UNIVERSITY OF NEW HAMPSHIRE SCHOOL OF LAW EDUCATIONAL REPORT: PATENT LANDSCAPE OF ALGAE BIODIESEL: APPLICABLE GENETIC ENGINEERING TECHNOLOGIES

SPRING 2011

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I. Abbreviations and Definitions

Below is a list of abbreviations and definitions for terms and keywords used throughout the ITTI Spring 2011 report.

Algae – defined herein as "microalgae." Microalgae are microscopic single celled algal species found in fresh and salt water.[1] Microalgae has proven to be a suitable oleaginous microorganism for lipid production.[2] Most notably, microalgae have relatively higher photosynthetic efficiency, biomass production, and growth rates compared to other lipid-producing organisms.[3]

Biofuel/biodiesel – defined herein as a fuel comprised of mono-alkyl esters of long chain fatty acids.[4] Biodiesel can be derived from lipid producing organisms.[5]

BLAST – defined herein as the acronym for Basic Local Alignment Search Tool. This program compares nucleotide or protein sequences to sequence databases and calculates the statistical significance of matches.[6]

Cyanobacteria – defined herein as a prokaryotic organism, specifically, a kind of blue-green bacteria that is found aquatically and is capable of performing photosynthesis.

DWPI – defined herein as Derwent World Patent Index®, which is the world's most comprehensive database of patent documents. DWPI includes over 20 million patent document families, which covers over 42.5 million patent documents. The DWPI database includes coverage from over 44 worldwide patent authorities.[7]

Eukaryote – defined herein as a single-celled or multicellular organism whose cells contain a distinct membrane-bound nucleus.

Genetic transformation/modification – defined herein as altering the genetic structure of wild-type algae by either transforming the algae with DNA, or otherwise modifying the algae for the purpose of creating algae more efficient at producing biodiesel than wild-type algae.

INPADOC (International Patent Document Center) – defined herein as a patent database maintained by the European Patent Office (EPO).

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[1] GuanHua Huang, et al, *Biodiesel Prod. by Microalgal Biotech.*, 87APPLIED ENERGY 39 (2010).
[2] *Id.*
[3] *Id.*
[4] http://www.biodiesel.org/resources/definitions/.
[5] *Id.*
[6] BLAST, NAT'L CTR. FOR BIOTECH. INFO., http://blast.ncbi.nlm.nih.gov/Blast.cgi (last visited May 15, 2011).
[7] Derwent World Patents Index, THOMSON REUTERS, http://thomsonreuters.com/products_services/legal/legal_products/a-z/derwent_world_patents_index/ (last visited May 9, 2011).

ITTI – defined herein as International Technology Transfer Institute, an intellectual property clinic at the University of New Hampshire School of Law.[8]

Lipid biosynthesis – defined herein as the manipulation of transcription factors and other regulatory principles in algae for the purpose of increasing oil levels in the organism. Lipid biosynthesis can occur through various biopathways and can vary from organism to organism. Lipids are a vast group of molecules which include sterols and phospholipids.

NCBI – defined herein as the acronym for National Center for Biotechnology Information. NCBI provides access to biomedical and genomic resources, such as BLAST.[9]

Oleaginous – defined herein as an organism having the nature of oil, being right in oil, or producing oil.[10]

Patent document – defined herein as issued patents and patent applications, which include but are not limited to US patents and patent applications, PCT patents and applications, and EPO patents and applications.

Patent family – defined here in as the collective worldwide application and publications for an invention. Patent protection is country specific and an applicant seeking protection for an invention must file for a patent in each country where patent protection is desired, either by filing national patent applications, or by making the application via one of the multi-national routes (e.g. an EP or a PCT application).[11]

PCT – defined herein as the Patent Cooperation Treaty, which is an international treaty aimed at providing a unified procedure for filing patent applications in the contracting states.[12] A contracting state is a country which has signed onto the treaty. A patent application filed under the PCT is commonly referred to as an international application, or PCT application.[13]

Photosynthesis – defined herein as a process in plants that uses energy from sunlight to convert carbon dioxide into organic compounds such as sugars.

Prokaryotes – defined here in as single celled organisms that do not have a nucleus, mitochondria or any other membrane bound organelles. Prokaryotes' DNA and other sites of metabolic activity are openly accessible within the cell, some free floating, some bound to the walls of the cell membrane, e.g., cyanobacteria.[14]

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[8] Globally Unique Int'l Tech. Transfer Inst. The UNH School of Law Advantage, http://law.unh.edu/itti/index.php (last visited May 9, 2011).
[9] NAT'L CTR. FOR BIOTECH. INFO., http://www.ncbi.nlm.nih.gov/ (last visited May 9, 2011).
[10] http://dictionary.reference.com (last visited Apr. 26, 2011).
[11] DIALOG, http://support.dialog.com/searchaids/dialog/dwpi_fam.shtml. (last visited April 26, 2011).
[12] Patent Cooperation Treaty, pmbl, June 19, 1970, *available at* http://www.wipo.int/pct/en/texts/articles/a0.htm.
[13] *Id.* at art. 2, *available at* http://www.wipo.int/pct/en/texts/articles/a2.htm#_2.
[14] http://www.earthlife.net/prokaryotes/welcome.html (last visited Apr. 26, 2011).

II. Executive Summary

Many companies are exploring new technologies that use algae in biodiesel production. While still an emerging field, biodiesel produced from the oils of algae is gaining more recognition as an alternative fuel source to traditional petroleum fuels.[15] As opposed to ethanol production from corn, using microalgae for biodiesel production confers an environmental advantage because microalgae do not directly require resources that are necessary for agricultural food production.[16] Also, some algae have the capability of producing up to ten times more oil than traditional agricultural biofuel crops.[17]

As the tangible market potential for biodiesel fuel increases, basic research into genetic modification of microalgae, towards enhancing the production and/or quality of biodiesel, has also accelerated. This research, although in some respects still emerging or nascent, is moving toward investing research funding into the genetic modifications that alter various metabolic pathways,[18] increasing the value of the algae as a biomass resource for biodiesel production. An increase in value drives an increase in property rights assertion, and in the case of microalgae genetic modifications, the principal property rights are intellectual, i.e., patent rights.

The purpose of this patent landscape study was to search for, identify, and categorize patent documents that are relevant to genetic transformation of algae with application to lipid biosynthesis, photosynthetic efficiency, and/or increased oil excretion. One factor in identifying leaders in a particular field of research is by the size of a patent portfolio. This report tentatively identifies several key industry leaders within the algae biofuel industry, including BASF Plant Sciences, Solazyme, Inc., Martek Biosciences, DuPont and Aurora Biofuels Inc.

BASF, headquartered in Germany, is the largest chemical company in the world. BASF conducts its business based on sustainable developments.[19] BASF structures its operations into six unique business sectors, two of which include agricultural solutions and oil and gas. BASF recently partnered with Monsanto, a leader in plant biotechnology to further research in the area of algae biofuel technologies.[20]

Solazyme, Inc. began in 2003 as a company formed to harness the prolific oil-producing ability of microalgae.[21] Solazyme, a privately-owned company based in San Francisco, California, has recently announced partnerships with both Chevron Technology Ventures and United States Department of Energy to develop the commercialization of microalgal fuel technologies.[22]

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[15] Randor Radakovits et al., *Genetic Eng'g of Algae for Enhanced Biofuel Prod.*, EUKARYOTIC CELL, Apr., 2010, at 486.
[16] *Id*.
[17] Emily Waltz, *Biotech's Green Gold?*, NATURE BIOTECH., Jan., 2009, at 15.
[18] *Id*.
[19] BASF, http://www.basf.com/group/corporate/en/about-basf/index?mid=0 (last visited April 24, 2011).
[20] *Id.*
[21] SOLAZYME, http://www.solazyme.com/company-overview (last visited April 24, 2011).
[22] Waltz, *supra* note 17.

Martek Biosciences is a company based in Columbia, Maryland that focuses its research on products derived from microalgae.[23] Martek has focused some attention in producing nutritional supplements from cultivated microalgae that are then used in products such as infant formula. However, it has several patents relevant to developing the natural oils found in microalgae.[24]

Founded in 1802, DuPont is a chemical company based in Wilmington, Delaware. DuPont has a wide range of products in its energy and utility business and within the oil and gas sector; however, it recently has also made a significant effort to develop clean, sustainable fuel technologies.[25]

Aurora Biofuels is a company that has headquarters in both Hayward, California and West Perth, Australia.[26] Aurora has worked to develop a salt water algae strain that is capable of growing in open ponds with sea water instead of fresh water.[27] Recently, they have developed affiliations with BIO, the world's largest biotechnology organization.[28]

The team members primarily used Thomson Innovation searching database. In addition to Thomson Innovation, the ITTI team also used the LEXIS TotalPatent® database.

These searches utilized keywords derived from the literature reviewed and initial searches to generate useful search strings; the searches also used United States Patent Classifications and International Patent Classifications that were identified through subsequent searches and team meetings. The combinations of keywords and classifications in search strings was useful for parsing the technology into compartments and allowing each team member to generate a different set of search results that keywords alone could not provide. This approach generated a broad set of patents. From here, ITTI used the keywords and classifications generated from this broad set of patents in subsequent rounds of searching. After each round of searching, team meetings would identify the most important keywords and classifications for use in subsequent search strings that became more defined and effective.

Examples of keywords include:

- Algae
- Microorganism
- Oleaginous
- Biodiesel
- Fatty Acid

The ITTI team additionally used Patent Lens, a free public resource initiative of Cambia, to specifically search nucleotide sequences.[29] Patent Lens obtains patent and patent application data

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[23] MARTEK, http://www.martek.com/about.aspx (last visited Apr. 24, 2011).
[24] Id.
[25] DUPONT,
http://www2.dupont.com/Oil_and_Gas/en_CA/environment/Clean_Technologies/clean_technologies.html (last visited Apr. 24, 2011).
[26] AURORA INC., http://www.aurorainc.com/company/contact-aurora/ (last visited Apr. 24, 2011).
[27] *Id.*
[28] *Id.*
[29] PATENT LENS, http://www.patentlens.net/ (last visited Apr. 24, 2011).

through subscriptions with WIPO, USPTO, EPO, IP Australia and INPADOC. It updates weekly and includes full-text of more than eight million patents and applications. It also includes DNA, RNA and Protein Sequences extracted from United States patent documents. This unique feature was useful to this project because nucleotide sequences could be copied into the search engine. However, Patent Lens only searches United States patents and patent applications for the sequences, and these sequences were last updated May 2, 2010. For more information, visit http://www.patentlens.net/sequences/blast/blast.html. Nucleotide sequence searching was useful because the search returned relevant patents that had sequences homologous to the one being searched. In conclusion, Patent Lens and NCBI provided useful and free databases to search genetic sequences. They were useful tools for searching genetic sequences of patent documents already coded and finding new relevant patent documents.

ITTI coded patent documents for genetic modification of algae using two relevancy categories with one category having four subcategories and Appendix B contains patents that could not be conclusively categorized as either relevant or irrelevant. The subcategories were lipid biosynthesis, photosynthesis, lipid secretion/excretion, and genetic transformation. Table 1 below shows the coding results for the 190 patent documents.

Category	Relevant	Irrelevant	Unable to Classify
Number of Patent Documents	62	123	5

Table 1: Coding Results

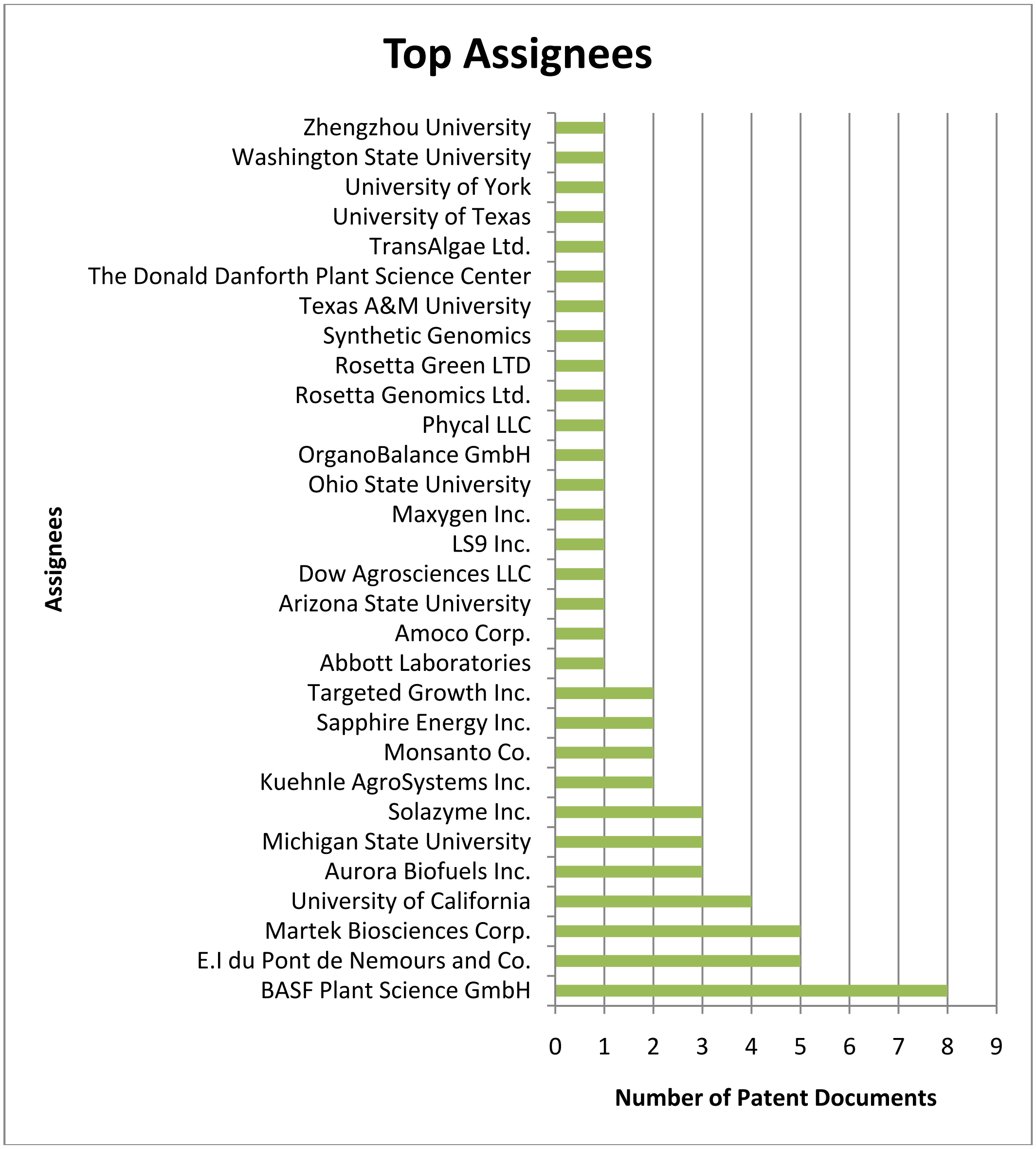

Figure 1: Leading Assignees

Our studies show that the field is nascent and currently dominated by a small group of organizations as evidenced in Figure 1. The World Map in Figure 2 shows the United States, Canada, and Australia to be the dominant leaders in number of filings for each country.

