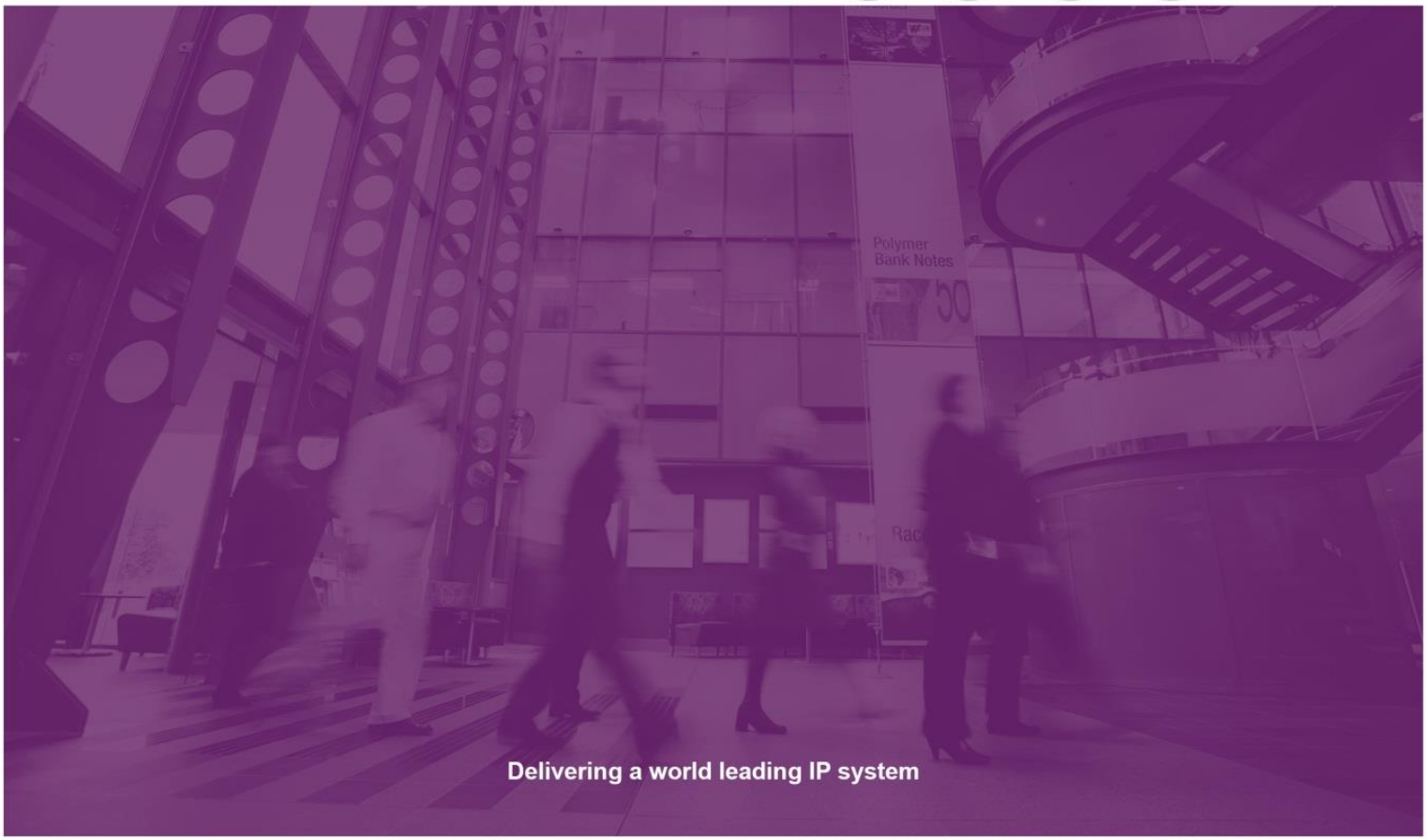
Australian Government
IP Australia

# Patent Analytics Report: Pollen Allergens

December 2015



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## Contents

# 1 Introduction

Allergic rhinitis is a common disorder worldwide, with a significant impact on the quality of life. It may also increase the risk of comorbidities such as asthma.[1] For patients with severe allergies, who may not respond well to usual therapeutic approaches such as intranasal corticosteroid sprays and oral or topical antihistamines, immunotherapy is a viable option.

Immunotherapy for allergic rhinitis involves repeated administration of high doses of allergen, such as grass pollen, with the aim of inducing clinical and immunological tolerance in the recipient. Immunotherapy formulations contain an extract of one or more species of grass pollen and are administered either as a course of subcutaneous injections or as daily sublingual drops or dissolving tablets. Regulatory standards[2] require that immunotherapeutics be standardised for allergenic potency using techniques such as enzyme-linked immunoassay (ELISA), which requires antibodies specific for the relevant allergen. Such antibodies can also be used to measure environmental levels of allergens[3].

Patents can be used as indicators of research output. A patent is a right that is granted for any device, substance, method or process that is new, inventive, and useful (see Appendix A for more information). Patent rights are legally enforceable and give the owner exclusive rights to commercially exploit the invention for a limited period of time.

It is a requirement of patent law that patent documents are published and that they fully disclose inventions. As a result of the disclosure requirement, patent literature reflects developments in science and technology. Patent documents include other useful information, such as international patent classifications and information about inventors and applicants.

Through the extraction and analysis of data associated with patent documents, it is possible to measure aspects of inventive activity such as scope, intensity, collaboration and impact. These metrics can be developed across technology sectors and by various units of measurement, such as individuals (inventors), institutions (applicants), regions and countries.

This report provides an overview of technology relating to pollen allergens in general, with a particular focus on immunoassays and diagnostics, through the lens of intellectual property (IP). It uses the scale and intensity of patent activity to provide an overview of innovation in the area.

