research centers with local players.

- However, not all companies have used the same market entry model.

- Some smaller players, and those with products that can be easily traded, have chosen to enter China through distribution agreements with local distributors.

- E.g. *Energy Release Products Corporation* (USA) distributes its nanotech surface conditioner product through *Beijing Erchina Venture Technology*.

Industrial parks

- Only 5-10 nanotech industrial parks have been established in China – besides the *National Nanotechnology Industrial Base* in Tianjin, they are mainly located in Shanghai and Jiangsu province.

- While most industrial parks focus on attracting investment and incubation for nanotech companies, most nanotech companies are not in industrial parks, as most of these parks are newly constructed and are focused on research.

- However, the central government is aggressively pushing to accelerate the growth of the nanotech industry by helping to fund and promote new parks.

    - A famous example includes the *International Nanotech Innovation Park* in Suzhou (near Shanghai), which began construction in 2007 – the third national-level innovation park.

    - The aim of this park is to create an internationalized innovation platform and technology incubator for nanotechnology, with the help of the Singaporean and Finnish governments and their research centers.

    - The park is the largest nanotech industrial base in China, with estimated annual output of over RMB 10 billion (~US$ 1.5 billion).

- In addition, some state-sponsored research institutes such as the *China National Academy of Nanotechnology & Engineering* (CNANE) are also planning to establish their own industrial parks.

    - CNANE is a state-sponsored research institute that is already an industrial base, research institute and product inspection center.

    - Plans to start a nanotech association (along with its 4 subsidiaries as main members) and is on track to officially announce the creation of a new nanotech park by end of 2009.

    - When completed in 2011, this new nanotech industrial park should offer access to both strong nanotech research and development facilities.

- The table below lists some of the key nanotech industrial parks in China:

Table: Key nanotech industrial parks in China

Industrial Park	Location	Year Established	Specialized Areas	Key players
International Nanotech Innovation Park (SIP BioBay)	Suzhou (Jiangsu province)	2007	Comprehensive R&D and incubation services for biotech and nanotech companies	Now have 100 biotech and nanotech players, e.g. *PegBio Co*., *Suzhou Institute of Nano-tech and Nano-bionics* (SINANO)
Nanotechnology Industrialization Base of China (main body is China National Academy of Nanotechnology & Engineering - CNANE)	Tianjin	2001	Basic nanotech research and applications: • Nanoparticle drugs • Nano-optics • Nano-filtering for sewage processing	4 subsidiaries of CNANE
Zhongguancun Yongfeng High-Tech Industrial Base	Beijing	2001	"New materials" including nanomaterials	Mainly domestic electronics and advanced material companies

Source: JLJ analysis on multiple sources

Public-private sector interaction

- Over 80% of local Chinese nanotech companies collaborate with universities or research institutes – either in China or abroad.
  - Collaboration models include: joint research centers, sharing of facilities, sponsorship arrangements, contract research, technology licensing agreements, or commercial spin-offs.
  - By outsourcing, companies save on R&D costs while gaining access to new research progress; research centers can obtain funds and see their research brought to market – a "win-win" cooperation model.
- However, cooperation between domestic companies and foreign research centers is still relatively uncommon, as they have few commonalities.
  - On one hand, domestic companies mainly focus on *nanopowder* and *coatings,* lower-value technology derived research from domestic research centers
  - Foreign research centers, on the other hand, mainly focus on new and more advanced technology research and development.

- The table below shows the most commonly found cooperation schemes

Table: Common types of public-private sector cooperation

Format	Example
Licensing **(Local company + Local research center)**	• *Shanghai Huaming Hi-Tech (Group) Co., Ltd.* licenses core technology from *East China University Of Science*
Joint Research **(Foreign company + Local research center)**	• *Shanghai University* cooperated with *Essilor*, a large ophthalmic product manufacturer from France, to develop high performance materials by setting up joint R&D center in China

Source: JLJ analysis on multiple sources

- Both local and foreign players, however, are often brought together to participate in large, state-level projects organized by the central government.

- However, these cooperative projects are still mainly focused on basic research.

- E.g. the *Shanghai Ministry of Science & Technology* cooperated with the *US Department of Energy* to research the application of carbon nanomaterial in lithium batteries and fuel cells; some innovations later transferred to enterprises.

Key technologies and assessment of domestic technologies

- China is strong in basic nanotech research and is a leader in *nanomaterial* research and application and *single atom operation*.

- However, China is still relatively weak in *nanodevice* research and applications.

- Chinese researchers have so far accomplished much in the assembly, characterization and manipulation of *nanostructure* and *functional nanomaterials*.

- In addition, they have also produced several achievements in nanodevices; some key examples are included in the table below:

Table: Key technologies & level of domestic technologies compared to international level

Category	Key Achievements	Application Industry	Assessment of Technology
Nanomaterial	Gallium nitride nanorod in 1997 (chemical vaporous depositon) - *Tsinghua University*	Display electronics, semiconductor	Strong and even leading in some material research
	Aligned carbon nanotube array in 1998 - *Chinese Academy of Science (CAS)*	Electronics, optics and other fields of materials science	
	One-dimension nanowire and nanocable in 1998 - *CAS* (carbothermic reduction, Sol-Gel process combined with Droplet Epitaxy)	Electronics	
	Nano-diamond made in 1998 (catalytic thermal treatment) - *China University of Science & Technology*	Construction material, oil industry	
Nanodevice	MOS device (100 nm) - *Tsinghua University*	Electronics, semiconductor	Behind international level
	Semi-conductor quantum dot laser (0.7-2.0um) - *CAS*		
	Bistable membrane for memory unit - Shanghai *Fudan University*		

Source: JLJ Analysis

- In addition, nanomaterials have also been applied to biology and life science, such as *pharmaceuticals* and *therapy*.