In addition, although the global filing of patents related to genetic modification of microalgae is primarily in the industrialized countries, e.g., the U.S., Japan and Europe, several emerging economies are now seen as jurisdictions where patent protection of these technologies is worth the expense. Examples of these emerging economies include: South Africa, China, and Mexico.

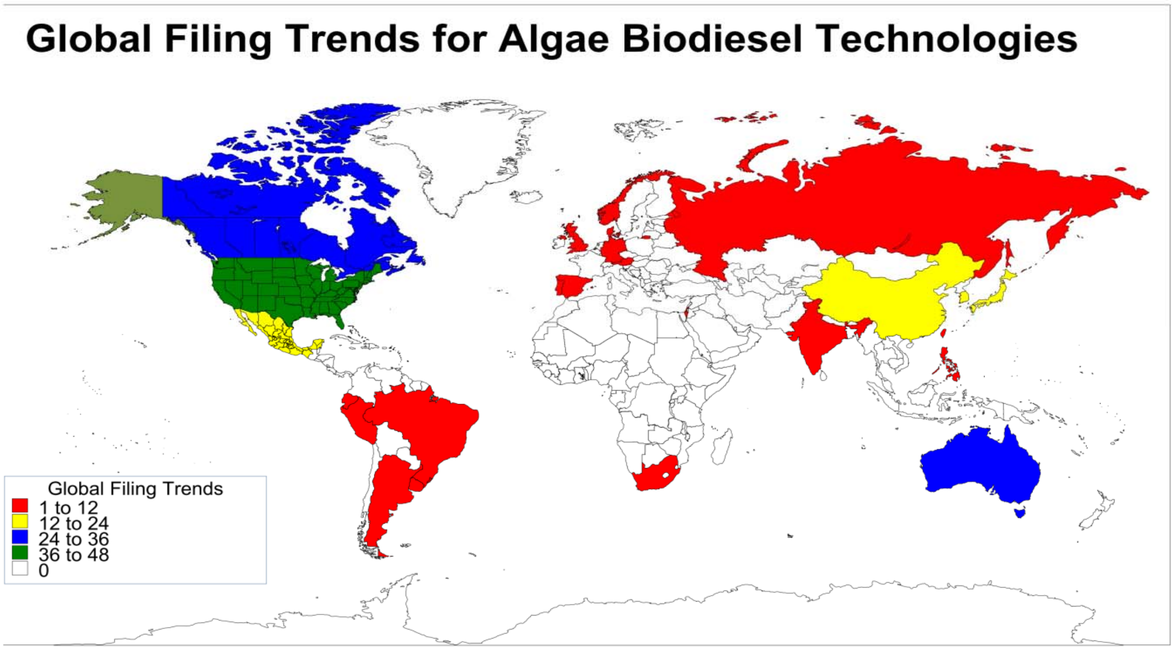

Figure 2: Number of Family Filings per Country

III. Scope of Technology Analyzed

Algae Biodiesel

Many companies are exploring new technologies that use algae in biodiesel production. While still an emerging field, biodiesel produced from the oils of algae is gaining more recognition as an alternative fuel source to traditional petroleum fuels.[30] As opposed to ethanol production from corn, using microalgae for biodiesel production confers an environmental advantage because microalgae do not directly require resources that are necessary for agricultural food production.[31] Also, some algae have the capability of producing up to ten times more oil than traditional agricultural biofuel crops.[32] Research has moved toward genetic modifications that alter various metabolic pathways.[33] The purpose of this patent landscape study was to search for, identify, and categorize patent documents that are relevant to genetic transformation of algae that affects lipid biosynthesis, photosynthetic efficiency, and increased oil excretion.

[30] RADAKOVITS ET AL., *supra* note 15.
[31] *Id*.
[32] WALTZ, *supra* note 17.
[33] *Id*.

IV. Disclaimer

This educational report is neither inclusive nor comprehensive. Rather, it is an informational resource intended to facilitate a better understanding of the international patent literature landscape with regard to the genetic transformation of algae for production of biodiesel.
This report is not a list of all potentially relevant patents. It is not a Freedom to Operate (FTO) opinion, but instead constitutes an educational analysis of potentially relevant material.
While the search platforms utilized in this project were extensive, it is likely that the International Technology Transfer Institute (ITTI) team did not obtain the entire spectrum of patents utilizing the various search strategies and methods articulated herein. Therefore, the ITTI team does not suppose that all relevant patents were discovered during the creation of this report.

As the ITTI team members are not experts in the field of genetic transformations of algae useful in the production of biodiesel, it is likely that the categorization of the patents found and coded are incomplete. The ITTI team cannot guarantee that the patents discovered were evaluated at the level of expert scientific sophistication.

The limited time frame (14 weeks), the academic demands, and the general press of business dictated the number of patents evaluated. As such, additional patents may have been available that were not considered due to time constraints.

V. About the Technology

Introduction

Current global energy concerns have increased awareness of unstable oil fuel prices, reliance on fossil fuels, and the harmful effects of CO_2 on the environment.[34] At the current rate of consumption, some estimates predict that oil resources will be depleted in less than 50 years.[35] This awareness has renewed the interest in finding alternative energy resources that will meet the demands of the growing modern industries.[36] Biodiesel is one such alternative energy resource that has become attractive in recent times due to its numerous benefits.[37]

[34] RADAKOVITS ET AL., *supra* note 15.
[35] HUANG ET AL., *supra* note 1, at 38.
[36] *Id*. at 39.
[37] Matthew Preiss & Stanley Kowalski, *Algae and Biodiesel: Patenting Energized as Green Goes Commercial*, 16 J. COMMERCIAL BIOTECH. 293–312 (2010).

The world's energy is dominated by nonrenewable resources, such as petroleum, coal, and natural gas which comprising 36%, 27%, and 23% of the world's total energy production, respectively.[38] The transportation sector makes up almost 30% of the world's total delivered energy and consumes greater than 50% of the world's liquid fuels, 95% of which is petroleum.[39] Biodiesel, methyl esters produced by the transesterification of biomass oils with alcohols, is generally made from soybean, vegetable, palm, sunflower, or rapeseed oils.[40] Biodiesel has become attractive in recent times because it is a renewable resource that has numerous positive environmental factors. Not only does biodiesel lower carbon dioxide emissions as compared to petroleum-based diesel, but it also decreases air toxicity levels.[41] In addition, biodiesel requires minimal change to existing infrastructure for fueling.[42]

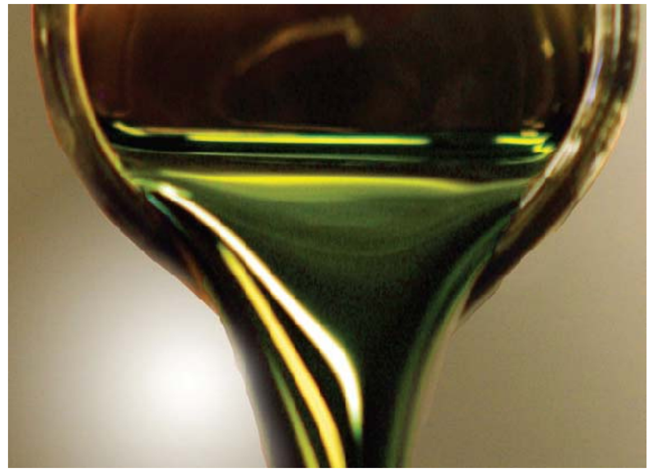
Figure 3: Algae Biofuel

Despite the many positive benefits of biodiesel fuel, the production cost is generally high due to the high cost of raw materials.[43] Because of these high production costs, the price of biodiesel to consumers is currently almost twice the cost of conventional diesel fuel.[44] In addition, the high oil per acre ratio for food crops is disadvantageous because it competes for valuable land resources. In order to address these challenges, research for lipid-rich oleaginous microorganisms has garnered great interest.[45] In particular, researchers have identified several types of microalgae as good oleaginous candidates for algal fuel production as early as the 1970s (See Figure 3).[46]

History of Microalgal Research

The oil crisis of the 1970s prompted the U.S. Department of Energy (DOE) to initiate research into the possible use of algae for biofuel production.[47] From the 1970s, the DOE invested almost $25 million towards algal fuels research.[48] However, these early efforts were not fruitful, mainly because the research did not result in technology that was economically competitive with

[38] *See* U.S. Department of Energy, U.S. ENERGY INFO. ADMIN., INT'L ENERGY ANNUAL 2006, 1980–2006 (2008) (referencing table 2.9: World Production of Primary Energy by Energy Type and Selected Country Groups (Quadrillion Btu)), *available at* http://www.eia.gov/pub/international/iealf/table29.xls.
[39] U.S. Department of Energy, U.S. ENERGY INFO. ADMIN., INT'L ENERGY OUTLOOK 2010 (2010), *available at* http://www.eia.doe.gov/oiaf/ieo/pdf/0484%282010%29.pdf.
[40] HUANG, *supra* note 1.
[41] PREISS & KOWALSKI, *supra* note 37.
[42] *Id.*
[43] HUANG, *supra* note 1.
[44] *Id*.
[45] *Id*.
[46] WALTZ, *supra* note 17.
[47] *Id*.
[48] *Id*.

petroleum-derived fuels.[49] In the 1980s and the 1990s, researchers continued the early efforts funded by the DOE, and attempted to make headway within this field using various approaches.[50] Around 1995, researchers identified and isolated algal genes that express enzymes to enhance oil production.[51] Through an initiative at the Research Institute of Innovative Technology for the Earth in Kyoto, the Japanese government continued research into the late 1990s .[52]

Now, due to increasing oil prices, a renewed interest in microalgal research and "algae fervor" has proliferated.[53] As examples of algae fuel investments, a small group of companies and start-ups currently lead the field in developing genetically-modified algae.[54] (See Table 2).

Company	Investment
Aurora Biofuels	$25 Million
Agenol	$70 Million
Sapphire Energy	$100 Million in 2008
Solazyme	$70 Million
Synthetic Genomics	Valued at $300 Million

Table 2: Companies Applying Genetic Techniques to Microalgae[55]

Understanding Microalgal Biotechnology for Biofuel Production

Advantages of Using Algae

The sudden attention and concentration on algal research can be understood after examining the benefits of algae in biodiesel production. First, algae have the potential to produce almost ten times more oil per acre than traditional biofuel crops.[56] (See Table 3). In addition, algae do not need as much land as traditional biofuel crops, and thus will not affect the production of food or other products derived from these crops.[57] Algae are also more versatile than traditional crops because they can grow in places that traditional crops cannot grow, such as in salt water.

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[49] David Glass, *Advanced Biotech. for Biofuels*, RENEWABLE FUELS BLOG (Jan. 21, 2010, 9:12 PM), http://dglassassociates.wordpress.com/.
[50] WALTZ, *supra* note 17.
[51] *Id*.
[52] *Id*.
[53] *Id*.
[54] *Id*.
[55] *Id*. at 17.
[56] WALTZ, *supra* note 17.
[57] HUANG, *supra* note 1.

Crop	Gallons of Oil/Acre/Year
Soybeans	43
Sunflower	86
Canola	171
Jatrjopha	214
Palm Oil	641
Microalgae	Up to 6,000 (with future technology)

Table 3: Potential Oil Yields per Acre per Year[58]

Second, microalgae grow extremely rapidly, and are highly oleaginous organisms.[59] Microalgae are single cell photosynthetic organisms that are capable of doubling in a 24-hour period.[60] (See Figure 4)[61]. Microalgae with oil content levels of 20-50% of the total biomass are not uncommon in microalgae.[62] In fact, algae contain between 8-24 times more triacylglycerol (natural oils) per area than other biomass resources.[63] Third, algae can grow using cheap resources such as waste carbon dioxide, nutrients in agricultural run-off or wastewater.[64] Finally, the by-products of algae biofuel production, such as biopolymers, proteins and animal feed, are valuable products in and of themselves.[65]

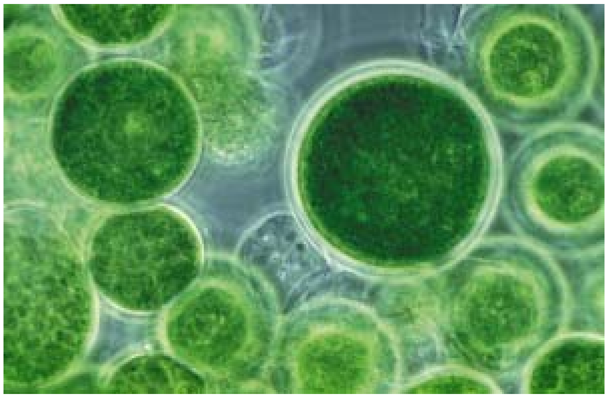

Figure 4: Microalgae

Algae Biodiesel Production Process

Algae biodiesel production process can be broken down into three distinct stages: growth, harvesting, and extraction and processing (e.g. transesterification). (See Figure 5). At each stage, factors such as energy input, material input (such as nutrients), and waste product treatment are considered to develop an economically viable oil product.[66]

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58 WALTZ, *supra* note 17, at 16.
59 HUANG, *supra* note 1.
60 Yusuf Chisti, *Biodiesel From Microalgae*, 25 BIOTECH. ADVANCES 294–306 (2007).
61 *The Green Optimistic*, http://www.greenoptimistic.com/2009/07/04/microalgae-biofuel-an-alternative-to-crop-biofuel/ (last visited May 14, 2011).
62 HUANG, *supra* note 1.
63 CHISTI, *supra* note 60.
64 WALTZ, *supra* note 17.
65 *Id*.
66 Stuart Scott et al., *Biodiesel From Algae, Challenges and Prospects*, 21 CURRENT OP. IN BIOTECH. 277, 277 (2010).