[1] Radulovic et al., Systematic reviews of sublingual immunotherapy (SLIT), Allergy, 2011, Vol 66: pp740–52

[2] European Medicines Agency, Guideline on allergen products, EMEA/CHMP/BWP/304831/2007

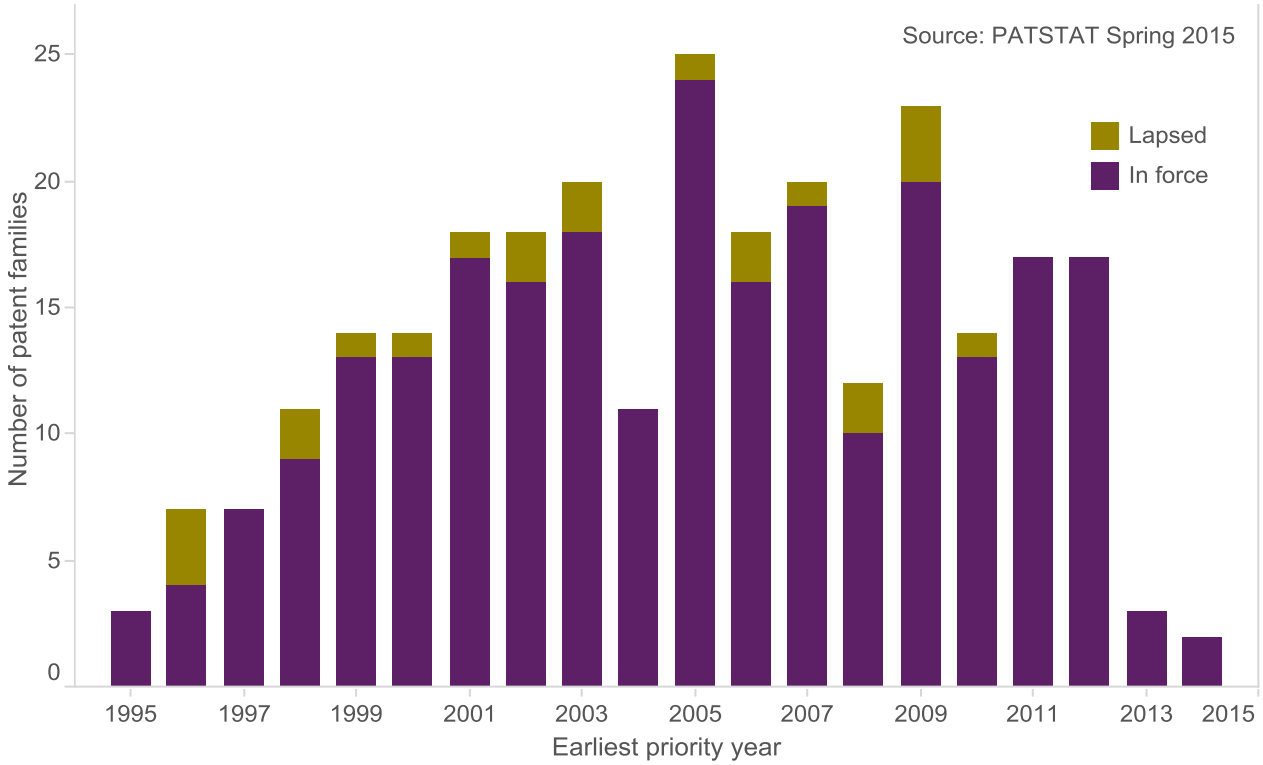
[3] Benitez et al., Determination of allergenic load and pollen count of Cupressus arizonica pollen by flow cytometry using Cup a1 polyclonal antibody, Cytometry B Clin Cytom., 2013, Vol. 86: pp63–9

# 2 General Overview: Pollen Allergen Technology

## 2.1 Scale of Patent Activity

We identified 274 unique INPADOC patent families relating to pollen allergens, using a combination of classification marks and keywords in PATSTAT (see Appendix B for a detailed search strategy). The timeframe for the analysis in this report is applications with a priority date after 1 January 1995 until 31 of December 2014. This is in order to concentrate on contemporary technology and also to reflect the fact that the majority of patents will expire 21 years from their earliest priority date. Figure 1 shows these patent families by priority year.

**Figure 1: Patent families by priority year.**




Although we did not identify a large number of patent families, the number of families has generally been steady since the late 1990s. The families are broken down by those with at least one family member in force (in purple), which make up 91 per cent of families, and those that have lapsed. Whilst the total number of patent families is not large, the high percentage of in force patents suggests each family has value to the applicant. The drop in patent families in 2013 and 2014 is due to publication lag of applications.