- Chinese researchers have made several advances in the assembly, characterization, and manipulation of *nanostructures* via a “bottom up” process (building up from the atomic/molecular level).

- China is one of the top 3 countries in quantity of nanotechnology research papers published (along with the United States and Japan).

- However, great gaps exist between China and international leaders in the number of nano technology patents and end-products.

- Nanotechnology products in China today are still mainly dominated by nanomaterials – around 80% are metal and *organic non-metallic nanomaterials* with low levels of sophistication.

- In terms of more sophisticated and higher-value *nanoproducts*, China still lags far behind the US and Japan, especially in *nanodevices* and *applications*.

- China is still weak in *design* and *fabrication* of *nanodevices* due to incomplete “top down” techniques based on existing micro-fabrication processes.

- The central government has recognized the need to expand beyond *nanomaterials* and to promote *nanodevices* and *applications*.

  - The *National Nanotechnology Development Guideline* (2001-2010) only regards the past emphasis on *nanomaterials* as a short-term goal.

  - The development of more advanced applications such as *nanobiotech, nanomedicine, nanoelectronics* and *nanodevices* is the true goal in the medium and long-terms.

- Therefore, key Chinese players are open to partnering with strong international players that can bring advanced nanotech applications

Key market dynamics and trends

The following are some of the key market dynamics and trends affecting the development of the nanotech industry in China, presently as well as in the near future.

1. Continued government support and targeting of nanotechnology

- China's US$ 586 billion economic stimulus package announced in 2008 allocated an additional US$ 19 billion for nanotech R&D.

- Besides continuing (and increasing) expenditures in basic research, the governments is actively seeking to foster a strong environment for nanotech innovation by sponsoring new innovation parks, such as the *International Nanotech Innovation Park* in Suzhou.

- Some experts predict that China's R&D infrastructure will continue improving due to government support; China is poised to become a dominant global contributor of both research and applications by 2012.

2. Shift from basic research to marketable applications

- While basic research will remain the primary type of nanotech research in the near future and *nanomaterial* production will continue growing quickly, more companies and research centers are focusing on *nanodevices* and applications.

- Even state-sponsored research institutes such as the *Chinese Academy of Science* (CAS) are reforming to help researchers think more like entrepreneurs and to look for ways to translate research into actual products.

- This has the potential to spur innovation, increase the number of Chinese nanotech patents, attract more risk capital, and to encourage more partnerships with major corporations to bring research to market.

3. Increasing cooperation between Chinese and foreign nanotech players

- Chinese players (both research centers and companies) have shown great willingness to partner with foreign players to develop their own nanotech capabilities, e.g. *CAS Suzhou Nanotech and Nanobionics Institute* has R&D agreement with *Finnish National Technological Resource Center.*

- China's strong research base and rapidly improving production ability will become increasingly attractive to foreign nanotech companies.

- Despite the global financial crisis, cooperation is still increasing, e.g. *Industrial Nanotech* announced in June 2009 that it has partnered with a Chinese company for manufacturing, sales, and distribution, in order to capitalize on China's continued growth and interest in energy efficiency.

4. Rapid growth of nanomaterials and growing demand for nanodevices

- Nanomaterials are applied in many industries including the *construction* and *chemicals* industries, which have benefited from the Chinese government's infrastructure-focused economic stimulus plan.

- While Chinese producers currently specialize in products with low-to-mid sophistication, their level of technology is rising.

- In addition to nanomaterials, demand for more high-level nanodevice products such as nano-semiconductors is also predicted to increase, due to continual innovations in the electronics and IT industries.

REGULATORY ENVIRONMENT

The Chinese legal system is still evolving and laws & regulations tend to undergo frequent, if not constant, change; regional differences also exist and national regulations often differ from what is implementation at the local level.

Biotechnology

- Biotechnology has been used in China since the mid 1980's; however, the government only issued its first general regulation on biosafety in 1993 with the *Rules on Genetic Engineering Safety*.

- Since 1993, the government has issued other biotech industry, biosafety and genetic engineering-related regulations to guide growth; shown in the table below:

Table: Relevant regulations affecting biotechnology industry

Year	Regulation	Content
1993	*Rules on Genetic Engineering Safety*	• Provisions for use of recombinant DNA technology in the carrier system • Management of physical or chemical methods to inject DNA from different sources directly into organisms
1996	*The Safety Administration Implementation Regulation on Agricultural Biological Genetic Engineering*	• Establishment of agricultural biological genetic engineering safety committee • All activities and companies in this field must be declared and approved
1997	*Safety inspections implemented for agricultural genetically modified organisms* (GMOs)	• All agricultural GMO[22]'s must be approved for safety
1998	*Interim Measures for the Administration of Human Genetic Resources*	• Must report all human genetic collection and export activities to a Human Genetics Resources Administration • If both Chinese and foreigners collaborate on research on human genetic samples, patents filed should be owned by both
2001	*National Biosafety Framework of China* by State Environmental Protection Administration	• Provisions for agricultural biological genetic engineering safety management problems • Classified the security levels of genetic engineering and provided corresponding management measures
2002	*Regulations on Safety of Agricultural Genetically Modified Organisms*	• Strengthens safety management of agriculture GMOs to guarantee human and animal health and safety • Promote agricultural GMO research
2009	*Policy on Accelerating the Development of the Biotechnology Industry*	• Designed to promote the innovation and industrialization of biotechnology industry • Defined bio-agriculture, bio-energy, bio-manufacturing, bio-medicine and bio-environment as the major areas for R&D • Promotes the expansion of large biotechnology enterprises • Promotes the construction and development of several highly concentrated and segmented biotechnology parks • Grants tax preferences for companies in the bio-technology industry • Provides financing support for biotechnology companies, expanding their financing channels

Source: JLJ Analysis from multiple sources

[22] GMO – Genetically Modified Organism

- As biotech is a targeted industry for development, foreign investment is generally encouraged and welcome, though policy can vary for specific products (found in the *Foreign Investment Industrial Guidance Catalogue*).
  - For example, manufacturing of biological liquid fuels is restricted.
  - Prohibited activities include production and development of genetically modified plant seeds, and development and application of human stem cells and gene diagnosis therapy technology.
  - Foreign-funded R&D centers are generally welcome, and they face the same sector restrictions in the areas they can research.
- China has also signed many international protocol governing biotech products, e.g. China signed the *Cartagena Protocol* in 2005, which requires exporters to give more information on GMO's and gives importers the power to reject GMO's.