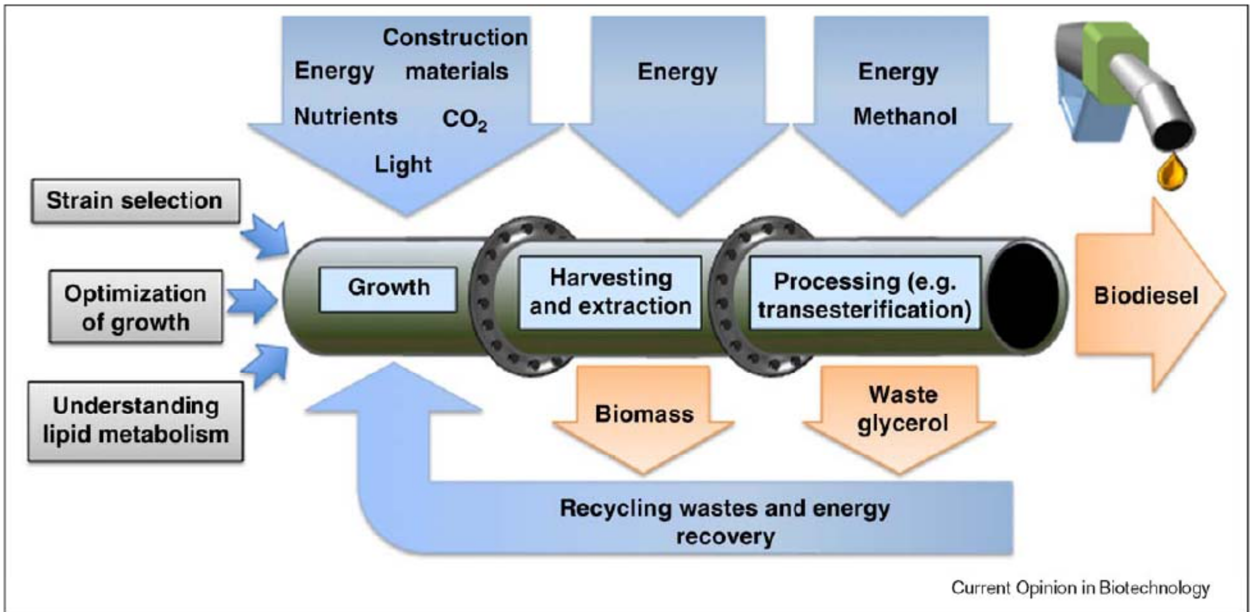

Figure 5: Algae Biofuel Production Process[67]

The first step in algae biofuel production is the growth of algal biomass and the production of fuel molecules.[68] In this stage, an appropriate algae strain is selected based on criteria such as, but not limited to, the quantity of lipids the strain accumulates and growth rates.[69] The chosen strain is carefully evaluated and optimized for growth because lipid production often decreases as growth increases.[70] Various materials, such as nutrients, CO_2, light, and energy are added at this stage to aid in the growth of the algal biomass. In addition, issues such as the type of bioreactor (open or closed), contamination by adventitious organisms, and the method of nutrient delivery are of particular concern.[71]

The second stage of the algae biofuel production process is to harvest the biomass grown, and then to extract the product from the biomass, such as triacylglycerides (natural oils). It is economically important to release the lipids from the biomass in an energy-efficient manner while recovering valuable co-products.[72] In addition, it is equally important to release the natural oils of the algae without contaminating the oils with other cell products such as DNA or chlorophyll.[73]

The third stage of the algae biofuel production process is the final processing of the extracted triacylglycerides, and the use of valuable co-products. The triacyglycerides that are extracted from the algae biomass are converted to biodiesel fuel when the triacyglycerides undergo

[67] *Id*.
[68] *Id*. at 278.
[69] *Id*.
[70] *Id*.
[71] *Id*.
[72] *Id. at* 279.
[73] *Id*.

transesterification with methanol to yield methyl esthers.[74] The glycerol co-products should be captured as it is a valuable co-product.

Industry Leaders

This report identifies several key industry leaders within the algae biofuel industry. One factor in identifying leaders in a particular field of research is by the size of a patent portfolio. In this industry, the top leaders are BASF Plant Sciences, Solazyme, Inc., Martek Biosciences, Du Pont and Aurora Biofuels Inc.

BASF, headquartered in Germany, is the largest chemical company in the world. BASF conducts its business based on sustainable developments.[75] BASF structures its operations into six unique business sectors, two of which include agricultural solutions and oil and gas. BASF recently partnered with Monsanto, a leader in plant biotechnology to further research in the area of algae biofuel technologies.[76]

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[74] *Id*.
[75] BASF, http://www.basf.com/group/corporate/en/about-basf/index?mid=0 (last visited Apr. 24, 2011).
[76] *Id.*
[77] SOLAZYME, http://www.solazyme.com/company-overview (last visited Apr. 24, 2011).
[78] WALTZ, *supra* note 17.
[79] MARTEK, http://www.martek.com/about.aspx (last visited Apr. 24, 2011).
[80] Id.
[81] DUPONT, http://www2.dupont.com/Oil_and_Gas/en_CA/environment/Clean_Technologies/clean_technologies.html (last visited Apr. 24, 2011).
[82] AURORA INC., http://www.aurorainc.com/company/contact-aurora/ (last visited Apr. 24, 2011).
[83] *Id*.
[84] *Id*.

Upcoming Challenges to Overcome

Although algae biofuel production is a promising new field, there are several technical barriers that must be overcome before microalgae become an economically viable option.[85] For example, algae are incredibly diverse and almost 200,000 species of algae exist.[86] This makes finding an ideal strain of algae difficult and time consuming.[87] After finding a suitable strain of algae, it is then necessary to optimize the strain to compensate for the trade-off between energy devoted to growing, and energy devoted to accumulating oils.[88] In addition, maintaining consistency while growing each batch of algae biomass and developing low-energy methods of harvesting and extraction are other important issues to consider.[89]

One of the most important goals of microalgal biodiesel fuel production is to reduce the cost during the production phase in order to lower the ultimate cost to a potential consumer. Currently, algae biodiesel costs approximately $13.25 per gallon to produce, whereas petroleum fuel sources are approximately $1.65 to $2.91 to produce.[90] A majority of the total production cost, almost 70%-90%, is accrued during the Biomass Growth/Cultivation stage and the Harvesting and Extraction stage.[91] Thus, researching genetic and metabolic engineering of algae would have the greatest impact on algal biodiesel economics.[92] This report considers research advances in photosynthetic efficiency, lipid biosynthesis, genetic transformation and oil excretion technologies.

Photosynthetic Efficiency

One idea behind improving photosynthetic efficiency is to engineer the strains to synthesize a large amount of photoreceptor molecules.[93] This is done by engineering cyanobacteria to express the enzymes pyruvate decarboxylase and alcohol dehydrogenase.[94]

Another method of increasing the photosynthetic efficiency is to increase the cellular tolerance to variety of stress factors, including High Light Stress.[95]

Lipid Biosynthesis

One concept behind lipid biosynthesis is to establish strategies that increase the expression of enzymes that are involved in the pathways of fatty acid synthesis.[96] Increasing the production

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[85] RADAKOVITS ET AL., *supra* note 15.
[86] WALTZ, *supra* note 17, at 16.
[87] *Id*.
[88] *Id*.
[89] RADAKOVITS ET AL., *supra* note 15.
[90] CHISTI, *supra* note 60.
[91] Michael J. Haas et al., *A Process Model to Estimate Biodiesel Prod. Costs*, 97 BIORESOURCE TECH. 671–78 (2006).
[92] Xin Meng, *Biodiesel Prod. From Oleaginous Microorganisms*, 34 RENEWABLE ENERGY 1–5 (2009).
[93] GLASS, supra note 49, at 2.
[94] *Id*.
[95] RADAKOVITS ET AL., *supra* note 15, at 496.
[96] *Id*. at 489.

rate or quality of the lipids is one way to increase the oil production in microalgae, which in turn will improve economic feasibility. Oleaginous algae accumulate large quantities of stored lipids in response to stresses such as nitrogen limitations, high salinity, or unsuitable temperatures.[97]

Genetic Transformation

The availability of rapid large-scale sequencing technologies have sparked a new growth in microalgae research.[98] In addition, several microalgae genome sequences already exist, allowing for easy genetic manipulation.[99] Several different transformation methods have been used to transfer DNA into microalgae cells.[100] These methods include agitation in the presence of glass beads, electroporation, and biolistic microparticle bombardment.

Oil Excretion Technologies

Perhaps the most costly processing occurs during the downstream steps of fuel production.[101] These steps include harvesting the microalgae and then extracting the fuel precursors from the biomass.[102] Several methods within the current technology allow one to concentrate the biomass and then extract the fuel precursors by settling and flocculation; however, these methods are slow and inefficient.[103] Other methods, such as centrifugation and filtration, are faster, but they are much more expensive and energy intensive.[104] One important problem for any extraction method is the fact that microalgal species have a tough outer cell wall that requires harsh lysis conditions to penetrate it.[105] Another problem is producing enough microalgal oil necessary for this method to realize economic benefits.[106]

A possible solution to overcome this extraction problem would be to manipulate the biology of algae cells so that the algae fuel secretes directly into the growth medium.[107] Various ways to accomplish this concept have been found utilizing the manipulation of established lipid-secretion pathways. These methods include secretion of triacylglycerol-containing, very-low-density vesicles from hepatocytes, triacylglycerol-containing vesicles from mammary glands, and the manipulation of ABC transporters.[108]

Pyrolysis technologies are another method of extracting oils from microalgal cells. Initially developed in 1986, this method relates to the decomposition of biomass under high temperatures

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[97] Inna Khozin-Goldberg & Zvi Cohen, *Unraveling Algal Lipid Metabolism: Recent Advances in Gene Identification*, 93 BIOCHIMIE 91, 91 (2011).
[98] RADAKOVITS ET AL., *supra* note 15, at 487.
[99] *Id.*
[100] *Id.*
[101] *Id*. at 492.
[102] *Id*.
[103] *Id*.
[104] *Id*.
[105] *Id*.
[106] HUANG, *supra* note 1, at 43.
[107] RADAKOVITS ET AL., *supra*, note 15, at 492.
[108] *Id*.

and low oxygen levels.[109] This method is suitable for extracting oil from microalgae because of the relatively low cost of the process as compared to the high quality of oil obtained.[110]

Liquefaction is a method that attempts to solve the problem of high water content in microalgae after the harvesting process. It requires a high level of energy to remove the high levels of moisture in the algae; thus, liquefaction has been developed to produce biofuel directly without first drying the microalgae.[111]

These methods provide lower production costs; however, the manipulation of pathways required to achieve the desired results is still unclear in some instances. In addition, the problem of oil contamination after extraction limits many of the methods.

VI. Patent Search Methodology and Results

Patent Search Methodology

The ITTI team identified algal biodiesel technology as an ongoing research topic at University of New Hampshire ("UNH") Durham. Professor Cavicchi communicated with Dr. Ihab H. Farag, a professor in the UNH biodiesel group, that ITTI would pursue this project as a potential point of synergy with UNH's biodiesel program. This is viewed as a complementary effort because ITTI has published in the field.[112]

The ITTI team, under the direction of Professor Jon Cavicchi and technical supervisor Dr. Stanley Kowalski, began reviewing recent literature on the technology relating to genetic transformations of algae for the production of biodiesel. The ITTI team commenced searching with basic search terms such as alga*, and biodies*, then reviewed the results.

The ITTI team commenced an intense three-month iterative search and coding process. Thomson Innovation was the primary patent searching platform, but the ITTI team also used other tools, including Lexis Total Patent™, the USPTO website, Patent Lens, and websites such as freepatentsonline.com.

The searches utilized keywords derived from the non-patent literature and the initial search results to generate useful search strings. The ITTI team initially divided the search into two groups: one group searched for patent records relevant to lipid biosynthesis while the other searched for patent records relevant to photosynthesis. Searches used the United States Patent Classifications, International Patent Classifications, and Derwent World Patent Classifications that the ITTI team identified in previous searches and team meetings. The combination of keywords and classifications in search strings was useful for parsing the technology into compartments and allowing each team member to generate a different set of search results that keywords alone could not provide. This approach generated a broad set of patents from which keywords and classifications were used in subsequent rounds of searching. After each round of

[109] HUANG, *supra* note 1, at 43.
[110] *Id.*
[111] *Id.* at 44.
[112] *See, e.g.*, PREISS & KOWALSKI, *supra* note 37.

searching, the ITTI team met and identified the most important keywords and classifications for use in subsequent search strings.

Because searches that included the specification and description fields were too broad, the ITTI team searched the fields of title, abstract, and claims or, at times, only the claims field alone.

Thomson Innovation

ITTI utilized Thomson Innovation, a patent search platform that integrates the best of the suite of Thomson tools, Aureka®, Delphion® and MicroPatent®. Thomson Innovation is a single, integrated solution that combines intellectual property, scientific literature, business data and news with analytic, collaboration, and altering tools in a robust platform.

TotalPatent™

ITTI also utilized TotalPatent™, a Lexis Nexis platform, to search patents and patent applications world-wide. TotalPatent™ provides several additional countries that are not included in other platforms.[113] Also, TotalPatent™ offers useful tools such as semantic searches, the ability to search for subsidiary companies and corporate structure, and analytics.

Gene Sequence Searching

The ITTI team additionally used Patent Lens, a free public resource initiative of Cambia, to specifically search nucleotide sequences.[114] Patent Lens obtains patent and patent application data through subscriptions with WIPO, USPTO, EPO, IP Australia and INPADOC. It updates weekly and includes full-text of more than eight million patents and applications. It also includes DNA, RNA and Protein Sequences extracted from United States patent documents. This unique feature was useful to this project because nucleotide sequences could be copied into the search engine. However, Patent Lens only searches United States patents and patent applications for the sequences, and these sequences were last updated May 2, 2010. For more information, visit http://www.patentlens.net/sequences/blast/blast.html.

Patent Lens uses NCBI's Blast Software to search sequences that are specifically listed in US Patents and published patent applications. ITTI obtained relevant gene sequences by searching patents on the USPTO website. ITTI found sequences in the Image File Wrapper using the USPTO's Public Pair.

Other search techniques:

1. Using the Patent Lens website, ITTI accessed the Blast tool located on the patent landscape menu and searched by inputting a genetic sequence into BLAST. A screen shot of BLAST is shown in Figure 6 and Figure 7, below.

[113] *See* LEXIS TOTAL PATENT, http://www.lexisnexis.com/totalpatent.
[114] PATENT LENS, http://www.patentlens.net/ (last visited Apr. 24, 2011).

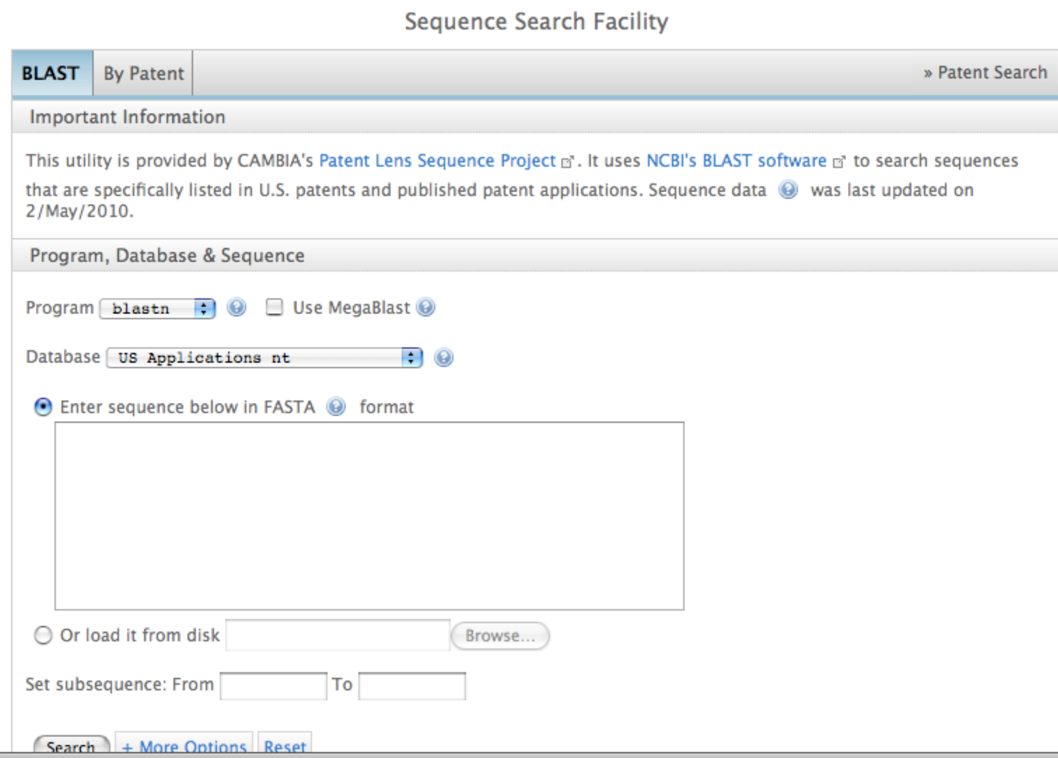

Figure 6: BLAST Screenshot

2. Next, ITTI clicked the "by patent" tab and input a patent number. A screen shot of searching by patent is shown in Figure 7 below.