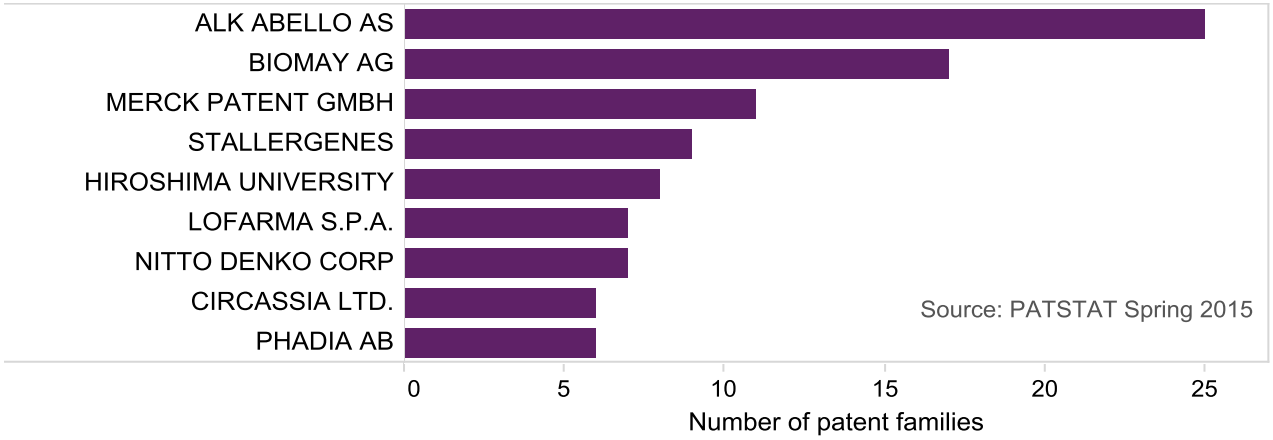
## 2.2 Top Applicants

Figure 2 shows the top applicants in pollen allergens based on number of patent families. Three of the top four applicants, ALK Abello, Biomay and Stallergenes, are companies that specialise in the development of allergy immunotherapy products. ALK Abello is a Danish company that launched the world's first sublingual tablet-based vaccine, GRAZAX®, in Europe in 2006.[4] GRAZAX® (known as GRASTEK is the United States and Canada) is indicated for treatment of grass pollen-induced rhinitis, specifically Timothy grass pollen allergy. Biomay's product portfolio includes recombinant grass pollen antigen vaccines comprised of wild-type allergens, peptide-carrier fusion proteins or

[4] ALK Abello, ALK Abello Milestones

hypoallergenic vaccines, as well as RNA vaccines for allergy prophylaxis.[5] Stallergenes, recently merged with Greer laboratories to create Stallergenes Greer, is headquartered in London (UK).[6] In 2014 they gained FDA approval for ORALAIR®, a sublingual allergy immunotherapy tablet containing extracts from five grass types— Sweet Vernal, Orchard, Perennial Rye, Timothy and Kentucky Blue grass.[7]

**Figure 2: Top Applicants**




Allergy is one of the Merck Group's six main business areas. Merck subsidiary manufacturing company Allergopharma has a portfolio including diagnostics, therapeutics and allergen avoidance[8]. Allergopharma offers high-dose, hypoallergenic, standardized products for the specific immunotherapy of pollen and mite allergies, together with a broad range of diagnostics and individual allergen extracts for personalized medicine. In 2014, Ragwitek™ was approved by the FDA as a sublingual tablet for treating short Ragweed pollen-induced allergic rhinitis.[9]

The academic institution with the largest number of patent families is Hiroshima University. These patents are primarily directed to Japanese cedar antigens.

Lofarma is an Italian company also specialising in allergy diagnosis and immunotherapies. Their allergy technology is based on the modification of natural allergens, such as Ragweed, to improve their bioavailability and pharmacokinetics.[10]

Nitto Denko is a Japanese company with a broad product portfolio, related to adhesives, coatings, polymers and release-technology.[11] Their patents relate to various methods for prolonging the shelf-life of allergens, including US 2012/0171251, which describes a sheet-form preparation of an allergic protein from cedar pollen.

Circassia is a British company whose grass allergy treatment is a novel mixture of synthetic peptide immunoregulatory epitopes identified using the company's ToleroMune® technology. The treatment has successfully completed a proof-of-concept phase IIb clinical study.[12]

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[5] Biomay, Research and development product pipeline

[6] Labiotech, Stallergenes merges with Greer

[7] Greer, Press release

[8] Allergoharma, Our Business

[9] FDA, Press release, April 17 2014

[10] Lofarma, Press release

[11] Nitto Denko, Core technologies

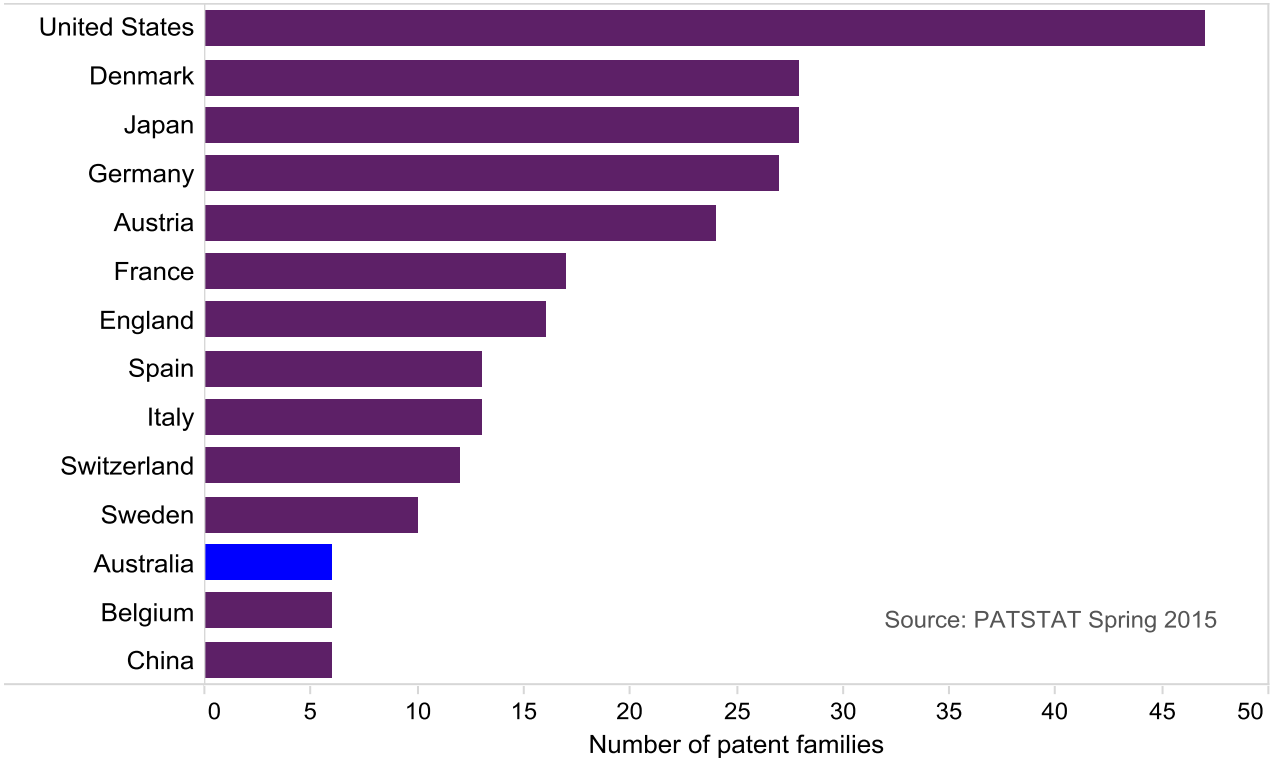
[12] Circassia, Technology Portfolio - Grass