Nanotechnology

- There are no general international regulations on nanotechnology; however its use in certain fields such as biomedicine is regulated.
- For example, medical devices made with nano-biological materials are classified as Class III[23] medical devices.
- The Chinese central government has supported both nanomaterial research and the establishment of standards & standards bodies for nanomaterials, as shown in the table below:

Table: Relevant standards and standards bodies affecting nanotechnology industry

Year	Standards / Standards Bodies	Content
2003	*Standardization Administration of the People's Republic of China* (SAC) established a "United Working Group for Nanomaterials Standardization ''	Put forth 16 standards in 2003 to gauge whether a nanomaterial is really "nano"
2005	AQSIQ and SAC[24] launched 7 voluntary nanomaterial standards	Standards govern terminology, testing methods, and nanoproducts
2005	Establishment of *National Nanotechnology Standardization Technical Committee*	Goal is to determine basic national standards for nanotechnology, including terms, method and safety requirements for nanoscale measurement, nanoscale processing, materials, devices etc.)

Source: JLJ Analysis from multiple sources

[23] Class III means that the devices are implanted into the human body to sustain life, and their security and effectiveness, must be strictly controlled/ monitored; Class III devices must pass through clinical trials.
[24] AQSIQ: General Administration of Quality Supervision, Inspection, and Quarantine;
SAC: Standardization Administration of China

- Nanotechnology is a targeted high-tech industry for development; the government generally encourages foreign firms to invest in this field, often offering incentives.

- However, firms wishing to receive tax benefits must get approval and certification from the government to verify that they are desirable “high-tech” firms.

- As in biotech, restrictions on foreign investment in nanotech depend on the specific product being sold, manufactured, or researched.

Intellectual Property Rights in China

- Protecting IPR is a key concern for companies entering the China market, especially those in high tech industries such as nanotech and biotech.

- Since joining the *World Trade Organization* (WTO) in 2001, China has strengthened its legal framework and amended its IPR laws and regulations to comply with the *WTO Agreement on Trade-Related Aspects of Intellectual Property Rights* (TRIPS)[25].

- It is important to emphasize that companies must register their patents and trademarks in China before they can be enforced; without registration there is no real protection

- Registration is not needed for copyrights, although it may be useful for enforcement actions.

- Failure to register IP results in no protection whatsoever, regardless of laws, regulations or enforcement of IP rights; which is no different from developed countries.

- China is notorious for its lack of IP protection; which lies in the enforcement of regulations, not in the lack of regulations.

- Historically, local protectionism, limited resources and training available to enforcement officials also has contributed to poor enforcement.

- However, there has been a clear trend towards increasing commitment from the central government in combating IP violations and strengthening enforcement.

Registering IP in China

Patents

- Chinese Patents are nationwide and valid for 20 years; there is no rule of first inventor in China, patents will be granted to the first applicant.

- This practice is consistent with the EU (but different from the US, which recognizes the “first-to-invent” rule).

- As a signatory of the *Patent Cooperation Treaty* in 1994, China is required to perform international patent searches and preliminary examinations of patent applications.

- Application should be submitted to the China’s *State Intellectual Property Office* (SIPO); although, the SIPO offices at the provincial and municipal levels are responsible for administrative enforcement.

[25] Please refer to Appendix A.2 for more details on China’s IPR regulations.

Trademarks

- China's has two trademark laws that were introduced in 2001 and 2002 respectively and covers the Chinese names.

- As in the case for patents, China has a 'first-to register' system that requires no evidence of prior use or ownership, leaving registration of popular foreign marks open to usage by third parties.

- However, the China Trademark Office will cancel "unfairly" registered trademarks.

- Italian companies looking to distribute their nanotech or biotech products in China should register their trademarks and/or logos with the *Trademark Office*. In addition, it is advisable to register the Chinese language versions of the trademark.

Copyrights

- China's copyright laws were amended in 2002; copyrighted works do not require registration for protection.

- Protection is granted to individuals/companies from countries belonging to the *copyright international conventions* of which China is a member.

- However copyright owners may wish to voluntarily register with China's *National Copyright Administration* (NCA) to establish evidence of ownership.

General enforcement of IPR in China

- There are two channels for addressing IPR infringement in China:

    1. *Administrative* – an IP rights holder files a complaint at the local administrative office; most common method used to address IPR infringement.

    2. *Judicial* – complaints are filed through the court system.

- Many government agencies and offices have responsibility over IP; it may be confusing or difficult to determine which IP agency has jurisdiction over a particular infringement case.

- Each agency is usually responsible for the protection of a specific area of IP-related law, or there may be geographical limits involving IP infringement occurring in several regions.

- China's courts also have similar rules and limitations regarding jurisdiction over infringements of IPR or counterfeiting activities.

Specific IPR protection for biotech and nanotech industries

- Currently, there are several Chinese patent laws that deal with patent protection for biotechnology-related inventions.

- The 1985 *Patent Law* stated that created species of plants, animals, and microbes were not patentable, but production methods used can be patented.

  - In addition, while methods to diagnose and to treat diseases cannot be patented, the biotech-related materials and equipment used can be patented.