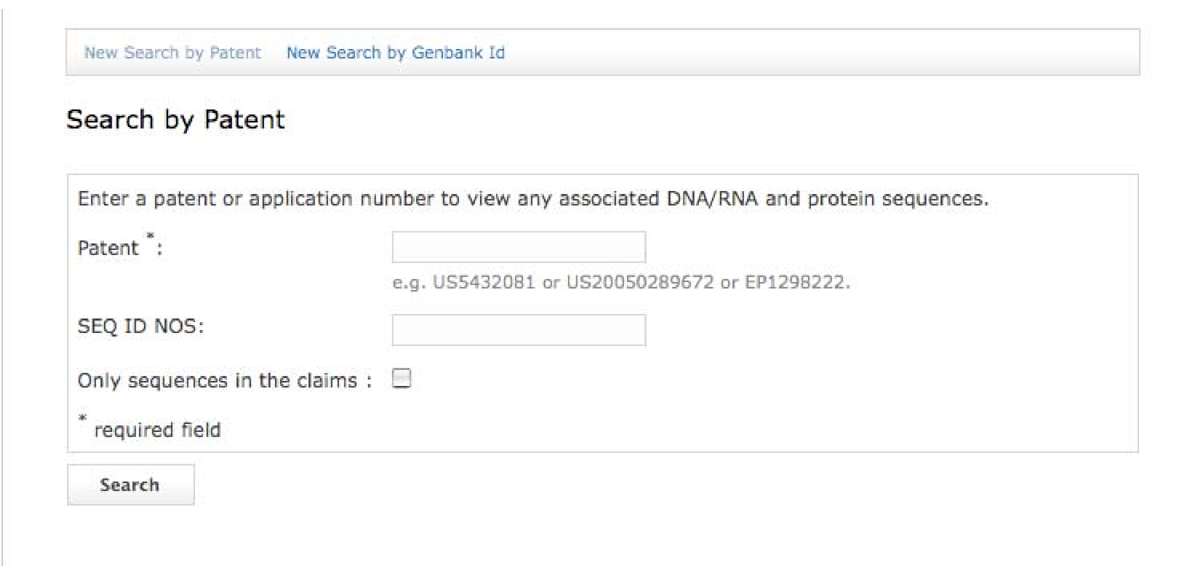

Figure 7: Search by Patent Screenshot

3. The ITTI team then analyzed the search results having an "E" value between 0.0 and 1.0. The "E" value, or the "Expect" value, represents the statistical significance threshold for reporting matches against database sequences. Lower expect thresholds are more

stringent, leading to fewer chance matches being reported. Results with values beyond 1.0 consisted of sequences that ITTI considered not relevant to our project.

One search strategy used to find patents directed to genetic sequences was to download algal sequences for essential enzymes that are required in lipid production. The ITTI team then copied these sequences into the Patent Lens database, which would then return patents that involve sequences homologous to the one entered. This enabled the team to find patents that might not have mention biodiesel, but are still relevant because they essentially claim the production of biodiesel using algae.

To download sequences of organisms, ITTI team members used the National Center for Biotechnology Information (NCBI) website. NCBI comprises GenBank, a DNA sequence database that comprises nucleotide and amino acid sequences for a large variety of organisms that are acquired from research labs all over the world. NCBI is a free website that is maintained by the National Institute of Health. An example of a downloaded sequence from NCBI is the nucleotide sequence of diacyl glycerol acyl transferase in Chlamydomonas reinhardtii, an algal strain that is often used to produce biodiesel. Diacylglycerol acyl transferase is an important enzyme in the production of lipids in algae, a step that is required to produce biodiesel. This nucleotide sequence was useful to search because the search returned relevant patents that had sequences homologous to Chlamydomonas reinhardtii's diacyl glycerol acyl transferase.

In conclusion, Patent Lens and NCBI provided useful and free databases to search genetic sequences. They were useful tools for searching genetic sequences of patent documents already coded and finding new relevant patent documents.

<u>Foreign Searches</u>

The ITTI team included some strictly international searches for this report. The following paragraphs describe which international countries were specifically searched and the search strategies for each of those countries.

Brazil

An international search of relevant documents in Brazil was conducted using Lexis TotalPatent. An initial search of broad terms such as "alga*" and "biodiesel" returned 16 documents, and more narrow search terms produced less documents. None of the patents or patent applications were relevant to our project.

China

Thomson Innovation® was first consulted in searching for patents or patent applications originating from China. In order to accomplish this, the "collections to search" were restricted to Chinese Utility Models and Chinese Applications. Previous search strings that brought desirable results were used within this narrow window to maximize the chances of finding relevant documents. The search then moved to Westlaw® and the CN-PAT-ALL database contained therein. This database contains full text human translations of Chinese patent documents published by the State Intellectual Property Office (SIPO) since 2007. Similar search strings were used and the results were the same from the initial Thomson Innovation® search. In order to be as thorough as possible and exhaust all resources, free web resources were consulted. These included www.intellogist.com, search.cnpat.com.cn, www.bios.net, and www.surfip.gov.sg. These free sources are free of charge for a reason and did not return any results applicable that were not already found.

India

To search for patent documents from India, Lexis TotalPatents® and BigPatents India were used. BigPatents India is the only site with all post-TRIPs Indian patent applications online and is accessible for free. Few patent documents related to the production of biodiesel from algae were found, but none of them were relevant to the technology related to the genetic transformation of algae to produce biodiesel.

News Websites

Because algae biodiesel is currently a hot technology area and new companies and players emerge regularly, the ITTI team monitored various news websites and blogs related to algae biodiesel. By monitoring the up-to-date algae biodiesel news as it emerged, the ITTI team became aware of major players and technologies relevant to algae biodiesel. Additionally, as a result of the companies, inventors, assignees, and technologies mentioned on the news websites and blogs, the ITTI team identified more key terms in order to create more effective search strings.

The news websites and blogs that ITTI monitored are listed below with a brief description.

1. **Xconomy** – Xconomy is a business and technology blog news website "dedicated to providing business and technology leaders with timely, insightful, close-to the scene information about the local personalities, companies, and technological trends that best exemplify today's high-tech economy."[115] The ITTI team searched xconomy weekly using the term "algae" to obtain the latest algae biodiesel related news that xconomy offered.
2. **WestClip** – WestClip is a clipping service provided by Westlaw that allows one to track the latest news and legal development in a particular field.[116] It runs searches, weekly, bi-weekly or monthly and directly reports the search results via email or fax.[117] For this project a WestClip search was performed, wherein the search terms used were broad such as alga* and biofuel, so as to cover any relevant legal news. The search was automatically performed once a week by features on WestClip, however, no relevant results were returned.

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115 XCOMONY, http://www.xconomy.com/about/ (last visited Apr. 13, 2011).
116 West Store, THOMSON REUTERS, http://west.thomson.com/westlaw/advantage/tools/west-clip/default.aspx (last visited Apr. 25, 2011).
117 *Id.*

3. **Oilgae** – Oilgae is an integrated algae biodiesel web resource. Founded in 2007, Oilgae ranks as one of the most well-known resources in the biofuels industry.[118] Oilgae publishes a daily industry news clip and an annual industry report.[119] The news clips and reports track biofuel industry leaders and rising startups. In addition, Oilgae is a subsidiary project of Clixoo, a global sustainability consultancy.[120]
4. **Advanced Biotechnology for Biofuels** - The blog "Advanced Biotechnology for Biofuels" is maintained by David Glass, Ph.D. in conjunction with D. Glass Associates, Inc., which is a consulting company specializing in several fields of biotechnology.[121] David Glass, Ph.D. is a veteran of nearly thirty years in the biotech industry, with expertise in industrial biotechnology regulatory affairs, patents, technology licensing, and market and technology assessments.[122] The blog focuses on general information pertinent to the various biotechnological advances and their impact on the production of renewable biofuels. In addition, the blog highlights various companies and their contributions to the field of study.
5. **Algae Industry Magazine (AIM)** – Algae Industry Magazine, is an online publication that aims at bringing inventors and the industry on a common platform.[123] It addresses the progress of the field with respect to the latest technology and innovation, interviews with the major companies involved in the biofuel production. It also has information on algae biofuel production, latest products in the field along with the economics of the field.[124] The publication also comprises of various videos that are regularly updated that show the different approaches that can be employed to produce biodiesel from algae.[125] This publication would be a helpful resource to start-ups as it also covers the latest infrastructure useful for algae biodiesel production.
6. **Algae2oil** – Algae2oil blog is a blog dedicated to providing news about the new technologies and developments in the field of bio-fuel produced from algae.[126] It gives an insight on the commercial usage of algae bio-fuel and the top leaders and inventors investing in the development of this field.[127] The ITTI team was able to find some articles which gave it insight into the top companies investing in the technology of producing bio-fuel from algae and therefore the top assignees for relevant patent documents. Unfortunately the blog has been inactive since February 2010.[128]
7. **Biofuelsdigest** – Biofuels Digest is the most popular biofuels daily blog in the world.[129] The blog's coverage includes producer news, research innovation, policy issues, conferences, and financial news of various biofuels such as ethanol or algae biodiesel.[130] The blog includes a report on the Biofuels Digest Index™, which is a

[118] OILGAE, http://www.oilgae.com/ref/about/about.html (last visited Apr. 25, 2011).
[119] *Id.*
[120] *Id.*
[121] *Advanced Biotech. for Biofuels*, http://dglassassociates.wordpress.com/ (last visited Apr. 25, 2011).
[122] *Id.*
[123] ALGAE INDUS. MAGAZINE, http://www.algaeindustrymagazine.com/ (last visited Apr. 25, 2011).
[124] *Id.*
[125] *Id.*
[126] ALGAE2OIL, http://algae2oil.blogspot.com/ (last visited Apr. 25, 2011).
[127] *Id.*
[128] *Id.*
[129] http://www.biofuelsdigest.com.
[130] *Id.*

group of public biofuel stocks, in the financial news section.[131] The ITTI team used Biofuels Digest's list of The 50 Hottest Companies in Bioenergy for 2010-2011 to assist in determining the most active companies in algae biofuels research and patenting.[132]

The ten-member ITTI team was divided into four groups and supervised by a project leader.

The IITI team used recent literature to develop a synonym list and to determine search keywords. ITTI then used these keywords for preliminary searches on Thomson Innovation, the USPTO and/or TotalPatent® websites. The keywords used in the two main categories in the search rounds are shown below in Table 4.

Term	Keyword
algae, algal, microalgae	alga*
microorganism	
oleaginous	
eukaryotic, eukaryote	eukaryot*
prokaryotic, prokaryote	prokaryot*
microalgae	
glycerol-3-phosphate	glycerol-3-phos*
biodiesel	biodies*
biofuel(s)	
ethyl ester(s), methyl esters	
fatty acid	
fatty acid synthase, FAS	
transesterification, transesterified	transesterif*
lipid	
oil	
gene, genetic	gene*
modification, modified	modif*
transformation, transform, transformed	transform*
engineered	
transgenic	
altered, altering	alter*
acyltransferase	
acetyl-CoA	
elongase	
heterotrophic	
photoautotrophic	
mixotrophic	
exogenous	
expression, expressed, over-	express*

[131] *Id.*
[132] *Id.*

expressed	
suppression, suppressed	suppress*
triacylglycerol, TAG	
photosynthetic, photosynthesis	photosynth*
light	
biosynthesis	biosynth*
excretion, excrete	excret*
secretion, secrete	secret*

Table 4: Keywords

The team commenced an intense three-month journey of patent searching and coding. The team members primarily used Thomson Innovation searching database. In addition to Thomson Innovation, the ITTI team also used the LEXIS TotalPatent® database.

These searches utilized keywords derived from the literature reviewed and initial searches to generate useful search strings; the searches also used United States Patent Classifications and International Patent Classifications that were identified through subsequent searches and team meetings. The combinations of keywords and classifications in search strings was useful for parsing the technology into compartments and allowing each team member to generate a different set of search results that keywords alone could not provide. This approach generated a broad set of patents. From here, ITTI used the keywords and classifications generated from this broad set of patents in subsequent rounds of searching. After each round of searching, team meetings would identify the most important keywords and classifications for use in subsequent search strings that became more defined and effective.

Many of these keywords were searched using the search field of “Title, Abstract and Claims” within Thomson Innovation. ITTI determined that searches under the “Description” and “Specification” fields would be too broad. It was useful to limit each search using the specific terms under the search field of “Claims”.

Patent Search Results

The search strings gave the ITTI team an outcome of 190 patent documents (after the deduplication process, described in detail below) for coding. Below is a list of search strings used in Thomson Innovation.