Phadia AB, a subsidiary of ThermoFisher scientific, is also among the top total applicants in this field. Their technology is based on the rapid diagnosis of allergens.[13]

## 2.3 Applicant Origin

Figure 3 shows the number of patent families originating from each country worldwide, based on applicant address. The most families have been filed by US entities, although US entities do not feature in any of the top individual filers. European countries Denmark Austria, Germany, and Spain all feature strongly (represented by ALK Abello, Biomay AG, Merck Group and Phadia AB). Australia is the equal 12th filer with Belgium and China. Japan rates highly in terms of number of families filed, which is consistent with Japanese tendency to file multiple applications in parallel.

**Figure 3: Applicant origin**

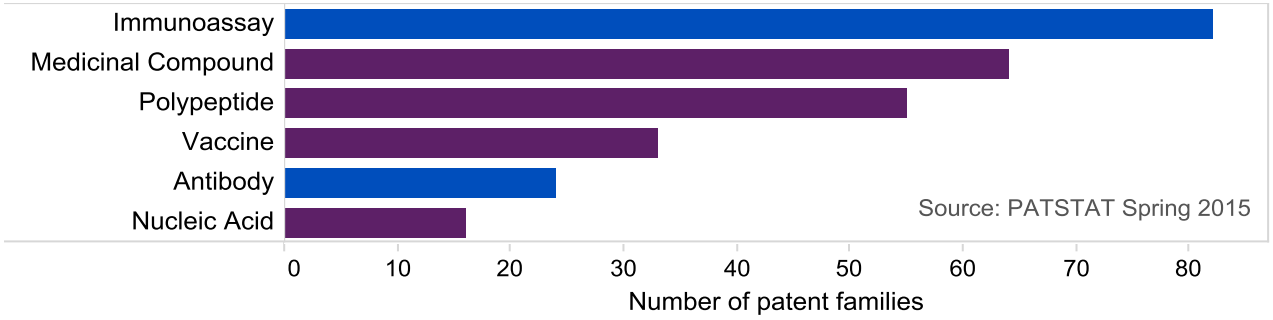



[13] Phadia, Products

# 3 Technology Breakdown

Figure 4 shows a breakdown of the technology categories. Each patent family was assigned a broad technology category based on classification marks (a detailed schema can be found in Appendix C).

**Figure 4: Technology Categories**




The major category was *Immunoassays,* which represent methods of making immunoassays, methods of using immunoassays to detect allergens or to detect antibodies in patients, as well as assaying the efficacy of anti-allergic vaccines or drugs. *Medicinal Compounds* represent drugs specifically used to treat pollen allergies. *Polypeptides* covers allergen proteins, as well as antigenic fragments (usually containing the dominant T-cell epitope) and mutated versions. The *Vaccine* category includes not only differing types of vaccines, but also differing compositions relating to the methods of delivery e.g. subcutaneous vs sublingual. Although broadly relating to therapeutics, *Antibodies* include patent families specific to the production/standardisation of antibodies. The final category, *Nucleic Acids*, includes patents to nucleic acids encoding allergens and those with immunomodulatory properties. Whilst the top individual category was *Immunoassays*, patents relating to therapeutic approaches (*Medicinal Compounds*, *Polypeptides* and *Nucleic Acids*—in purple in Figure 4) made up the majority of the technologies (61 per cent).

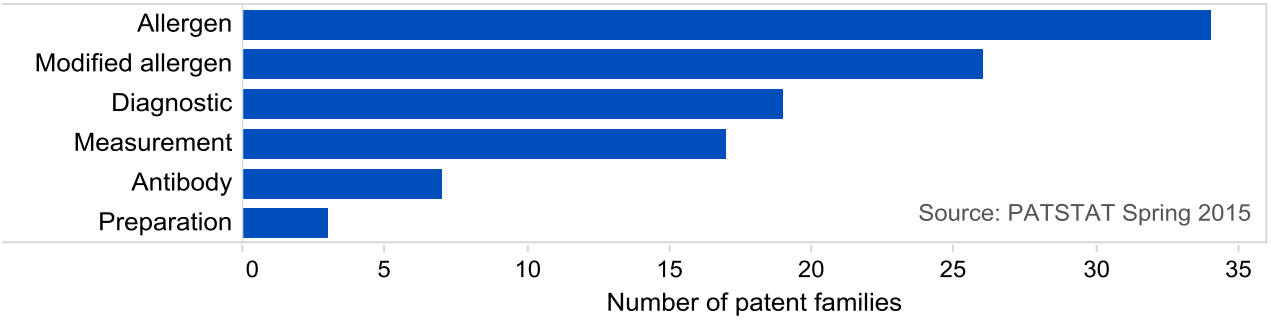
## 3.1 Sub-classification of Immunoassays and Antibodies technologies