  - However, the 1992 revision of the law expanded coverage to both products and methods used to create drugs, chemicals, food, and biological species.

  - This revision put bioproducts into the scope the law's protection.

- Generally, biotech applications in *food*, *medicine*, *energy*, and *environment* – fields that are related to people's lives and have practical and commercial value – are protected by Chinese IPR law.

  - For example, new plant varieties fall under the jurisdiction of both the *Patent Law* (breeding methods section) and *Regulations of Protection of New Plants Varieties of the PRC.*

  - Additionally, the *Regulations for the Implementation of the Patent Law of the PRC* has specific regulations to protect microbial inventions and applications.

  - Patents for microorganism-related inventions are facilitated under the *Budapest Treaty* and the *Guidelines for Patent Examination.*

- While China currently lacks nanotech-specific IPR legislation, nanotech-related IPR issues are still covered under general IPR laws; the government has become more aware of IPR issues in this industry.

IPR considerations for Italian entrants

- Entrants into the China market must be mindful of trade secrets and must manage access to proprietary knowledge, including what is publicly accessible (i.e. websites).

- Italian entrants must make sure to register their patents[26] and trademarks as early as possible and take the appropriate legal action in the event of infringement.

  - China grants patents and trademarks to the first applicant (i.e. "first-to-register") not necessarily to the inventor.

- It is important to also register any trademarks in Chinese.

[26] It is important that patents be discussed with a lawyer.

- Other Considerations for IPR protection include:

  - gradually introducing technologies to the market – allows entrants to test the market and to evaluate trustworthiness of partners;

  - choose partners, distributors, or agents carefully and conducting proper due diligence.

- Most importantly, Italian players must adopt a "holistic" approach to protecting IP – adopting preventative methods protecting IP[27], developing relationships with government officials, as well as a using the proper legal approach to disputes.

Examples of recent IPR disputes

- Biotech and nanotech players must be careful about IPR security, as exemplified by past cases[28]:

  - *biotech - Zhejiang Hangzhou Xinfu Pharmaceutical's* leading vitamin VB5 technology was illegally acquired by *Xinfa Co.* through payments to *Xinfu* staff.

  - *nanotech - Guangdong Jiawei Chemicals Industrial Co*.'s core ultrafine calcium carbonate technology was sold to another company by a *Jiawei* executive for personal gain.

- In addition, Chinese players have become increasingly sophisticated in taking legal action to overturn the validity of their competitor's domestically-issued patents as a competitive strategy, for example:

  - *Pfizer's* Viagra drug received a Chinese patent in 2001.

  - In 2004, a group of 12 Chinese generic drug manufacturers sued to have the patent invalidated on the grounds of a lack of novelty and the fact that it failed to register the Chinese version of "Viagra", or *"Weige"* in Chinese.

  - If the patent were to be invalidated, production of generic copies of Viagra would therefore become legal.

  - While the *State Intellectual Property Office* (SIPO) initially overturned the patent, it later sided with *Pfizer's* appeal in 2006.

[27] This includes physically limiting access to IP and compartmentalizing the IP so no one person has access to it.
[28] Note: such cases are not common occurrences

CONSIDERATIONS FOR ITALIAN PLAYERS

This section covers key opportunities and barriers that Italian companies should carefully consider when approaching the Chinese market.

Key opportunities in the biotech and nanotech industries

1. High demand for foreign nanotech and biotech technologies

- Chinese biotech and nanotech companies typically focus on the production of lower and mid-end applications, e.g. *nanopowders* and *biogenerics*.

- Players from the United States, Japan, and Western Europe are generally strong in advanced marketable biotech and nanotech applications.

- In particular, some Italian firms are strong in the areas of *biomedicine*, *bioenergy*, and *bioenvironment* applications and have the ability to differentiate themselves from other foreign and domestic players.

- Other key areas where foreign players have an advantage include *nanodevices* and industrial *biotech*.

2. Government support for foreign investment in biotech and nanotech

- China generally encourages foreign investment in high-tech fields such as nanotechnology and biotechnology, and has issued a series of preferential policies, especially tax benefits.

- Local governments also tend to offer preferential tax policies to high-tech foreign firms that invest in their region.

- E.g. High-tech companies that setup in Special Economic Zones (e.g. Shanghai Pudong New Area) can receive income tax exemptions in the first 2 years of operation and a 50% tax reduction in years 3-5.

- China's US$ 586 billion economic stimulus package announced in 2008 allocated an additional US$ 19 billion for nanotech research & development.

- Additionally, in June 2009 the Chinese government announced that it will spend US$ 9.2 billion over 2 years to accelerate the development of biotech in 2009-2010.

3. Domestic players are open to cooperation

- Cooperation between the public and private sector – as well as between private sector firms – is common and an important part of the R&D process.

- Regional universities are especially keen to partner with local and foreign-invested companies, especially ones that show a strong ability to develop advanced applications.

- Cooperating with a domestic player can give Italian players access to significant resources in terms of research and development for new applications.

Key challenges in the biotech and nanotech industries

1. Attention to IPR aspects

- China has a significant body of legislation governing IPR, although enforcement can be inconsistent and vary by province and city.

- However, China's enforcement record has been improving steadily in recent years.

- As companies engaged in nanotechnology and biotechnology are heavily dependent on the commercialization of intellectual property, the protection of intellectual property rights is critical.

- Italian players must adopt a "holistic" approach to protect their IP – adopting preventative methods protecting IP, developing relationships with government officials, as well as a using the proper legal approach to disputes are crucial.

2. Finding the "right" partner may be challenging

- Though domestic players may be willing to cooperate with an Italian player that can provide advanced technology, finding the right Chinese partner may not be an easy task.

- Italian players may be able to leverage the Chinese partner in order to be able to navigate the Chinese market and to establish relationship with local government.