2.A. Patent Search Tables

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algae, biodies*, lipid, biosynth*
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(algae and biodies* and lipid and biosynthe*);
Total Hits	7

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algae, biodies*
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(algae and biodies*);
Total Hits	206

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algae, biodies*, triacylglycerol, TAG
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(algae and biodies* and (triacylglycerol or tag));
Total Hits	6

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO

	Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algae, biodies*, acetyl-coA, acetyl-coenzyme, CoA
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(algae and biodies* and (acetyl-coA or acetyl-coenzyme or CoA));
Total Hits	2

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Alga*, glycerol-3-phos*
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(alga* and glycerol-3-phos*);
Total Hits	10

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Solazyme
Classification/ Sub-Classification	Not Applicable
Search String	PA=(Solazyme);
Total Hits	73

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Acyltransferase, triacylglycerol, TAG, acetyl-CoA, acetyl-coenzyme, CoA, glycerol-3-phos*, lipid, biosynthe*, synthe*, alga*, oleaginous, organism
Classification/ Sub-Classification	Not Applicable
Search String	CTB=((acyltransferase or (triacylglycerol or TAG) or (acetyl-CoA or acetyl-coenzyme or CoA) or glycerol-3-phos* or (lipid and (biosynthe* or synthe*)))

	and (alga* or (oleaginous and organism)));
Total Hits	460

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application ***Asian Translated:*** Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Acyltransferase, triacylglycerol, TAG, acetyl-CoA, acetyl-coenzyme, CoA, glycerol-3-phos*, lipid, biosynthe*, synthe*, alga*, oleaginous, organism, biodies*
Classification/ Sub-Classification	Not Applicable
Search String	CTB=((acyltransferase or (triacylglycerol or TAG) or (acetyl-CoA or acetyl-coenzyme or CoA) or glycerol-3-phos* or (lipid and (biosynthe* or synthe*))) and (alga* or (oleaginous and organism)) and biodies*);
Total Hits	21

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application ***Asian Translated:*** Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Sapphire, Energy
Classification/ Sub-Classification	Not Applicable
Search String	PA=(sapphire ADJ energy);
Total Hits	50

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application ***Asian Translated:*** Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	General, Atomics, Alga*
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(alga*) AND PA=(General ADJ Atomics);
Total Hits	10

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application

	Asian Translated: Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Alga*, biodies*, biofuel*, oil
Classification/ Sub-Classification	US 435/134
Search String	UC=(435/134) AND CTB=(alga* and (biodies* or biofuel* or oil));
Total Hits	72

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Alga*
Classification/ Sub-Classification	US 435/134
Search String	UC=(435/134) AND CTB=(alga*));
Total Hits	129

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Alga*
Classification/ Sub-Classification	US 435/257
Search String	UC=(435/257) AND CTB=(alga*));
Total Hits	16

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	University, of, California
Classification/ Sub-Classification	N/a
Search String	PA=(university ADJ of ADJ california);
Total Hits	22,265

Database	Thomson Innovation

	Full Text: U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	University, of, California, alga*
Classification/ Sub-Classification	N/a
Search String	CTB=(alga*) AND PA=(university ADJ of ADJ california);
Total Hits	213

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	University, of, California, alga*, biodies*, biofuel*
Classification/ Sub-Classification	N/a
Search String	CTB=(alga* and (biodies* or biofuel*)) AND PA=(university ADJ of ADJ california);
Total Hits	2

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	The, ohio, state
Classification/ Sub-Classification	N/a
Search String	ORG=(UNIV ADJ OHIO ADJ STATE) OR PER=(UNIV ADJ OHIO ADJ STATE);
Total Hits	1,102

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Alga*, univ*, ohio, state
Classification/ Sub-Classification	N/a

Search String	CTB=(alga*) AND PA=(UNIV ADJ OHIO ADJ STATE);
Total Hits	15

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Univ*, Montana
Classification/ Sub-Classification	N/a
Search String	PA=(university ADJ of ADJ montana);
Total Hits	99

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	University, of, york
Classification/ Sub-Classification	N/a
Search String	PA=(university ADJ of ADJ york);
Total Hits	243

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	University, of, york, alga*
Classification/ Sub-Classification	N/a
Search String	CTB=(alga*) AND PA=(university ADJ of ADJ york);
Total Hits	7
Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Alga*, biodies*, bio-dies*, biofuel, bio-fuel, transform*
Classification/ Sub-	N/a

Classification	
Search String	CTB=(alga* and (biodies* or bio-dies* or biofuel or bio-fuel) and transform*);
Total Hits	42

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(photosynthetic and genetic and lipid)
Total Hits	18

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Title:	MANIPULATION OF SNF1 KINASE FOR ALTERED OIL CONTENT IN OLEAGINOUS ORGANISMS US2009549439A
Classification/ Sub-Classification	435/136; B04, D16
Search String	CTB=(alga* and eukaryot* and polyunsaturated);
Total Hits	27

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Title:	Growing of eukaryotic microorganisms capable of producing lipids by adding carbon source and limiting nutrient source to fermentation medium to obtain specified biomass density US2003371394A
Classification/ Sub-Classification	435/136; B04, D16
Search String	CTB=(alga* and eukaryot* and polyunsaturated);
Total Hits	27

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application

	Asian Translated: Japanese Utility Models, Japanese Granted, Japanese Application
Title:	
Classification/ Sub-Classification	435*
Search String	CTB=(alga* and lipid);
Total Hits	147

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Title:	Mortierella alpina glycerol-3-phosphate o-acyltransferase for alteration of polyunsaturated fatty acids and oil content in oleaginous organisms
Classification/ Sub-Classification	435/069.1
Search String	CTB=(alga* and lipid);
Total Hits	15

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Title:	Mortierella alpina glycerol-3-phosphate o-acyltransferase for alteration of polyunsaturated fatty acids and oil content in oleaginous organisms
Classification/ Sub-Classification	435/134
Search String	CTB=(alga* and lipid);
Total Hits	51

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Title:	Method for Increasing the Content of Polyunsaturated Long-Chained Fatty Acids in Transgenic Organisms
Classification/ Sub-Classification	435/134
Search String	CTB=(alga* and lipid) and UC=435/134

Total Hits	15

Database Title:	Thomson Innovation Novel method for the production of polyunsaturated fatty acids
Keywords	CTB = (alga* and genetic)
Classification/ Sub-Classification	US class = 435/134
Search String	CTB=(alga* and genetic) AND UC=(435/134);
Total Hits	6

Database Title:	Thomson Innovation
Keywords	CTB = (alga* and photosynth*)
Classification/ Sub-Classification	US class = 435/167
Search String	CTB=(alga* and photosynth*) AND UC=(435/167);
Total Hits	4—apparatus patents

Database Title:	Thomson Innovation Method, apparatus and system for biodiesel production from algae
Keywords	CTB = (alga* and photosynth*)
Classification/ Sub-Classification	US class = 435/134
Search String	CTB=(alga* and photosynth*) AND UC=(435/134);
Total Hits	9

Database Title:	Thomson Innovation
Keywords	CTB = (lipid and photosynth*)
Classification/ Sub-Classification	US class = 435/134
Search String	CTB=(lipid and photosynth*) AND UC=(435/134);
Total Hits	

Database Title:	Thomson Innovation
Keywords	Biofuel
Classification/ Sub-Classification	US class = 435/134
Search String	CTB=(biofuel*) AND UC=(435/134);
Total Hits	40

Database	Lexis Total Patent: US, EP, WO, JP, DE, FR, GB, CA, CN
Keywords	Algae, microalgae, excretion, secretion, lipid, oil
Classification/ Sub-	Not Applicable

Classification	
Search String	TITLE-ABST-CLAIM(((Alga! or microalga*) and (excret! or secret!) and (lipid or oil))) and DATE(>=1991-03-11)
Total Hits	65

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	See search string
Classification/ Sub-Classification	c12N000504 or c12N000112 or c12P000764 or c12N000121 or c12N000113 or c12N001574 or c12N001580 or c12N001585 or c12N001587 or c12N000120 or c12N000119 or c12n001581 or c12N000510
Search String	CTB=(oil or lipid or secret* or excret*) and (gene or genetic* or transgenic or transform*) and (alga or algae or microalgae or oleaginous or eukaryotic)
Total Hits	1559

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	See search string
Classification/ Sub-Classification	c12N000504 or c12N000112 or c12P000764 or c12N000121 or c12N000113 or c12N001574 or c12N001580 or c12N001585 or c12N001587 or c12N000120 or c12N000119 or c12n001581 or c12N000510
Search String	TI=(oil or lipid or secret* or excret*) AND CL=(gene or genetic* or transgenic or transform*) and (alga or algae or microalgae or oleaginous or eukaryotic) AND AIOE=(c12N000504 or c12N000112 or c12P000764 or c12N000121 or c12N000113 or c12N001574 or c12N001580 or c12N001585 or c12N001587 or c12N000120 or c12N000119 or c12n001581 or c12N000510) AND ALL=(biodiesel* or biofuel*);
Total Hits	24

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese

	Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	See search string
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(biodiesel or biofuel) AND TI=(gene or genetic* or transgenic or transform*) AND CL=(alga or algae or algal or microalgae or oleaginous or eukaryotic) AND CTB=(oil or lipid or secret* or excret*);
Total Hits	13

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	See search string
Classification/ Sub-Classification	c12N000504 or c12N000112 or c12P000764 or c12N000121 or c12N000113 or c12N001574 or c12N001580 or c12N001585 or c12N001587 or c12N000120 or c12N000119 or c12n001581 or c12N000510
Search String	ALL=(biodiesel or biofuel) AND TI=(gene or genetic* or transgenic or transform*) AND CL=(alga or algae or algal or microalgae or oleaginous or eukaryotic) AND CTB=(oil or lipid or secret* or excret*) AND AIOE=(c12N000504 or c12N000112 or c12P000764 or c12N000121 or c12N000113 or c12N001574 or c12N001580 or c12N001585 or c12N001587 or c12N000120 or c12N000119 or c12n001581 or c12N000510);
Total Hits	8

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Applications, European Granted, European Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Enhanced Patent Data - DWPI
Keywords	Alga
Classification/ Sub-Classification	Not Applicable
Search String	(alga* and TLA1)
Total Hits	10

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Application, European

	Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	Alga, genetic, transformation
Classification/ Sub-Classification	Not Applicable
Search String	(alga* and (gene* and transformation) and biodiesel) (genetic* AND engineer*) AND microalgae AND biofuel
Total Hits	205

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	Genetic and engineering
Classification/ Sub-Classification	
Search String	(genetic* AND engineer*) AND microalgae AND biofuel
Total Hits	154
Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	Genetic and engineering
Classification/ Sub-Classification	
Search String	(genetic* AND engineer*) AND microalgae AND biodiesel
Total Hits	188

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	Microalgae and biofuel
Classification/ Sub-Classification	
Search String	(genetic* AND engineer*) AND microalgae AND biofuel
Total Hits	154

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	Genetic engineering
Classification/ Sub-Classification	
Search String	(genetic AND engineering) AND microalgae AND biodiesel
Total Hits	98
Database	Thomson Innovation Full Text: U.S. Granted, US Applications, WIPO Application, European Granted, European Application Asian Translated: Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	Biodiesel
Classification/ Sub-Classification	
Search String	Microalgae and (genetic AND engineering) AND biodiesel
Total Hits	115

Database	Thomson Innovation Full Text: U.S. Granted, US Applications, WIPO Application, European Granted, European Application Asian Translated: Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	N/A
Classification/ Sub-Classification	435/134
Search String	Biodiesel
Total Hits	110

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application,
Keywords	N/A
Classification/ Sub-Classification	435/134

Search String	Genetic and engineering
Total Hits	339- mostly Martek BioScience came up

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Applications, European Granted, European Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Enhanced Patent Data - DWPI
Keywords	N/A
Classification/ Sub-Classification	435/134
Search String	Algae and biodiesel
Total Hits	72

Database	Thomson Innovation *Full Text:* U.S. Granted, US Applications, WIPO Applications, European Granted, European Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Enhanced Patent Data - DWPI
Keywords	N/A
Classification/ Sub-Classification	435/134
Search String	Algae and sequence
Total Hits	304

Database	Lexis Nexis Total Patent Brazil
Keywords	Biodiesel
Classification/ Sub-Classification	
Search String	Biodiesel
Total Hits	634

Database	Thomson Innovation *Full Text:* U.S. Granted
Keywords	Algae, biodiesel, photosynthesis, photooxidation
Classification/ Sub-Classification	Not Applicable

Search String	ALL=(photooxidation and photosynthesis and transgenic)
Total Hits	9

Database	Thomson Innovation *Full Text*: U.S. Granted
Keywords	Algae, biodiesel, photosynthesis, transgenic, and chloroplast
Classification/ Sub- classification	Not applicable
Search String	alga* and biodiesel and photosynthesis and transgenic and chloroplast
Total hits	3

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, biodiesel, photosynthesis, transgenic, and chloroplast
Classification/ Sub- Classification	Not Applicable
Search String	ALL=(alga* and biodiesel and photosynthesis and transgenic and chloroplast)
Total Hits	78

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, biodiesel, photosynthesis, transgenic, and chloroplast
Classification/ Sub- Classification	Not Applicable
Search String	ALL=(alga* and biodiesel and photosynthesis and transgenic and chloroplast)
Total Hits	37

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications

	Asian Translated: Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, biodies*, triacylglycerol, TAG
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(alga* and acetyl-CoA and biodiesel and photosynthesis and transgenic)
Total Hits	74

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Ohio State University, alga*, oleaginous, and photosynthesis
Classification/ Sub-Classification	Not Applicable
Search String	(ORG=(UNIV ADJ OHIO ADJ STATE ADJ RES ADJ FOUND) OR PER=(UNIV ADJ OHIO ADJ STATE ADJ RES ADJ FOUND)) AND (TXT=(alga* or oleaginous and photosynthe*))
Total Hits	8

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, photosynthesis, biodiesel, and gene
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(alga* and photosynthe* and biodiesel and gene*)
Total Hits	68

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted,

	German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, photosynthesis, and gene
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(alga* and photosynthe* and gene)
Total Hits	221

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, photosynthesis, biodiesel, and gene
Classification/ Sub-Classification	800/290
Search String	UC=800/290 AND CTB=(alga* and photosynthe* and biodiesel and gene*)
Total Hits	80

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, oleaginous, and transgenic
Classification/ Sub-Classification	No US available; DWPI = B04, C03, C06, D13, D16, D21, D23, E17, P13
Search String	cmp=("ABBOTT" OR "ADVCARDIOSYS" OR "ADVMEDOPTIC" OR "INTRALASE" OR "VISX" OR "BASF" OR "CIBASPEC" OR "COGNIS" OR "ENGELHARD" OR "HTEAG" OR "SUNGENE" OR "BERKHATH" OR "COLUMBIAINS" OR "CTB" OR "ISCAR" OR "JMANVILLE" OR "MITEK" OR "PAMPEREDCHEF" OR "RUSSELL" OR "SCOTTFETZER" OR "SHAWIND") AND CTB=((alga* or oleaginous) and transgenic)
Total Hits	117

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, oleaginous, and Maxygen
Classification/ Sub-Classification	435/006; 435/440; 536/023.1; 536/024.3; DWPI = A11, A23, B04, B05, C07, D16, E19, E23, E24, H04, J01, J04, M25, C06, P13
Search String	cmp=("MAXYGEN") AND CTB=((alga* or oleaginous) and (oil or fuel or diesel))
Total Hits	6

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, oleaginous, and ExxonMobil
Classification/ Sub-Classification	No US available; DWPI = B04, C03, D16
Search String	cmp=("EXXMOBIL" OR "EXXON" OR "MOBIL") AND CTB=((alga* or oleaginous) and gene*)
Total Hits	88

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, oleaginous
Classification/ Sub-Classification	Not applicable
Search String	cmp=("DIVERSA") AND CTB=(alga* or oleaginous)

Total Hits	24

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, oleaginous, polyunsaturated, fatty acid, PUFA, desaturase
Classification/ Sub-Classification	Not applicable
Search String	ALL=((polyunsaturated ADJ fatty ADJ acid* or PUFA) and desaturase* and (alga* or oleaginous))
Total Hits	1370

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App
Keywords	Algae, biodies*, lipid, algae
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(alga* and biodies* and lipid);
Total Hits	54

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App
Keywords	Alga*
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(alga* and glycerol-3-phos*);
Total Hits	10

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Oil
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(Methods ADJ for ADJ Increasing ADJ Oil ADJ Content ADJ in ADJ Plants) AND DP>=(20000101);

Total Hits	5

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Oil
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(Use ADJ of ADJ a ADJ Gene ADJ for ADJ Increasing ADJ the ADJ Oil ADJ Content ADJ in ADJ Plants) AND DP>=(20000101);
Total Hits	5

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Algae, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(algae and biodiesel and AGS) AND PA=(Solix) AND DP>=(20000101);
Total Hits	2

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Transgenic, algae, lipid, biosynthesis
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(transgenic and algae and lipid and biosynthesis) AND DP>=(20000101);
Total Hits	2668

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Transgenic, algae, lipid, biosynthesis, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	(ALL=(transgenic and algae and lipid and biosynthesis) AND DP>=(20000101)) AND (ALL=(biodiesel));
Total Hits	102

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Transgenic, algae, biodiesel, lipid, biosynthesis
Classification/ Sub-	Not Applicable