We have provided a more detailed breakdown of patents relating to *Immunoassays* and *Antibodies* (in blue in Figure 4), which are the two categories directly related to diagnostic and measurement technologies in the field. This breakdown includes 105 patent families, and each patent family within *Immunoassays* and *Antibodies* was manually assigned to one of the following subcategories based on the title and abstract of a representative patent application from the family:

- Allergen: patent families related to new pollen allergens that include immunoassays relating to development of antibodies or immunoassays to said allergens.
- Modified Allergens: patent families describing inventions for modifying pollen allergens to make them more suitable for vaccination.
- Diagnostic: patent families related to biomarkers or assays for prognosis/monitoring of allergies.
- Measurement: patent families relating to the analysis of pollen/allergens.
- Antibody: patent families specific to production/standardisation of antibodies.
- Preparation: patent families relating to the preparation of pollen allergens/vaccines.

Figure 5 shows a breakdown of the above mentioned subcategories. The largest number of families were found in the *Allergen* and *Modified Allergen* subcategories, with antibody and preparation least represented.

**Figure 5: Technological subcategories within the immunoassay and antibody fields**




## 3.2 Applicants in Immunoassay and Antibody technologies

### Allergen

The applicant with the largest number of patent families for *Allergens* is Hiroshima University. This is due to a cluster of applications in 2005 relating to Japanese cedar Pollen allergens. The Japanese company Nishikawa rubber also has several applications related to Japanese cedar Pollen allergens. The other principal filers were Biomay AG, Merck and Phadia. Patent families form the University of Queensland and Monash University are also represented in this subcategory.

### Modified Allergen

Within the *Modified Allergen* subcategory the most active filers are Biomay AG and Lofarma. Anergis, a Swiss biotechnology company, also has two patent families in the area.[14]

### Diagnostic

The top filing in the diagnostic category is the Japanese company Genox Research, with 3 patent families predominantly relating to biological markers for detection of pollinosis, which were all filed in 1999. The University of Chicago also has several filings in the category of diagnostics, which relate to methods for assessing allergen hypersensitivity.

### Measurement

The *Measurement* subcategory is principally occupied by Japanese companies, however, only a low proportion of these patent families are still in force. These generally relate to systems for harvesting pollen from the atmosphere as well as detection kits. This data demonstrates that large Japanese industrial companies such as Mitsubishi have had an interest in commercialising allergen detection technology.

### Antibody

The fields of *Antibody* and *Preparation* had the smallest number of patent families. However, they contain inventions that are still considered to be relevant and influential.

Application WO 2006/081822, assigned to ALK Abello, relates to a method for standardising allergen extracts comprising major and minor allergens by determining and adjusting relative amounts to meet predefined requirements, in particular for use as allergy vaccines and as standards in diagnostic assays and kits. This patent exemplifies research on two allergens in olive

[14] Anergis, Home page

tree pollen, major allergen Ole e 1 and minor allergen Ole e 9, and also the PhI p 6 allergen from Timothy grass pollen. Ole e 9 and PhI p 6 allergens were purified and used to produce specific antibodies, and specific Ole e 1 and Ole e 9 enzyme-linked immunosorbent assays (ELISAs) were set up to quantify allergen concentrations. The technique is broadly applicable to other allergens.

## Preparation

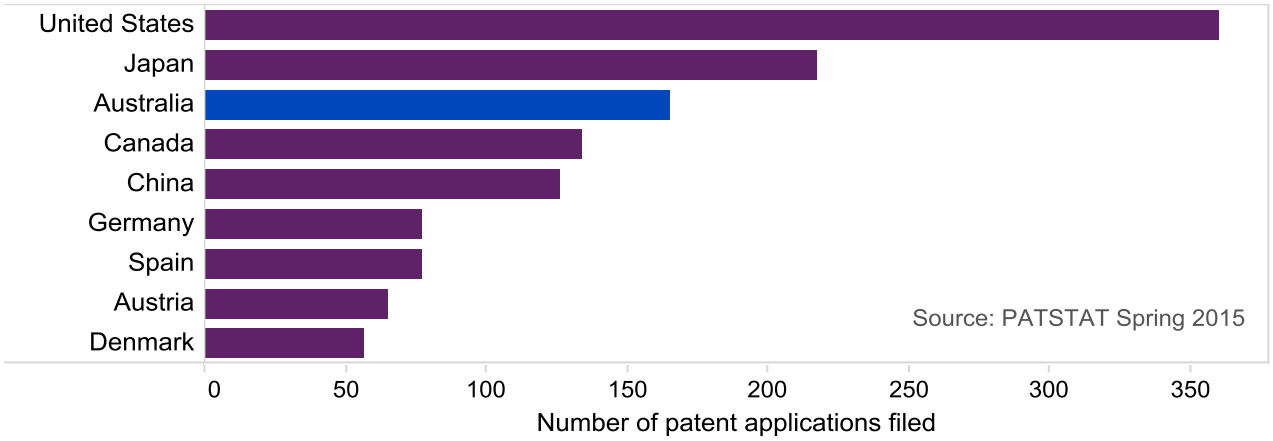
Although there are only three patent families in this field, the patent family stemming from WO 2001/013946, assigned to Merck, is notable as it relates to methods for isolating and purifying five allergens (PhI p 1, 2, 3, 10 and 13) from Timothy grass pollen using a combination of hydrophobic interaction chromatography, gel filtration and cation exchange chromatography. This patent family is primarily directed to the preparation and use of these purified allergens for immunotherapy. Conjointly, the purified allergens may be used in methods of pollen allergy diagnosis.