- However, it is critical to conduct proper due diligence when selecting the partner and the process may prove challenging.

- Additionally, key domestic players such as research centers often have multiple partnerships; new entrants must be mindful of their IPR and guard against potential conflicts of interest when choosing a domestic partner.

- Different language, culture end distant geography are also aspects to take into account when considering a cooperation with a Chinese player.

3. Biotech and nanotech industries lack a national association

- There are currently no national associations for either the overall nanotech or biotech industries; however, some sectors within the industry (e.g. biomedicine) are relatively well organized.

- The lack of industry organization can be a challenge to new entrants that would benefit from such a channel to connect with other industry players / partners.

Practical options for Italian players approaching the China market

Possible market entry strategies

- There are several possible market entry options for Italian nanotech and biotech players; however, entry mode depends greatly on sector and objectives.

- Entry mode would depend on the company's business objectives, and it is often the case that there is no perfect solution to a specific company's objectives.

- The four (plus one) main entry methods for entry into the China market (more details provided later) include:

    1. *Use of distributors/Agents* – simplest of all methods, if the company sells products

    2. *Representative Office* – the most simple legal setup format; it requires no capital investment but a limited in business scope

    3. *Joint Venture* – cooperative or equity Joint Ventures with local company

    4. *Wholly Foreign Owned Enterprise* (WOFE) – multiple types exist and is determined by business scope

    5. *[Acquisition of Local Company* – generally not suitable for SMEs as it requires significant resources and M&A experience to conduct proper due diligence]

- The four methods have been adopted by foreign entrants, examples include:

Table: Examples for each entry mode

Entry Models	Examples
Distributors/agents (if sell in China)	• ***Biotech industry*** - *Abnova*, the world's biggest recombinant proteins and antibody producer, started its business in China through general agent (*Cillix Co., Ltd.*) in Shanghai.
	Nanotech industry - *Energy Release Products Corporation*, distributed energy release, a nanotech surface conditioner, through agents in China.
Rep. Office (RO)	• ***Biotech industry*** - *Monsanto*, an international feed producer through gene technology, started its business by setting up a sales office, and still use the same channel today together with distributors and other JVs.
	(Nanotech industry - no examples found)
Joint Venture (JV) with a local partner	• ***Biotech industry*** - *United Pharmaceutical* (Philippines) setup a JV[29] with *Institute for Life Sciences* (Shanghai). The JV is now a subsidiary of *United Pharmaceuticals*
	• ***Nanotech industry -*** *Shanghai University* partnered with *Essilor,* a large ophthalmic product manufacturer from France, to develop high performance materials by setting up joint R&D center in China
WFOE	• ***Biotech industry*** - *Novozymes*, the world's leading enzyme producer, setup a manufacturing WFOE and later also established its own R&D center
	Nanotech industry - *Applied Materials*, the world's biggest nanotech semi-conductor producer, established a manufacturing WOFE and later setup a R&D center

Source: JLJ Analysis

- It is essential that Italian players wishing to enter the market seek advice from a professional service provider when considering establishing a presence in China as the regulatory environment and registration process can be complex.

- The table below provides a broader description of the entry options for Italian players.

- Is important to emphasize that, while the table provides a general framework for market entry, these are not prescriptive strategies as each individual company's situation differs and may require a customized strategy.

[29] In this case, the original joint venture was a separate company from *United Pharmaceuticals*

Table: Description of entry options for Italian players

Entry Option		Reason for Choosing Option	Description/Activities	Pros	Cons
1. Use Distributors/agents		Sell / Distribute Products in China	• Distributor to import and sell product in China; need one with strong network • No legal entity needed	• Requires no direct investment in China • Low risk • Use distributors' network to develop brand awareness	• May be challenging to identify a committed distributor • Results may be uncertain
2. Set up a Rep. Office (RO)		Manage distributors, conduct market research and business development activities	• Manage distributors • Network, conduct transactions on behalf of parent company • Able to conduct marketing activities	• Simplest way of establishing direct China presence • Low investment • Allows company to learn local market conditions • May develop business/ client network first	• Still a "llght" presence; (RO cannot conduct commercial transaction or issue invoice);
3. Establish a Joint Venture (JV) with a local partner – Equity or Cooperative JV		Reasons for JV may include time to market, technology fit, sales channels, local network, etc	• Joint venture with a local company • Equity or cooperative JV • Must check if product category is restricted or prohibited (e.g. stem cells)	• Faster time-to-market • Leverage China knowledge of local partner • Potentially, lower initial investment than WFOE	• Chinese partner may offer less in terms of technology (but may provide market access) • Potential IP issues • Need to manage relationship with JV partner - conflicts not uncommon, difficult to maintain control
4. Wholly Foreign Owned Enterprise (WFOE)	**Manufacturing WFOE**[30]	Manufacture Products in China	• Set up factory and manufacture nanotech or biotech products • May use distributors to then sell within China	• Full control and ownership of the company • Most sustainable in the long run • WFOE's are most popular for players committed to China • Typically greater control of IP • Individual types of WFOE's may have additional pros	• Higher investment and commitment required • Relatively more time to setup / develop the business • Individual types of WFOE's may have specific cons
	FICE[31]	Sell / Distribute Products in China	• Trade and sell/distribute nanotech or biotech products within China		
	Service WFOE	Outsource R&D or other Services	• Suitable for smaller operations looking to outsource R&D to China		
	Foreign Funded R&D Center[32]	Outsource R&D	• Full R&D facility set up in China		
5. [Acquisition of local company]		Reasons for Acquisition will vary	• Alternative to WFOE or JV	• May acquire local channels/ knowledge quickly • No problems associated with having JV partner	• Potentially highest investment required • Potentially risky, especially without local knowledge or previous experience • Difficult to conduct proper due diligence

Source: JLJ Analysis

[30] The feasibility of setting up a Manufacturing WFOE depends on the specific sector and the individual company's situation. having access to high-quality suppliers; possible Intellectual Property concerns related to production processes and know-how; availability of high-quality machinery and qualified personnel, etc.
[31] FICE – Foreign Invested Commercial Enterprise
[32] Encouraged, restricted, prohibited research areas found in the *Foreign Investment Industrial Guidance Catalogue*

SUMMARY AND CONCLUSIONS

- Both the nanotech and biotech industries in China have experienced rapid growth, and are seen as key industries to China's future economic development.