Classification	
Search String	((ALL=(transgenic and algae and lipid and biosynthesis) AND DP>=(20000101)) AND (ALL=(biodiesel))) AND (ALL=(biodiesel and increase));
Total Hits	98

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(Solix) AND DP>=(20000101);
Total Hits	18

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Alga*
Classification/ Sub-Classification	Not Applicable
Search String	PA=(samsung ADJ electronic) AND TI=(brown and alg* and biofuel);
Total Hits	0

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Lipid
Classification/ Sub-Classification	Not Applicable
Search String	PA=(solazyme) AND ALL=(lipid and pathway) AND DP>=(20000101);
Total Hits	46

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(Photon ADJ 8) AND DP>=(20000101);
Total Hits	0

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	n/a

Classification/ Sub-Classification	Not Applicable
Search String	ALL=(traveling ADJ wave and parallel ADJ filmreactor) AND DP>=(20000101);
Total Hits	0

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Oil
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(Use ADJ of ADJ a ADJ Gene ADJ for ADJ Increasing ADJ the ADJ Oil ADJ Content ADJ in ADJ Plants) AND DP>=(20000101);
Total Hits	5

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Oil
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(Use ADJ of ADJ a ADJ Gene ADJ for ADJ Increasing ADJ the ADJ Oil ADJ Content ADJ in ADJ Plants) AND DP>=(20000101);
Total Hits	5

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	Biodiesel, algae, oil, lipid
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(biodiesel and algae and oil and lipid) AND DP>=(20000101);
Total Hits	5

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	algae, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	(ALL=(biodiesel and algae) AND DP>=(20000101);
Total Hits	46

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	Biodiesel, algae, transgenic
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(biodiesel and algae and transgenic) AND DP>=(20000101);
Total Hits	4

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(BASF ADJ plant ADJ sciences) AND DP>=(20000101);
Total Hits	1

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(BASF) AND DP>=(20000101);
Total Hits	4894
Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App, CN Util, CN App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(BASF ADJ Plant) AND DP>=(20000101);
Total Hits	1298

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App, CN Util, CN App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(BASF) AND DP>=(20000101);
Total Hits	40194

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App, CN Util, CN App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	(PA=(BASF) AND DP>=(20000101)) AND (ALL=(plant));
Total Hits	5768

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App, CN Util, CN App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(BASF ADJ plant) AND DP>=(20000101);
Total Hits	1310

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App, CN Util, CN App
Keywords	Algae, biodiesel, oil
Classification/ Sub-Classification	Not Applicable
Search String	PA=(basf ADJ plant) AND DP>=(20000101)) AND (ALL=(biodiesel and oil and algae));
Total Hits	1

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	Transgenic, algae, oil, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(algae and oil and biodiesel and transgenic) AND DP>=(20000101);
Total Hits	3

Database	Thomson Innovation *Full Text:* WO App, CN Util, CN App
Keywords	Transgenic, algae, biodiesel
Classification/	Not Applicable

Sub-Classification	
Search String	(ALL=(biodiesel and algae and transgenic) AND DP>=(20000101);
Total Hits	106

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	Transgenic, algae, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(biodiesel and algae and transgenic) AND DP>=(20000101);
Total Hits	4

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	n/a
Classification/ Sub-Classification	Not Applicable
Search String	PA=(Solix) AND DP>=(20000101);
Total Hits	18

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Algae, transgenic, lipid, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(transgenic and algae and lipid and biosynthesis) AND DP>=(20000101)) AND (ALL=(biodiesel))) AND (ALL=(biodiesel and increase
Total Hits	98

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Lipid, algae, transgenic
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(transgenic and algae and lipid and biosynthesis) AND DP>=(20000101)) AND (ALL=(biodiesel));
Total Hits	102

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App

Keywords	Transgenic, algae, lipid
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(transgenic and algae and lipid and biosynthesis) AND DP>=(20000101);
Total Hits	2668

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Algae, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(algae and biodiesel and AGS) AND PA=(Solix) AND DP>=(20000101
Total Hits	2

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Oil
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(Use ADJ of ADJ a ADJ Gene ADJ for ADJ Increasing ADJ the ADJ Oil ADJ Content ADJ in ADJ Plants) AND DP>=(20000101
Total Hits	5

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App
Keywords	Oil
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(Methods ADJ for ADJ Increasing ADJ Oil ADJ Content ADJ in ADJ Plants) AND DP>=(20000101
Total Hits	5

Database	Thomson Innovation *Full Text:* US Grant, US App, WO App, EP Grant, EP App, JP Util, JP Grant, JP App
Keywords	Algae
Classification/ Sub-Classification	Not Applicable
Search String	<>CTB=(alga* and glycerol-3-phos*);
Total Hits	10

Database	Thomson Innovation *Full Text:* CN Util, CN App
Keywords	Alga*, biodies*, lipid
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(alga* and biodies* and lipid);
Total Hits	54

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese
Keywords	Algae, biodies*, lipid, biosynth*
Classification/ Sub-Classification	Not Applicable
Search String	ALL=((algae and biodiesel and (lipid and biosynthesis) and (fatty and acid) and carboxylase)) OR AB=((algae and biodiesel and (lipid and biosynthesis) and (fatty and acid) and carboxylase)) OR CL=((algae and biodiesel and (lipid and biosynthesis) and (fatty and acid) and carboxylase));
Total Hits	135

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algae, biodiesel
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(algae and biodiesel);
Total Hits	235

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algae, biodiesel, triacylglycerol, TAG
Classification/ Sub-	Not Applicable

Classification	
Search String	CTB=(algae and biodiesel and (triacylglycerol or tag));
Total Hits	8

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algae, biodiesel, acetyl-coA, acetyl-coenzyme
Classification/ Sub-Classification	Not Applicable
Search String	CTB=(algae and biodiesel and (acetyl-coA or acetyl-coenzyme));
Total Hits	4

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Algepower Inc.
Classification/ Sub-Classification	Not Applicable
Search String	PA=(Algepower Inc.);
Total Hits	0

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Aurora Biofuels
Classification/ Sub-Classification	Not Applicable
Search String	PA=(Aurora Biofuels); PA=(LiveFuels);
Total Hits	21

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	LiveFuels

Classification/ Sub- Classification	Not Applicable
Search String	PA=(LiveFuels);
Total Hits	16

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Bioalgene
Classification/ Sub- Classification	Not Applicable
Search String	PA=(Bioalgene);
Total Hits	0

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	Targeted, growth
Classification/ Sub- Classification	Not Applicable
Search String	PA=(Targeted ADJ growth);
Total Hits	30

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, WIPO Application, European Granted, European Application *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application
Keywords	LS9
Classification/ Sub- Classification	Not Applicable
Search String	PA=(LS9);
Total Hits	55

Database	Thomson Innovation *Full Text:* Enhanced patent data from DWPI
Keywords	Algae, biodiesel, lipid, biosynthesis, fatty, acid, carboxylase

Classification/ Sub-Classification	Not Applicable
Search String	ALL=((algae and biodiesel and (lipid adj biosynthesis) and (fatty adj acid) and carboxylase))
Total Hits	16

Database	Thomson Innovation Enhanced Patent Data - DWPI
Keywords	Algae; Biofuel; Diesel; transformation
Classification/ Sub-Classification	Not Applicable
Search String	alga* AND (biofuel or diesel) And transform*
Total Hits	21

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications Enhanced Patent Data - DWPI
Keywords	Algae; Oleaginious; Diesel; Biofuel; Oil; Genetic; Transformation
Classification/ Sub-Classification	Not Applicable
Search String	(Alg* or oleagin*) AND (diesel OR biofuel OR oil) AND (genet* AND transf*)
Total Hits	218

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted
Keywords	Alg*, Biofuel, Oil, Diesel
Classification/ Sub-Classification	Not Applicable
Search String	Alga* AND (oil OR biofuel OR diesel) AND sapphire energy
Total Hits	18

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications Enhanced Patent Data - DWPI
Keywords	Alg*, Biofuel, Oil, Diesel

Classification/ Sub-Classification	Not Applicable
Search String	Alga* AND (oil OR biofuel OR diesel) AND sapphire energy
Total Hits	28

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Alg*, Biofuel, Oil, Diesel
Classification/ Sub-Classification	Not Applicable
Search String	Alga* AND (oil OR biofuel OR diesel) AND Du Pont
Total Hits	83

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae, Biofuel, Oil, Diesel
Classification/ Sub-Classification	Not Applicable
Search String	(oil OR biofuel OR diesel) AND Chlamydomonas reinhardtii OR Dunaliella salina OR D.tertiolectaOR Haematococcus pluvialis OR Scenedesmus dimorphus OR Desmarestia viridis OR Nannochloropsis oculata OR N. salina
Total Hits	126

Database	Thomson Innovation *Full text*: U.S. Granted, European Granted, US Applications, European Application, WIPO Applications Enhanced Patent Data - DWPI
Keywords	Algae; Diesel; Biofuel; Oil; Lipid
Classification/ Sub-Classification	Not Applicable

Search String	alga* AND (biofuel or diesel) And lipid*
Total Hits	66

Database	Thomson Innovation *Full Text:* U.S. Granted, European Granted, US Applications, European Application, WIPO Applications Enhanced- DWPI
Keywords	Algae, Species of Algae; Transformation; Lipid; Fuel; Diesel
Classification/ Sub-Classification	Not Applicable
Search String	alga* AND (Chlamydomonas reinhardtii OR Dunaliella salina OR D.tertiolectaOR Haematococcus pluvialis OR Scenedesmus dimorphus OR Desmarestia viridis OR Nannochloropsis oculata OR N. salina) AND (transf* OR lipid) AND (fuel or diesel)
Total Hits	11

Database	Thomson Innovation *Full Text* U.S. Granted, European Granted, US Applications, European Application, WIPO Applications Enhanced- DWPI
Keywords	Algae, Transformation
Classification/ Sub-Classification	435/006 or 435/195
Search String	Alga* and transf* and (435006 or 435006)
Total Hits	69

Database	Thomson Innovation *Full Text:* U.S. Granted, European Granted, US Applications, European Application, WIPO Applications Enhanced- DWPI
Keywords	Algae; Fuel; Diesel
Classification/ Sub-Classification	435196 or 435041 or 435252.1 or 435143 or 435254.21 or 435320.1 or 435252.3 or 435254.11 or 435193 or 435254.3 or 435023.1
Search String	Alga* and (biodiesel or biofuel) AND [435196 or 435041 or 435252.1 or 435143 or 435254.21 or 435320.1 or 435252.3 or 435254.11 or 435193 or 435254.3 or 435023.1]
Total Hits	61

Database	Thomson Innovation

	Full Text: U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae; Transformation; Lipids
Classification/ Sub-Classification	435196 or 435041 or 435252.1 or 435143 or 435254.21 or 435320.1 or 435252.3 or 435254.11 or 435193 or 435254.3 or 435023.1
Search String	alga* and (transf* or lipid*) AND [435196 or 435041 or 435252.1 or 435143 or 435254.21 or 435320.1 or 435252.3 or 435254.11 or 435193 or 435254.3 or 435023.1]
Total Hits	543

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae; Transformation; Lipid; Biofuel; Biodiesel
Classification/ Sub-Classification	435196 or 435041 or 435252.1 or 435143 or 435254.21 or 435320.1 or 435252.3 or 435254.11 or 435193 or 435254.3 or 435023.1
Search String	alga* and (transf* or lipid*) AND (biofuel or biodiesel) AND [435196 or 435041 or 435252.1 or 435143 or 435254.21 or 435320.1 or 435252.3 or 435254.11 or 435193 or 435254.3 or 435023.1]
Total Hits	34

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae; Transformation; Lipid; Biofuel; Biodiesel; Sapphire Energy
Classification/ Sub-Classification	Not Applicable
Search String	alga* and (transf* or lipid*) AND (biofuel or biodiesel) AND “sapphire energy”

Total Hits	17

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae; Transformation; Lipid; Biofuel; Biodiesel; Solazyme
Classification/ Sub-Classification	Not Applicable
Search String	alga* and (transf* or lipid*) AND (biofuel or biodiesel) AND “sapphire energy”
Total Hits	1

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae; Transformation; Lipid; Biofuel; Biodiesel; Aurora Biofuels
Classification/ Sub-Classification	Not Applicable
Search String	alga* and (transf* or lipid*) AND (biofuel or biodiesel) AND aurora biofuels
Total Hits	6

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Algae; Transformation; Lipid; Biofuel; Biodiesel; diacylglycerol
Classification/ Sub-Classification	Not Applicable
Search String	Diacylglycerol AND alga* and (transf* or lipid*) AND (biofuel or biodiesel)
Total Hits	17

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Thraustochytrid; thioesterase; alg*; Martek Biosciences
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(thraustochytrid AND thioesterase AND alg*) AND IN=(Martek Biosciences)
Total Hits	52

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Thraustochytrid; acyltransferase; alg*; Martek Biosciences
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(thraustochytrid AND acyltransferase AND alg*) AND IN=(Martek Biosciences)
Total Hits	117

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Fuel, Martek Biosciences
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(fuel) AND IN=(Martek Biosciences)
Total Hits	117

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Rosetta Green
Classification/ Sub-Classification	Not Applicable
Search String	IN=(Rosetta Green)
Total Hits	1

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Martek Biosciences
Classification/ Sub-Classification	Not Applicable
Search String	IN=(Martek Biosciences)
Total Hits	1176

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Alg*; Acyltransferase; Martek Biosciences
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(aIg* AND acytransferase) AND IN=(Martek Biosciences)
Total Hits	118

Database	Thomson Innovation *Full Text:* U.S. Granted, British Applications, US Applications, French Application, WIPO Application, German Utility Models, European Granted, German Granted, European Application, German Applications *Asian Translated:* Japanese Utility Models, Japanese Granted, Japanese Application, Chinese Utility Models, Chinese Applications, Korean Utility Models, Korean Granted/Examined, Korean Applications Enhanced Patent Data - DWPI
Keywords	Alg*; Thioesterase; Martek Biosciences
Classification/ Sub-Classification	Not Applicable
Search String	ALL=(aIg* AND thioesterase) AND IN=(Martek Biosciences)
Total Hits	57

Patent Search Results Summary

3.A. Categorization Summary

ITTI coded patent documents for genetic modification of algae using two relevancy categories with one category having four subcategories and Appendix B contains patents that could not be conclusively categorized as either relevant or irrelevant. The categories are defined below.

Coding Categorization of Patent Documents

1. Relevant: To be relevant, the patent must claim a genetic modification of algae to increase photosynthetic efficiency, increase oil excretion, improve lipid biosynthesis or a method of genetic transformation. The claimed genetic modification or method of genetic transformation must make the algae more useful for biodiesel production. A patent document could also be found to be relevant even if the claims did not specifically mention algae.

   For example, a claim describes “A microalgae of the genus Prototheca containing an exogenous thioesterase gene.” as found in patent US 2011/0047863A1 was found to be relevant because the patent claims a genetic modification of algae to change an enzyme involved in lipid biosynthesis.

   However, the claim language, “A composition produced by a microorganism, wherein the composition comprises one or more fatty esters,” as from patent document US20100257777A1, would be insufficient for this category because the claim is for a composition not a genetic modification.

2. Irrelevant: patents categorized as irrelevant fall outside of the relevant category. For example, patents not including any genetic modification or method of genetic transformation of algae.