# 4 Target Markets

## 4.1 Worldwide

In order to look at target markets of the technologies directed to pollen allergies, we can look at the countries where applicants elected to enter national phase. As shown in Figure 6, the highest number of filings are in the US and Japan. Australia is third, with similar numbers of applications to Canada and China. This shows relative strength of the Australian market in this field. The results in individual European countries represent member state patents which are generated when a European application is granted.

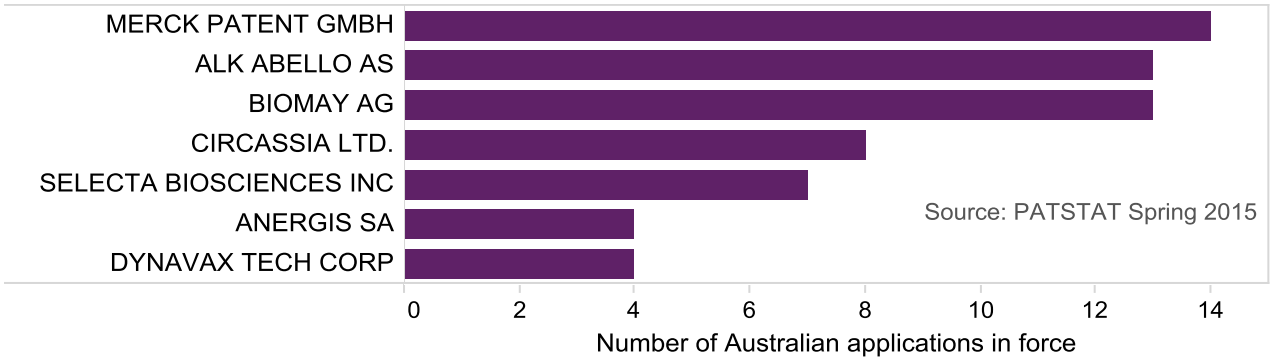
**Figure 6: Worldwide patent application coverage**




## 4.2 Australia

Figure 7 shows the major applicants with in-force applications (pending and granted) in Australia. Merck, ALK Abello, and Biomay and Circassia make up the largest rights holders. This indicates that these major players believe Australia to be an important market. Of the other major applicants, Selecta Biosciences features prominently. They have a platform technology using nanoparticles to co-present antigens and immunotherapeutic molecules to specific immune cells. Allergy is an area that is being targeted.[15] Dynavax has both agonists and inhibitors of Toll-like receptors (TLRs) to modulating immune responses. TLRs are an important class of receptors that cells use to recognise foreign bodies including pollen allergens.[16]

**Figure 7: Applicants with Australian applications in force.**




[15] Selecta Biosciences, Technology platform

[16] Dynavax, Our pipeline

# 5 Influential patent applications

## 5.1 Family Size

The size of a patent family can be a proxy for the importance of the intellectual property protected. Larger families represent more patents filed in different countries, and/or duplicate applications filed in individual countries to protect different aspects of the invention. The number of patent applications filed in each jurisdiction provides an indication of the perceived value the invention in each country because rights can only be enforced if a patent has been granted in that country. Also the higher the perceived value, the larger number of countries or markets the invention will be filed in.

The largest patent family in the dataset is based on WO 2012/149454 to Selecta Biosciences, and is directed to the use of nano-carriers to induce tolerance to antigens, which is the technology referred to in section 4.2. This is a series of related applications that was grouped together as a single family by the INPADOC classification system due to overlapping priority claims, and is found within the subcategory of *Modified Allergens*.

Other large families in that subcategory are WO 2002/040676 to ALK Abello, WO 2004/081028 to the University of Lausanne and WO 2003/025009 to the University of Melbourne. All of these relate to recombinant pollen antigens with tolerogenic qualities.

The largest families in the categories for *Vaccine* and *Medicinal Products* were predominantly related to methods of formulation and administration of allergens for inducing tolerance. These include WO 1999/053899 to Teijin Pharma, and WO 2000/044349 to Idea AG.

The plant species that receive the most commercial interest can be ascertained by considering the largest patent families in the categories *Polypeptide* and *Nucleic Acid*, which include applications for cloning of new allergens, as well as patents in the *Allergen* manual subcategory.

The most active company in this field is Merck, with numerous large patent families directed to cereal allergens (WO 2005/059136), Poacea antigens (WO 2004/108758, WO 2006/008018, WO 2000/065060) Ryegrass (WO 2005/058936) and Timothy grass (Phl p 4) (WO 2004/000881). Pharmacia also is named on two large patent families related to Tmothy grass allergens (WO 2003/080658 and WO 2001/030816). Other species with large families include Birch (WO 2007/073907, Lofarma), Ragweed (WO 2010/018378, Circassia), Mugwort (WO 2003/102189, Biomay), and Bermuda grass (WO 2003/024998, Monash University).

In the *Antibody* subcategory, there are no large families with more than 20 members, although the largest are directed to various aspects of therapeutic rather than diagnostic antibodies.

In the subcategory directed to immunoassay *Diagnostics*, there were also no large families. The largest families in that area include WO 2002/054082 (Pharmacia), WO 2005/083385 (Alk Abello), and WO 2006/084299 (Biomay), again demonstrating the involvement of these companies in this field.

In the subcategory directed specifically to *Measurement* via immunoassay, the largest family was WO 2007/011405 to Bioforce Nanosciences, which is directed to a broadly applicable technique for high-throughput analysis of molecular interactions, of which pollen antibodies are mentioned as an application.

In the *Preparation* subcategory, the largest family was WO 2001/013946 to Merck which was discussed in section 3.2.