- The development of both industries is mainly driven by basic research conducted in university or state-sponsored research centers.

- China is a strong international player in basic research, particularly in nanotechnology; however, few discoveries have been marketable.

- The private sector has strong ties with publicly-funded research centers, collaborating in a variety of ways to bring basic research to market.

- Most domestic companies are small companies, generally focusing on commercializing nanomaterials and low to mid-end bioproducts.

- While few in overall number, foreign-invested companies tend to bring more advanced technologies / products to China, and have entered through a variety of models depending on their specific field and product / technology

- Partnerships between foreign-invested companies and both private and public sector players are common, as demand for advanced technologies is high

- Recognizing a lack of advanced applications, as well as the need to shift development away from basic research and toward marketable applications, the government has instituted policies to raise the level of innovation in the market.

- Opportunities exist for Italian entrants, especially those with strong innovation ability and specializing in more sophisticated applications.

- However, it is still a challenging market, and SMEs should pay attention to IPR aspects.

- In addition, it can be crucial (yet difficult) to find a good local partner in certain fields (e.g. *bioenvironment*), made more difficult by a lack of national industry organizations that can provide a channel for networking and market information

- In entering China, proper entry mode selection, innovation pipeline, and IP protection are keys to success.

- Italian players that can identify good opportunities in this market, should consider to invest time and resources to set up a direct presence in China and be ready for a long-term commitment.

APPENDIX

A.1 Definition of biotechnology and nanotechnology

Definition of "Biotechnology"

- **Biotechnology** in China (according to the *State Science Commission*) is a kind of technology that is applied on living organisms and is used to change/reform living organism or to process biomaterial into products or services for use.

  - The "living organism" involves *animal*, *plants* and *microorganism*.

  - The "biomaterial" involves part of living organisms and substances that the living organism uses during their life process, such as *organic matter* and some *minerals*.

  - The "products" involve *cereals*, *food*, *medicine*, *energy*, *chemicals*, etc.

  - The "services" involve *sickness prevention* and *treatment*, *environmental pollution inspection*, *control* and *recovery* etc.

- Biotechnology in this report mainly refers to **modern biotechnology**, which began with the 1953 discovery of the structure of deoxyribonucleic acid (DNA) and started from the 1980s in China; it includes the following different technologies:

Table: Elements of modern biotechnology

Categories	Technologies
DNA (genetic code)	• Genomics, gene engineering, pharmacogenetics, gene probe, gene array/synthesis/enlarge
Protein and molecular	• Proteomics, protein/peptide array/synthesis, fat/protein/ glycotechnology, hormone and growth factors, Branches of peripheral nerve/signal/pheromones
Cell and tissue feeding engineering	• Cell/tissue feeding, tissue engineering, hybridization, cell fusion, vaccine/prevention stimulus, embryo operation
Process biotechnology	• Bioreactor, fermentation, bio-production, bio-solvent, bio-pulping, biocatalytic desulfurization, bio-remedy, bio-filtration
Small cell organism	• Gene therapy, virus carrier method

Source: JLJ analysis from multiple sources

- **Biotechnology industry** in this report covers three areas:

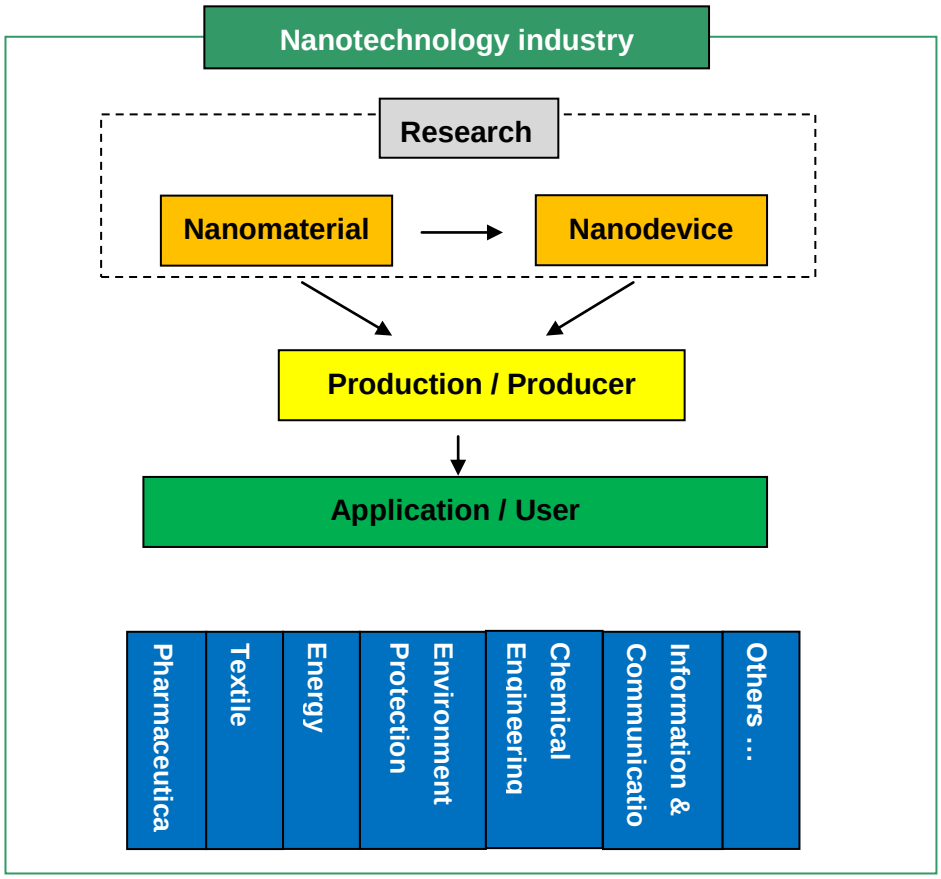
  - Biotechnology research development;
  - Bio-product manufacture;
  - Sales of bio-products and applications in different industries.