   For example, a claim describes “method comprising: (i) harvesting algae by fish that feed on the algae; and (ii) extracting lipids from the fish; wherein the lipids are used as a biofuel feedstock.” “A method for producing a biofuel feedstock” as found in patent US20100081835A1 was found to be irrelevant because the patent does not claim a genetic modification.

The four descriptive subcategories of the relevant technology category comprise:

I. Photosynthesis

   For patents claiming a genetic modification affecting photosynthesis, a highly relevant patent is one that includes algae as the transformed cell and results in increased production of oil in the algae. For example, “A method of enhancing bio-oil or bio-diesel production, the method comprising suppressing Tla1 gene expression in an algae to be used for bio-oil or bio-diesel production…" as found in US20100221739A1, would be highly relevant because it claims suppression of a gene resulting in increased photosynthetic productivity.

Of the 190 patent families found, ITTI determined 62 to be relevant. Of the 62 coded to be relevant, 9 belong to the photosynthesis subcategory. The results indicate that genetically altering photosynthetic pathways in algae to provide for production of biodiesel is an emerging field having fewer patents than other areas.

II. Lipid Secretion/Excretion

To be considered relevant technology, the patent document must include at least one claim to genetically-modified algae. Also, the genetic modification must pertain to lipid secretion. Optionally, the patent document additionally claims genetic modifications to metabolic pathways for photosynthesis or lipid metabolism. The term "algae" is broadly construed and includes microalgae, microbes, algae, oleaginous microorganisms, and cyanobacteria. Among the sixty-two relevant patent records, four records pertained to lipid excretion or secretion.

For example, a published patent application includes an independent claim that recites "[a]n oleaginous microbe comprising that [sic] has been engineered to secrete enhanced amounts of oil by upregulating PI-3 kinase activity."[133] In the same application, a dependent claim recites "the microbes are engineered to over-express the autophagy-associated genes to increase oil secretion"[134] These claims recite genetic modifications affecting lipid secretion (PI-3 kinase regulation) in algae ("oleaginous microbes" includes microalgae).

III. Lipid biosynthesis

To be considered relevant and inclusive for lipid biosynthesis, the patent document must include language in a claim referring to the manipulation of a lipid biosynthetic pathway thus increasing the production of fatty acids/lipid within the cells of the organism. For example, "a nucleic acid encoding a lipid biosynthetic activity, the method comprising: recombining a plurality of parental nucleic acids to produce one or more recombinant lipid biosynthetic nucleic acids comprising a distinct or improved lipid biosynthetic activity…" as described in WO2000061740A1, would be relevant because the document claims a method for increasing the activity of a lipid biosynthetic pathway through means of a genetic transformation.[135] Among the 62 relevant patent documents, 39 were relevant for lipid biosynthesis.

[133] TRANSFORMATION OF GLYCEROL AND CELLULOSIC MATERIALS INTO HIGH ENERGY FUELS, PCT Application Serial No. WO2010009348A2, cl.27 (filed July 16, 2009) (assigned to Texas A&M University System).
[134] *Id.* at cl.37.
[135] MODIFIED LIPID PROD., PCT Application Serial No. WO20000061740A1, cl.1 (filed Oct. 19, 2000).

IV. Genetic transformation

This is a broad category because every relevant patent document in this report had to claim genetic transformation. Any patent documents that claimed a specific sequence or method of genetic transformation, rather than a "gene of interest", were categorized as relevant documents. An example of a relevant patent document claiming genetic transformation is Publication Number WO2011026008A1 "Biofuel from Recombinant Oleginous Algae Using Sugar Carbon Sources". This patent document claims the genetic transformation of wild algae to express a nucleotide sequence encoding a sugar metabolizing enzyme used by the transformed algae to produce biofuel precursors. Therefore this document is relevant to this report.

Patents not including any genetic modification or method of genetic transformation of algae, but simply a "gene of interest", were deemed irrelevant. Such an example is patent document publication number WO1989000606A1 "Microorganism Production of Omega-3 Lipids". This patent document is irrelevant because it does not claim a nucleotide sequence or method of genetically transforming algae. Instead it claims a method of cultivating algae that produce more omega-3 fatty acids. This is not relevant for this project, so these patents were not included in the coding process.

3. Irrelevant patent documents = Patents categorized as irrelevant fall outside of the relevant category. For example, patents not including any genetic modification or method of genetic transformation of algae and patents lacking claims without having a detailed specification or abstract would be categorized as irrelevant.

4. Appendix B: Patent documents were placed in this section when they could not be conclusively categorized as either relevant or irrelevant. For example, patent documents with non-English claims that have been machine translated, patent documents without claims but containing information that gives an impression of relevancy, and patent documents that appear relevant but do not distinctly describe their applicable use in regards to algae fall into this category.

   Example. CN101892091A describes a method for expressing fatty acid ethyl ester synthase (FAEES) and producing biodiesel in a new type body through recombined algae. This patent document has relevant claims and descriptions as it is incorporating biodiesel production with recombined algae. However, this is a machine translated patent document and its accuracy cannot be fully ascertained.

   Example. US20020045232A1 describes a method for increased fatty acid production in plants by genetic transformation. This document would appear to be relevant but does not specifically mention algae and claims to be useful for cosmetics, paints, and pharmaceutical purposes. Therefore, it may be relevant but its contributions towards the issue at hand is unknown.

3.B. Patent De-Duplication Process

Each of the eight team members conducted searches independent of one another. All of the members' search strings were combined and then de-duplicated according to the INPADOC Family ID. This de-duplication process refers to the removal of patent documents within the same family so as to reduce redundancy during the patent coding process. There is no option that allows one to directly de-duplicate patents into one-per-family in Thomson Innovation®. Therefore, we utilized the *Display and Sort* option in Thomson Innovation® to group together the family members having the same INPADOC Family ID, and manually reduced the patent documents.

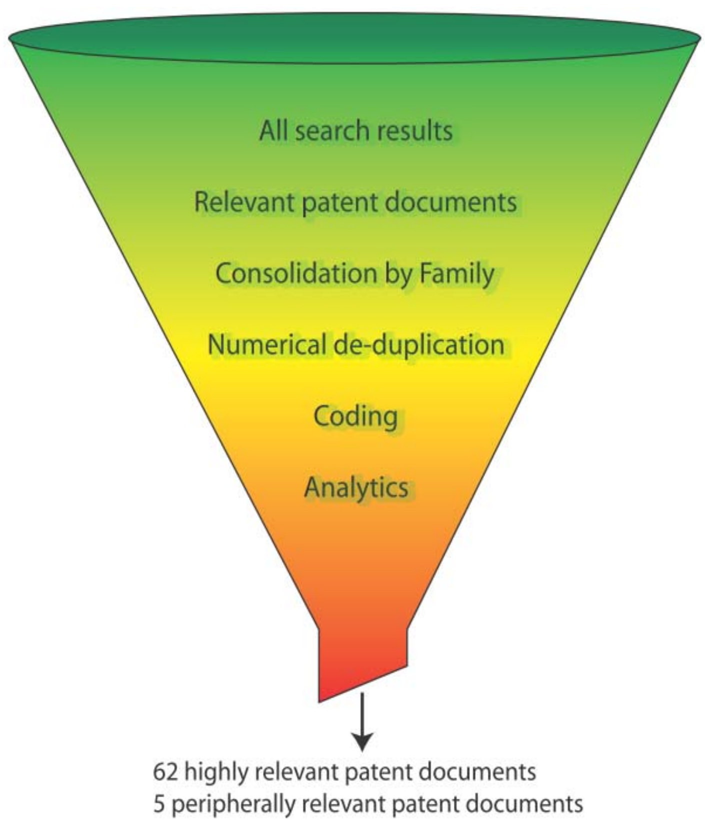
The manual de-duplication process included several steps. First, all issued US patents within one INPADOC family were kept. Second, for a family with no US issued patent, all EP issued patents were kept for coding. Finally, when no issued patent was available within one INPADOC family, patent applications with the earliest priority date were kept for review. Generally, WIPO applications have the earliest priority date within one family. However, some families only contained foreign patents or patent applications, such as Japanese patents and patent applications, Korean patents and patent applications or Chinese patents and patent applications. For these foreign patents or patent applications, ITTI reviewed the translations offered by Thomson Innovation and based coding off these translated documents, making a note on the coding spreadsheet that they were translated by Thomson Innovation.

3.C. Patent Coding Results Summary

Final de-duplication resulted in 190 patent documents. The results were then extracted, using MicroPatent®, into PDF files containing title, abstracts and claims for coding. The 190 patent documents were assigned among the eight team members for coding.

Each team member analyzed the claims in the documents, including an analysis of the specification when necessary to interpret the claims, and then coded under one or more of the following ten categories:

1. Algae
2. Oleaginous
3. Biodiesel/biofuel
4. Lipid Biosynthesis
5. Photosynthesis
6. Genetic transformation
7. Eukaryotic
8. Prokaryotic
9. Gene SEQ
10. Use of genetically-modified host



Of the 190 patent documents, 62 were found to be relevant technology, as noted by the green highlighting on the Master Spreadsheet shown in Section 3D. A patent document is relevant after meeting three requirements. First, the document had to specifically claim algae (or an organism defined in the specification as algae). Second, the patent had to claim a genetic transformation of the algae or the use of genetically transformed algae. Third, the patent document had to indicate that it could be useful for biodiesel production by either claiming that purpose or not limiting the claims to another use. The coding results were inserted into the Master Spreadsheet.

Of the 190 patent documents, 5 could not be conclusively coded as either relevant or irrelevant, as noted by the yellow highlighting on the Master Spreadsheet shown in Section 3E. These 5 documents were unable to be conclusively coded as either relevant or irrelevant for various reasons, including machine-translated claims, a complete lack of claims or an inability to determine the applicability of the claimed technology without further investigation.

Additionally, some of the yellow coded patent documents included claims in a language other than English. If all of the claims, abstract, and description were in a language other than English, the team was unable to code the document. Therefore, these patent documents may be categorized as irrelevant even though they are possibly relevant if the claims specified transformation of algae for biodiesel. Further investigation is required for the yellow-coded patent documents.

3.D. Spreadsheet for Relevant Technology Patent Documents

Publication Number	OriginalTitle	DWPI Title	Algae	Oleaginous	Biodiesel/ biofuel	Lipid Biosynthesis	Photosynthesis	Genetic transformation	Eukaryotic	Prokaryotic	Gene SEQ	Use of genetically modified host	Notes	Reviewed By
WO1999064616A2	POLYUNSATURATED FATTY ACIDS IN PLANTS	Expressing polyunsaturated fatty acids in cells transformed with sequence encoding a desaturase enzyme, used as dietary supplements	specification			1							only has one claim	Kara
US20100251601A1	ENHANCED PRODUCTION OF FATTY ACID DERIVATIVES	New recombinant cell comprises a gene encoding a fatty acid derivative enzyme, useful for preparing a composition, e.g. biofuel composition, producing fatty acid derivatives, and for increasing production of fatty acid derivatives	specification		148, 154	1, 4		146	Y	Y			microorganism defined as algae in the description	Class
US20110047863A1	Production of Oil in Microorganisms	Producing renewable diesel or jet fuel comprises culturing population of microorganisms in fixed carbon source, isolating lipid components from cultured microorganisms, and subjecting isolated lipid components to chemical reactions	1, 8, 17, 35		22, 33, 38	3, 12, 29, 30, 31		1					secretion	Class
US20090298143A1	SECRETION OF FATTY ACIDS BY PHOTOSYNTHETIC MICROORGANISMS	New cell culture of a recombinant photosynthetic microorganism, where the microorganism is modified to contain a nucleic acid molecule, useful for converting inorganic carbon to fatty acids	specification		24, 25	1							recombinant photosynthetic microorganism defined to include algae; secretion	Class

CN101805743A	A preparation method for transgenic dunaliella for improving photosynthesis efficiency	Preparing transgenic Dunaliella for improving photosynthesis efficiency by cloning gene related to carbon fixing or photosynthesis, transforming into Dunaliella chloroplast gene, subculturing, and obtaining stable transgenic strain	2				1-7	1			3		strictly Chinese docume nt	Ross
WO200813043 7A2	MODIFIED CYANOBACTERIA | The transformed cyanobacteria.	New modified photoautotrophic bacterium comprises genes of interest whose expression has been altered or whose gene product function has been changed, useful for increasing the production of a desired product, e.g. lipid and carbohydrate						1						Ernest
US5661017A	Method to transform algae, materials therefor, and products produced thereby	Genetic transformation of chlorophyll-C containing algae using vector containing control sequences of Cyclotella cryptica acetyl-CoA carboxylase gene	1			1		1			31			Kara
WO201102600 8A1	BIOFUEL FROM RECOMBINANT OLEGINOUS ALGAE USING SUGAR CARBON SOURCES	New recombinant oleaginous alga useful for forming bio fuel precursors comprises heterologous genes that increase the ability of the alga to use natural saccharides for algal growth	1		27-29	Y						Y		Neha
US7901928B2	Acyltransferases for alteration of polyunsaturated fatty acids and oil content in oleaginous yeasts	New nucleic acids encoding diacylglycerol acyltransferase and phospholipid:diacylgly cerol acyltransferases useful for altering polyunsaturated fatty acid content in triacylglycerols in oleaginous yeasts	5, 13			1					1, 2			Neha

WO2001009296A1	NUCLEIC ACID SEQUENCES ENCODING POLYENOIC FATTY ACID ISOMERASE AND USES THEREOF	New polyenoic fatty acid isomerase polypeptides and polynucleotides, useful for producing conjugated fatty acids from polyenoic fatty acyl substrates, which are useful in industrial, animal feed and human nutritional applications	19						4		6-10		Monsanto	Emily
US6884921B2	ω-3 fatty acid desaturase	Cell for desaturating omega-6 fatty acid to a corresponding omega-3 fatty acid, comprises a recombinant FAT-1 (omega-3 fatty acyl desaturase) polypeptide	5			1, 16, 18		1, 2, 6, 7, 16	5	5	1, 3, 6, 16, 18			Anna
US20100221739A1	SUPPRESSION OF TLA1 GENE EXPRESSION FOR IMPROVED PHOTOSYNTHETIC PRODUCTIVITY	Enhancing hydrogen production, comprises suppressing Tla1 gene expression in alga (Chlamydomonas reinhardtii, Scenedesmus obliquus or Chlorella vulgaris), and cultivating the alga under conditions in which hydrogen is produced	1		3		Y							Kara
WO2007149583A2	COMPOSITIONS AND METHODS FOR USING ACYLTRANSFERASES FOR ALTERING LIPID PRODUCTION ON THE SURFACE OF PLANTS | COMPOSITIONS ET PROCÉDÉS UTILISANT DES ACYLTRANSFÉRASES POUR MODIFIER LA PRODUCTION DE LIPIDES SUR LA SURFACE DE PLANTES	New expression vector comprising a nucleic acid sequence encoding an acyltransferase polypeptide, useful for making a transgenic plant or for providing an extracellular lipid comprising free fatty acids and monoacylglycerols	6, 25			Y		7						Kara
EP108580A1	Method for introducing foreign genes into green algae utilizing T-DNA of agrobacterium	Genetically engineered green algal cells with t-DNA sequence of agrobacterium plasmid and contg. foreign gene present	1,6					1,6	3	3				Sanjana