## 5.2 Forward citations

A publication that is cited against future patent applications may represent a fundamental invention in its field. In this way, a count of forward citations provides a means of identifying the patent families of most importance. A family that has been cited in many other search reports is also evidence of the amount of follow-on research in that technology.[17]

The most highly cited patent families are directed to immunostimulatory nucleic acids. These were related to pollen in the sense that they can be used as adjuvants to pollen antigen vaccines. Representative publications from these families are WO 2003/057822 to Idera Pharmaceuticals and WO 2004/005476 to Coley Pharmaceutical Group. Both of these companies have immunostimulatory nucleic acid therapeutic products under development, and the high level of forward citations most likely reflects a high level of further research and development in this highly specialised field.

The most highly cited families in the *Immunoassay* or *Antibody* categories all related to methods of modifying allergens. WO 2002/040676 to ALK Abello which is directed to methods of generating mutant allergens by site-directed mutagenesis was the most cited with 16 forward citations. Other highly cited families directed to similar techniques were WO 2006/058359 to Biomay and WO 2003/025009 to the University of Melbourne. Another technique which received forward citations was methods of producing tolerogenic fusion proteins and conjugates, WO 2002/088317, which is assigned to the University of California.

The number of forward citations for pollen immunoassays and indeed pollen allergens is quite low, which reflects a relatively low level of concentration across the field of pollen immunoassays, (none having more than five forward citations). Once a new allergen has been cloned or modified, it is only likely to be cited against further applications directed to the same allergen or mutant. This further suggests that there are relatively few patent applications directed to any given allergen.

[17] The metric used in this study counted total forward citations recorded in WIPO, EPO and USPTO searches in the OECD Patent Citations database. Older applications will tend to have higher forward citations. However due to the relatively small sample size of this data set it was not possible to normalise the results on the basis of date.

# 6 Conclusion

This patent analytics study set out to encompass not only pollen allergen vaccines, but also immunoassay technologies (according to the IPC marks usually associated with antibodies and immunoassays) that were related to pollen allergens. However, only a small number of the applications returned by the search related to immunoassay technology.

Despite a low number of patent families located overall, the majority of the families still had at least one in-force member (Figure 1) indicating the commercial relevance of the work that is undertaken in the field.

Even within those technologies with the relevant IPC mark for immunoassays or antibodies, the majority of the patent families were directed to either wild type or modified allergens. The presence of an immunoassay or antibody classification in those cases was presumably a secondary indexing. This is perhaps not surprising given the ubiquity of antibody-based techniques in molecular biology.

The fact that only seven patent families could be identified pertaining directly to antibodies, and 17 pertaining to immunoassay-mediated measurement, suggests that there has not been a significant amount of research relating to pollen immunoassay techniques in general over the past 20 years. This may be due to the fact that standard techniques for generation of antibodies are well established. Furthermore, in the patenting area, it is generally considered that the disclosure of a new antigen makes it obvious to generate antibodies[18] (and therefore makes them generally unpatentable in their own right).

Analysis of patent family data on different pollen species gives an indication on which species are considered the most commercially relevant, including Birch, Poaceae, Ryegrass, Timothy grass and Japanese cedar. Monash University has a patent family relating to Bermuda grass antigens. The low numbers of forward citations on pollen antigens indicates that once an allergen has been cloned, this does not generate a significant amount of follow-on patenting activity for that allergen.

Although the US has the greatest share of parent families, the most significant applicants are European. Merck, Alk Abello and Biomay appear consistently as the top applicants across each of the technology classification, and also appear among the holders of the largest patent families. This is consistent with the fact that these companies have active product portfolios in the field of pollen allergen immunotherapy.

In summary, the patent landscape of pollen allergens is concentrated around pollen vaccines in commercial development.

[18] Trilateral Project 24.1 Comparative Study on Biotechnology Patent Practices (USPTO, EPO, JPO) see top of p23

# Appendix A: Definitions

## Patents, applications and publications

A patent is a right that is granted for any device, substance, method or process that is new, inventive and useful. Australian patent rights are legally enforceable and give the owner, or patentee, exclusive rights to commercially exploit the invention in Australia for a period of up to 20 years. In this report, an application refers to a single patent filing. A patent application is usually published within 18 months of its earliest filing date (also known as the priority date). We consider that the priority date is most relevant for our analysis as it is the closest date to that when the invention occurred.

There are two major routes for filing a patent application: international route and direct filing. The international route involves filing a Patent Cooperation Treaty (PCT) application, which establishes a filing date in all 148 contracting states. Subsequent prosecution at national patent offices, referred to as national-phase entry (NPE), is made at the discretion of the applicant. A patent can only be enforced once it has been granted and a PCT application must enter the national phase to proceed towards grant. Alternatively, applications can be filed directly in the countries of interest.

A patent application is considered to be in force when it has not lapsed (due to expiry or non-payment of renewal fees), been revoked or withdrawn. Data was taken from the most recent legal status action in the PATSTAT database. A family has been designated as being in force if it contains at least one in force application.

## Patent families

Applications generally relating to the same invention but filed in different countries are known as patent families. Patent families enable us to analyse inventive activity regardless of the number of countries in which protection is sought. Patent families are commonly used in analytics as they generally represent a single invention. We determine patent families based on INPADOC classification. INPADOC patent families give a unique family ID to patents that have a least one priority document in common.[19,20] For metrics, the number of patent families is typically used. There are some exceptions where individual applications are reported on, as each application represents a legal right in an individual country. When analysing the number of applications or families per applicant, related commercial entities have been grouped under a single, harmonised applicant name.

When individual publication numbers are quoted, we have chosen a representative publication from the respective patent family. These are usually WO documents which are publications of PCT applications. These are useful as representatives and they are usually in English.