- This report does not include research on instrument producers (instruments indicate the equipment for technology research and testing etc.).

Definition of "Nanotechnology"

- ***Nanotechnology*** in this report is defined as the *design*, *characterization*, *production*, and *application* of *structures*, *devices*, and *systems* by controlled manipulation of size and shape at the nanometer scale (atomic, molecular, and macromolecular scale) to produce structures, devices, and systems with at least one novel/superior characteristic or property.

- ***Nanotechnology industry*** in this report involves basic research & development, production & sales of mainly *nanomaterials* and *nanodevices*, and their *applications* in different industries, as depicted in the figure below:



Source: JLJ analysis on multiple sources

- This report does not include research on instrument producers (Instruments indicate the equipment for technology research and testing etc.).

A.2 General IP-related laws and regulations

- Core legislation such as the *General Principles of Civil Law* and the *Constitutional Law* have IPR-related provisions.
- In addition, the government has put forth a series of IPR-specific laws and regulations, listed in the table below:

Table: Main IPR-related laws and regulations

Category	Year	Law or regulation	Content
Patent	1985 (revised in 2008)	*Patent Law of the PRC*	Fundamental patent law regulation to encourage innovation and promote science and technology development
	2001	*Regulations for the Implementation of the Patent Law of the PRC*	Clarification of Patent Law
	2006 (revised)	*New Guidelines for Patent Examination of PRC*	Guide for patent applicants and patent examiners
Trademark	2001	*Trademark Law of the PRC*	Sets out general guidelines on administration of trademarks; protection of trademark owners' exclusive rights
	2002	*Regulations for the Implementation of the Trademark Law of the PRC*	Clarification of Trademark Law
Copyright	1999 (revised in 2001)	*Copyright Law of the PRC*	General guideline on protection of copyrights
	2001	*Rules for the Implementation of the Copyright Law of the PRC*	Clarification of Copyright Law, adding detailed implementation methods
Others	1993	*Law against Unfair Competition of the PRC*	Prohibits unfair competition behaviors involving misleading and deceptive use of trademarks, trade secrets, copyrights
	1995 (revised 2003)	*Regulation of the PRC on the Customs Protection of Intellectual Property Rights*	China Customs will protect trademarks, copyrights and patent rights of imported or exported goods
	1997	*Regulations on the Protection of New Plants Varieties of the PRC*	Regulation to protect and encourage use of new varieties of plants, and to promote development of agriculture and forestry
	2008	*Rules for the Implementation of the Regulations on the Protection of the New Varieties of Plants (Agricultural section)*	Regulates new plant varieties; variety rights given only if no harm to public interests and no ecological damage
	2008	*Rules for the Implementation of the Regulations on the Protection of the New Varieties of Plants (Forestry part)*	Regulates forest plant varieties; variety rights given only if no harm to public interests and no ecological damage

Source: JLJ analysis on multiple sources

- In addition to national regulations, local governments have also put forth IPR-related regulations, e.g. *Regulations of Beijing Municipality on the Protection and Promotion of Patents (2005).*
- China is also a party to several major international conventions and agreements on IPR protection such as:
  - *Paris Convention for the Protection of Industrial Property* – allows patent application in all member countries using original filing date.
  - *Patent Cooperation Treaty* – provides a unified process to apply for patent in multiple member countries.
  - *Budapest Treaty* – streamlines process for application for microorganism-related patent in multiple nations.
  - *International Convention for the Protection of New Varieties of Plants* - agreement for international protection of new varieties of plants.
  - *World Trade Organization (WTO) Agreement* on *Trade Related Aspects of Intellectual Property Rights (TRIPS)* requiring all WTO nations to enact laws to meet minimum IPR protection standards and enforcement method