## Classification

Patents are initially classified by technology into a hierarchical system known as the International Patent Classification (IPC). A further classification system referenced in this report is the Cooperative Patent Classification (CPC). The CPC began in 2013 and is a bilateral system which developed by the EPO and the USPTO which provides more in depth classifications.[21]

[19] Espacenet, Patent families

[20] Martinez, 'Insight into Different Type of Patent Families', OECD Science, Technology and Industry Working Papers, No. 2010/2, OECD Publishing, Paris; see section 3.2, 'Extended families'.

[21] European and United States Patent Offices, Cooperative Patent Classification System

## Appendix B: Methodology

To identify technologies related to pollen allergens we searched the Spring 2015 edition of the Worldwide patent statistical database (PATSTAT), developed by the EPO, and covering data from over 100 countries. It includes bibliographic and abstract data for publications to the beginning of April 2015, essentially comprising publications with a priority date up to November 2013 due to the 18 month delay between priority date and publication. However some documents with later priority dates are published less than 18 months from the priority date and are in the database.

Patents associated with pollen allergens are commonly indexed with the classification mark A61K39/36, which encompasses medicinal preparations (i.e. vaccines) relating to pollen allergens. This mark does not entirely capture patents associated with non-medicinal aspects of pollen allergens, particularly those associated with diagnostics and measurement. To account for these patents we searched C07K 16/-, a mark for immunoglobulins in general, and G01N 33/53 (and sub-marks), with the keyword pollen in the title or abstract. Both searches were done using IPC and CPC classification marks.

The logical structure of the search strategy was as follows:

A61K39/36 OR ((C07K16 OR G01N33/53-57) and pollen)

Results were grouped into INPADOC patent families and all members from the identified families were added to the dataset. Bibliographic data (dates, classification, applicant details and legal status) were retrieved from the PATSTAT database.

The data was then cleaned to eliminate duplicate records and screened for spelling variations in applicant names. The cleaned data set was analysed to eliminate irrelevant records and to classify the data into technology areas (see Appendix C).

Given the imprecise classification of patents in this area, 44 patent families were removed as they did not contain inventions related to pollen allergens based on their titles and abstracts.

Citation data was taken from the OECD Citations database (September 2015 edition)[22] and the highest citation count of all members of a family was allocated to that family.

[22] Webb et al., Analysing European and International Patent Citations: A Set of EPO Patent Database Building Blocks, STI Working Paper 2005/9, 2005, OECD, Paris

## Search Strategy

The following code was used to query PATSTAT in an SQL database:

```
select distinct a.appln_id
from patstat.tls201_appln a
left join patstat.tls203_appln_abstr aa on aa.appln_id=a.appln_id
left join patstat.tls209_appln_ipc ipc on ipc.appln_id=a.appln_id
left join patstat.tls224_appln_cpc cpc on cpc.appln_id=a.appln_id
where (ipc_class_symbol like 'A61K 39/36' or cpc_class_symbol like 'A61K 39/36')

union

select distinct a.appln_id
from patstat.tls201_appln a
left join patstat.tls203_appln_abstr aa on aa.appln_id=a.appln_id
left join patstat.tls209_appln_ipc ipc on ipc.appln_id=a.appln_id
left join patstat.tls224_appln_cpc cpc on cpc.appln_id=a.appln_id
where (ipc.ipc_class_symbol like 'C07K 16%'
       or cpc.cpc_class_symbol like 'C07K 16%'
       or ipc.ipc_class_symbol like 'G01N 33/53%'
       or ipc_class_symbol like 'G01N 33/54%'
       or ipc_class_symbol like 'G01N 33/55%'
       or ipc_class_symbol like 'G01N 33/56%'
       or ipc_class_symbol like 'G01N 33/57%'
       or cpc_class_symbol like 'G01N 33/53%'
       or cpc_class_symbol like 'G01N 33/54%'
       or cpc_class_symbol like 'G01N 33/55%'
       or cpc_class_symbol like 'G01N 33/56%'
       or cpc_class_symbol like 'G01N 33/57%')
and regexp_like (aa.appln_abstract, 'pollen', 'ix')
```

## Appendix C: Technology classification

Patent families were classified into technology categories by a hierarchical schema. Patent publications each have one or more classification index marks according to the IPC and CPC schemas. Because each patent family (and indeed each application in a family) could contain multiple classification marks, we assigned families to categories according to an order of precedence shown in Figure 8.

This hierarchical order places preference on applications that are indexed as G01N 33/* (a classification mark that relates generally to methods of analysis of biological material) and includes *Immunoassays*. The next most relevant index mark was C07K 16/* which relates specifically to *Antibodies*. The remaining patent families were classified as to whether they were indexed as *Polypeptides, Nucleic Acids, Medicinal Compounds* more generally, or *Vaccines* in particular. Due to the search strategy used, all families would be indexed as one of G01N 33/*, C07K 16/* or A61K, so no families were excluded from this schema.

Because there is some overlap between IPC marks in terms of the types of technologies, patent families falling within the first two categories (*Immunoassays* and *Antibodies*) were grouped for further analysis.

Similarly, when considering patent family size and forward citations, *Polypeptides* and *Nucleic Acids* were considered together as both tend to relate to aspects of recombinant allergens, and *Medicinal Compound* and *Vaccine* were also considered together.

Results from the pollen antibody and immunoassay search were manually allocated into the following categories, as set out in section 3.1, based on a representative title and abstract.

- Allergen: patent families related to new pollen allergens that include immunoassays relating to development of antibodies or immunoassays to said allergens.
- Modified Allergens: patent families describing inventions for modifying plant allergens to make them more suitable for vaccination.
- Diagnostic: patent families related to biomarkers or assays for prognosis/monitoring of allergies.
- Measurement: patent families relating to the analysis of pollen/allergens.
- Antibody: patent families specific to production/standardisation of antibodies.
- Preparation: patent families relating to the preparation of plant allergens/vaccines

**Figure 8: Classification schema**