A.3 Glossary of key terms

Biotechnology

Table: Key biotechnology-related terms

Term	Explanation
Biochemical Engineering	branch of chemical engineering or biological engineering that mainly deals with the design and construction of unit processes that involve biological organisms or molecules, such as bioreactors
Bioreactor	refers to any device or system that supports a biologically active environment
Cell Engineering	use the techniques of engineering to alter genetic materials of cells on the cell or cell organ level to create new organism or products
Cloning	production of genetically identical organisms
Coagulating Agent	a material that has coagulation and flocculation effects when placed in water
DNA Probe	a single-stranded DNA sequence used in laboratory experiments to detect the presence of a complementary sequence among a mixture of other singled-stranded DNA sequences; mostly used to detect diseases and virus
Enzyme Engineering	application of an enzyme's catalytic activity to convert from certain compounds into others necessary for bioreactors; mostly applied in the food, light manufacturing and medical industries
Flocculating Agent	chemicals that promote flocculation by causing colloids and other suspended particles in liquids to aggregate, forming a flock; used in water treatment processes
Functional Genomics	also called post genomics; unlike genomics, functional genomics focuses on the dynamic aspects of genomes, not the static aspects of the genomic information
Gene Therapy	insertion of genes into an individual's cells and tissues to treat disease
Genetic Engineering	uses techniques of molecular cloning and transformation to alter structure and characteristics of genes directly and inserting them into viable cells; process can transform original characteristics of organism to get new products
Genetic Modification	involves the deliberate modification of an organism's genetic material by moving, introducing or eliminating specific genes; mainly used in agriculture and medicine
Genomics	study of the genomes of organisms and how to use genes; main tools and methods include bioinformatics, genetic analysis etc
Life Science	branch of natural science dealing with the structure, behavior, and interactions of living organisms; includes biology and its subsets
Metabolic Engineering	practice of optimizing genetic and regulatory processes within cells to increase the cells' production of a certain substance; applied in the production of beer, wine, cheese, pharmaceuticals, and other biotech products
Microbial Engineering	also called Zymolysis engineering, this is a technology of applying microbial zymolysis to generate useful materials through modern engineering methods or directly inserting applied microbes into bioreactor
Modern Biotechnology	term used to describe a range of processes and techniques especially at the molecular level, which include genetic engineering technology (DNA recombination technology) and protein engineering technology
Molecular Genetics	field of biology that studies the structure and function of genes at a molecular level
Molecular Markers	pieces of DNA that are easily detectable and located near genes of interest; particularly useful in breeding programs and can also be used to make DNA fingerprints of animals and plants
Protein Engineering	process of developing useful or valuable proteins
Proteomics	large-scale study of proteins, particularly their structures and functions; newly developed discipline
Structural Genomics	study of 3-dimensional structures to research the range of protein structure and function found in organism, cell, or in genomes
Tissue Engineering	uses synthetic or naturally derived biomaterials to replace damaged or defective tissues, such as bone, skin, and even organs
Traditional Biotechnology	divided into microbial engineering, cell engineering, enzyme engineering and genetic breeding engineering

Source: JLJ analysis of multiple sources, including Shanghai Nanotechnology Promotion Center, Oxford Journals, etc.

Nanotechnology

Table: Key nanotechnology-related terms

Term	Explanation
High Polymer Nanocomposites	materials composed of a polymeric host in which particles (buckyballs, nanotubes, semiconductor of metallic nanocrystals, clays) of nanoscale dimensions are incorporated
Nanodevice	functional device made from nanomaterial and nanotechnology
Nano functional coating	prepared by forming a nano-scale network pattern of silicone (polymethyl siloxane: PMS) on a surface using cyclic siloxane through chemical vapor deposition
Nano functional membrane	~1 nm carbon ultra-thin film coated on a micro-grid and developed for electron microscopy observation; applied in electronics industry
Nano interface material	substance that bonds two different kinds of materials at the nanoscale level to create a composite with properties of both, e.g. combining biogenic and artificially engineered materials to create substitute tissues
Nano-life science	nanotechnology applied to life sciences
Nano Magnetic Liquid Material	special kind of nanostructure magnetic material which consists of a colloidal suspension of tiny (about 10 nm) magnetic particles suspended in a carrier liquid; used for finishing machines that polish workpieces
Nanomaterial	material with structure created at the nanometer level in at least one dimension; these are mostly passive objects but have special properties when aggregated in large quantities
Nanorod	One morphology of nanoscale objects, these may be synthesized from metals or semiconducting materials; applications range from display systems to microelectromechanical systems (MEMS)
Nano Semiconductor	semiconductor device shrunk to the nanometer level that can has specific light, electricity, heat and mechanical characteristics; applications in nano diode, integrated circuit etc
Nano Stealth Material	nanomaterial with special characteristics of light, heat, magic and electricity, which give it extremely good wave-absorbing characteristics
Nanostructure	object of intermediate size between molecular and microscopic (micrometer-sized) structures
Nanotube	a nanometer-scale wire-like structure that is most often composed of carbon, exhibit extraordinary strength and unique electrical properties, and are efficient conductors of heat; potentially applied in electronics, optics and other fields of materials science
Nano Wire	nanostructure with a diameter on the order of a nanometer; can be used to link tiny components into extremely small circuits
Scanning probe microscope (SPM)	imaging instrument for measuring surfaces on a fine scale, down to the level of molecules and groups of atoms, or at a distance of over 100 micrometers in length and width and 4 micrometers in depth
Single atom operation	involves three operations – moving, removing, and placing a single atom

Source: JLJ analysis of multiple sources, including Shanghai Nanotechnology Promotion Center, Oxford Journals, etc.

A.4 Key trade shows and conferences in China

- The table below lists some of the key biotech and nanotech trade shows and conferences in China in 2009:

Table: Trade shows and conferences in China (2009)

Type	Name	Dates	Location	Content	Sponsoring Organizations
Trade show + Conference (Biotech)	BioEco 2009 (1st Circular)	June 26th -28th	Tianjin	• Biomedicine • Bioagriculture • Bioenergy • Industrial and environment biotech	• Ministry of Science and Technology of China • Tianjin Municipal Government
Conference + Trade show (Biotech)	International Union of Biochemistry and Molecular Biology (IUBMB)	August 2nd -7th	Shanghai (Shanghai International Convention Center)	• Genome dynamics and gene regulation • Protein structure • Dynamics and proteomics • Cell signaling and network	• Chinese Society of Biochemistry and Molecular Biology • Chinese Society for Cell Biology
Conference (Nanotech + Biotech)	Biotech and Nanotech Cooperation & Development Forum between China and Italy	June 25th	Shanghai (Jingan Hilton Hotel)	Knowledge exchange and cooperation in biotech and nanotech	• Shanghai International Trade Commission • Italian Trade Commission

Source: JLJ analysis on multiple sources

A.5 Database of key players

- Separate Excel file provided
- Includes over 50 basic contact profiles each of key nanotech and biotech players, including research centers, companies, and industrial parks
- Companies include producers (foreign-invested, domestic, JV, and SOE) and a sample of distributors