US20100151539A1	Recombinant Microalgae Cells Producing Novel Oils	New recombinant nucleic acid encoding a promoter that is upregulated in a cell of Protoheca, useful for encoding a promoter and producing e.g. triglyceride oil, which is useful to produce e.g. lipase for the production of renewable diesel	1, 7			25		25	Y		Y		Solazyme	Sanjana
US7906706B2	PUFA polyketide synthase systems and uses thereof	New isolated nucleic acid and polypeptide having acyltransferase activity, useful for efficiently producing lipids enriched in various polyunsaturated fatty acids and other bioactive molecules	2			1 - acyltransferase		7		y	y		enzyme sequence maximizing lipid production	Ernest
WO2000061740A1	MODIFIED LIPID PRODUCTION	Methods of modulating lipid production in cells and whole organisms, especially corn, peanut, barley, millet, rice, soybean, sorghum, wheat, oats and sunflower, by selection from libraries of recombined nucleic acids and organisms	2			1,3							genome library	Sanjana
WO2009149465A1	TRANSFORMATION OF ALGAL CELLS	Transforming algal cell by preparing transformation construct, preparing particle for bombarding algal cell, adhering transformation construct to the particle, bombarding algal cell with the particle and growing algal cell into a colony	1				3	1			14, 15			Sanjana

WO2010108114A3	POLYUNSATURATED FATTY ACID SYNTHASE NUCLEIC ACID MOLECULES AND POLYPEPTIDES, COMPOSITIONS, AND METHODS OF MAKING AND USES THEREOF	New polyunsaturated fatty acid synthase nucleic acid molecule, for producing at least one polyunsaturated fatty acid (PUFA), and for producing lipids enriched for docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) or its combination											no claims	Ernest
US20080138851A1	TROPHIC CONVERSION OF OBLIGATE PHOTOTROPHIC ALGAE THROUGH METABOLIC ENGINEERING	Novel algal cell which grows in substantial absence of light comprising chimeric DNA encoding protein that transports catabolizable carbon source into the cell, useful for producing desired algal products in fermentor	1, 18					18					Martek	Kara
US20090023180A1	Reduction of Shading in Microalgae	Increasing utilization efficiency of absorbed light energy comprises transforming the microorganism with RNA interference (RNAi) construct and exposing the transformed microorganism to light					42	42					photosynthetic microorganism incapable of flagella-based motility = algae	Kara
US20090209015A1	COMPOSITIONS AND METHODS FOR PRODUCTION OF BIOFUELS	Producing fatty acids useful as biofuels, by maintaining recombinant cells expressing heterologous animal thioesterase-II and heterologous animal fatty acid synthase, collecting cells, and extracting fatty acids from cells and/or medium	17			1		1	13	14				James
US20090317878A1	NUCLEAR BASED EXPRESSION OF GENES FOR PRODUCTION OF BIOFUELS AND PROCESS CO-PRODUCTS IN ALGAE	New vector comprises an algal-specific nuclear promoter or an algal virus promoter and algal-specific intergenic spacer region (IGS), useful for nuclear integration and expression of genes	1, 2			8		10					genetic transformation system	Ross

US20100021912A1	Methods of Modulating Lipid Concentrations in Eukaryotic Cells	Novel genetically engineered eukaryotic cell culture useful for modulating lipid concentrations in eukaryotic cells, for generating biofuels and treating diseases based on excessive lipid storage e.g. obesity and diabetes mellitus	7-11, 20		23				1-6, 12-19, 20, 21, 22				storing lipids as opposed to lipid biosynthesis	Ross
US20100062502A1	MANIPULATION OF SNF1 KINASE FOR ALTERED OIL CONTENT IN OLEAGINOUS ORGANISMS	New transgenic oleaginous eukaryotic host cell e.g. Yarrowia lipolytica comprising a heterotrimeric sucrose non-fermenting 1 protein kinase having reduced activity, useful for producing oil or lipids having increased e.g. lipid content	5	1		1		16	1, 5, 10, 16					Ross
US20100087006A1	Use of fluorescent protein in cyanobacteria and algae for improving photosynthesis and preventing cell damage	Method for mitigating release of advantageous genetically engineered trait into natural ecosystem, by selecting mutated algae or Cyanobacterium to express mitigating trait and transforming mutated strain with advantageous trait	1, 12, 15, 21-23		Y		1, 15	1, 15						Ross
US20100170148A1	Host Cells and Methods for Producing Fatty Acid Derived Compounds	Producing a C18 aldehyde in a genetically modified host cell comprises culturing a genetically modified host cell under a suitable condition, where genetically modified host cell comprises a first, second, or third enzyme	14					26				1	use of genetically engineered to make lipid	James
US20100184130A1	ENGINEERED BIOMASS WITH INCREASED OIL PRODUCTION	New genetically modified plant having green biomass or having an increased amount of oil as compared to a non-genetically modified plant, useful for making a biofuel, e.g. biodiesel fuel	specification		abstract	1, 6		1, 6, 25	1		7, 13, 25		genetically modified plant with green biomass (includes algae in spec)	Anna

US20100184169A1	Modified Photosynthetic Microorganisms With Reduced Glycogen and Their Use in Producing Carbon-Based Products	New modified photosynthetic microorganism e.g. Cyanobacterium useful for producing carbon-based product e.g. feedstock for biofuel, has polynucleotides encoding protein of glycogen breakdown pathway or its variant			60, 61	4, 18, 53		38		11 (cyanobacterium)	1, 5-10, 25-30		cyanobacteria is very close to algae	Anna
US20100192258A1	Enzyme Directed Oil Biosynthesis In Microalgae	Expressing diacylglycerol acyltransferase comprises providing algae or rutabaga and a vector containing algae gene encoding diacylglycerol acyltransferase operably linked to promoter and transfecting the algae or rutabaga with the vector	1, 6			1		1, 6, 12	1, 6, 12		1, 12			Anna
US20100255550A1	Regulatory Factors Controlling Oil Biosynthesis In Microalgae And Their Use	Composition useful producing transgenic plant oils, comprises a nucleic acid sequence encoding a biosynthetic oil gene transcription regulator or an amino acid sequence comprising a biosynthetic oil gene transcription regulator	7, 16, 17, 28			9, 24		17, 24			1, 6		algae promoter	Sanjana
US20100255551A1	MODIFIED PHOTOSYNTHETIC MICROORGANISMS FOR PRODUCING TRIGLYCERIDES	Producing triglyceride or fatty acid in photosynthetic microorganism, involves culturing modified photosynthetic microorganism comprising exogenous polynucleotides encoding enzymes associated with triglyceride or lipid biosynthesis	cyanobacterium			68, 87	68	68					photosynthetic microorganism, Cyanobacterium	Ross
US20100317073A1	MOLECULAR APPROACHES FOR THE OPTIMIZATION OF BIOFUEL PRODUCTION	Enhancement of lipid production in alga species used for producing biofuels comprises feeding oleaginous alga with growth medium comprising glycerol	1,2					2				2	method of enhancing lipid production	James

US20100330039A1	Schizochytrium Fatty Acid Synthase (FAS) and Products and Methods Related Thereto		schizochytrium			14, 16, 22		13		y	1		schizochytrium - marine microalgae; enzyme for maximizing lipid synthesis	Ernest
US7465850B2	Use of a gene for increasing the oil content in plants	Increasing total oil content in plant or its propagation material, by transgenically expressing a triacylglycerol-synthesis enhancing protein from yeast in plant, and selecting plants having increased total oil content				1		17			1, 2		increasing oil content in transgenic plants	James
US7566554B2	PUFA polyketide synthase systems and uses thereof													Ernest
US7645604B2	Delta-9 elongases and their use in making polyunsaturated fatty acids	New polynucleotide encoding Delta9 elongase, useful for making long-chain polyunsaturated fatty acids or microbial oil	5					5					genetically transformed algae	Ross
US7723574B2	Process for the production of Δ5-unsaturated fatty acids in transgenic organisms	Preparation of delta 5-unsaturated fatty acid compounds in an organism, useful in e.g. food industry sector, comprises introducing into an organism, lipid compounds and a nucleic acid sequence; and expressing the nucleic acid sequence		10		1, 19, 20		1, 22, 28, 30	9, 11, 27, 30, 10, 24, 28, 30	9, 28, 30	1, 3, 16-21		microorganism	Anna
US7777098B2	Method for producing unsaturated ω-3-fatty acids in transgenic organisms	Production of omega-3 fatty acids or glycerides useful in fodder, nutrients, cosmetics or pharmaceuticals involves introducing a nucleic acid sequence into an organism which codes for an omega-3-desaturase activity									1, 11, 17		transgenic microorganism	Emily

WO2008060571A8	METHODS AND COMPOSITIONS FOR PRODUCTION AND PURIFICATION OF BIOFUEL FROM PLANTS AND MICROALGAE | PROCÉDÉS ET COMPOSITIONS POUR PRODUIRE ET PURIFIER UN BIOCARBURANT À PARTIR DE VÉGÉTAUX ET DE MICRO-ALGUES	Recovering oil product, useful as e.g. bio-diesel, comprises obtaining crude extract from organismal biomass, applying the crude extract to composition comprising nanomaterial, and recovering the oil product	y		y			y				y	no claims	James
WO2009120366A2	ALGAL GLYCEROL-3 PHOSPHATE ACYLTRANSFERASE | GLYCÉROL-3 PHOSPHATE ACYLTRANSFÉRASE ALGACÉE	New isolated, purified or recombinantly produced algal glycerol-3 phosphate acyltransferase, useful for altering levels of high-palmitate oils in a plant, producing biodiesel from algal cells, and for producing ethanol	9		20	Y - acyltransferase		9						Ross
WO2010009348A2	TRANSFORMATION OF GLYCEROL AND CELLULOSIC MATERIALS INTO HIGH ENERGY FUELS | TRANSFORMATION DE GLYCÉROL ET DE MATÉRIAUX CELLULOSIQUES EN CARBURANTS À HAUTE TENEUR ÉNERGÉTIQUE	Making a biofuel by providing a nitrogen-limiting, minimal growth media comprising glycerol and/or sugars generated from cellulosic biomass and growing an oleaginous microbe to secrete an oil	14-16	18	6, 18	11		14-16					secretion	Ross
WO2010011754A2	CONTINUOUS PRODUCTION AND EXCRETION OF WAXY PRODUCTS FROM PHOTOSYNTHETIC ORGANISMS | PRODUCTION ET EXCRÉTION CONTINUES DE PRODUITS CIREUX À PARTIR D'ORGANISMES PHOTOSYNTHÉTIQUES	New cell comprises at least one transgenic insert comprising acyl-coenzyme A (CoA):ethanol acyltransferase (AEAT), useful for producing FAEE in cell and for excreting product from cell	7, 8, 33, 34			1 - acyltransferase	34	7,8				7, 8	secretion	Ross

WO2010105095A1	ENGINEERING SALT TOLERANCE IN PHOTOSYNTHETIC MICROORGANISMS | GÉNIE GÉNÉTIQUE DE LA TOLÉRANCE AU SEL DANS LES MICROORGANISMES PHOTOSYNTHÉTIQUES	New isolated polynucleotide capable of transforming photosynthetic organism, useful producing at least one product e.g. therapeutic protein, nutritional protein, industrial enzyme and fuel product	3		85			1					salt tolerance (16)	Emily
WO2010113149A1	COMPOSITIONS AND METHODS FOR INCREASING OIL CONTENT IN ALGAE | COMPOSITIONS ET PROCÉDÉS POUR ACCROÎTRE LA TENEUR EN HUILE D'ALGUES	New transgenic alga e.g. Chlamydomonas reinhardtii, Chlorella vulgaris or Haematococcus pluvialis comprising an exogenous transgene e.g. a polynucleotide encoding a polypeptide	1			1		1			8, 18		phytohormone	Emily
WO2010151854A2	LTTR-MODULATED EXPRESSION IN GENTICALLY MODIFIED PHOTOSYNTHETIC ORGANISMS | EXPRESSION MODULÉE PAR LTTR DANS DES ORGANISMES PHOTOSYNTHÉTIQUES GÉNÉTIQUEMENT MODIFIÉS	Conferring polynucleotide transcription in photosynthetic organism involves administering LysR type transcriptional regulator modulator to the organism so that transcription of polynucleotide linked to the regulator cis-element is modulated	9, 17, 18				1	2						Neha
WO2011011463A2	MANIPULATION OF AN ALTERNATIVE RESPIRATORY PATHWAY IN PHOTO-AUTOTROPHS | MANIPULATION D'UNE VOIE RESPIRATOIRE ALTERNATIVE CHEZ LES PHOTO-AUTOTROPHES	Increasing triacylglyceride production in an algal cell during imbalanced growth conditions involves knocking out an alternative oxidase gene	1			12					1, AOX		production of triacylglycerol in algal cells; AOX = alternative oxidase; nannochloropsis; Auroroa	Sanjana

WO2011011568A2	METHODS AND COMPOSITIONS FOR THE PRODUCTION OF FATTY ACIDS IN PHOTOSYNTHETIC PROKARYOTIC MICROORGANISMS | PROCÉDÉS ET COMPOSITIONS POUR LA PRODUCTION D'ACIDES GRAS CHEZ DES MICRO-ORGANISMES PROCARYOTES PHOTOSYNTHÉTIQUES	Producing fatty acid in photosynthetic prokaryotic microorganism comprises introducing nucleic acid comprising promoter sequence operably linked to a heterologous nucleic acid sequence (or in) a photosynthetic prokaryotic microorganism	14				1	50		1			cyanobacterium	Sanjana
US20110030097A1	COMPOSITIONS AND METHODS FOR ENHANCING OIL CONTENT IN PLANTS	New plant transformed with microRNA and related nucleic acid sequences, useful for developing further transgenic plants with enhanced oil content	11, 12, 13			1, 19		1			6, 8, 15		transgenic plant, described as algae	Ross
EP2292741A1	Genetically modified organisms for the production of lipids	Isolated genetically modified non-mammalian organism e.g. Mycobacterium, Drosophilas, Streptomyces, peanut for production of second lipid e.g. prenol lipids, isoprenoid, triterpene, squalene, squalene	7			2, 8		1	7					Ross
US20090176272A1	EXPRESSION OF NUCLEIC ACID SEQUENCES FOR PRODUCTION OF BIOFUELS AND OTHER PRODUCTS IN ALGAE AND CYANOBACTERIA	Producing gene products of interest in marine algae comprises transforming the marine alga with a vector having a first chloroplast genome sequence, a second chloroplast genome sequence and a gene encoding the product of interest	1, 16		specification	4, 5, 6, 7		19			3		specification mentions biofuels	Kara

US7524658B2	Mortierella alpina lysophosphatidic acid acyltransferase homolog for alteration of polyunsaturated fatty acids and oil content in oleaginous organisms	New nucleic acid molecule encoding lysophosphatidic acid acyltransferase (LPAAT) enzyme isolated from Mortierella alpina, useful altering the quantity of oil in oleaginous organisms, e.g. oleaginous bacteria, yeast, algae, and fungi	specification			1, 2		1, 2			1			Ross
US20090205066A1	FATTY ACID DESATURASE GENES FROM PLANTS	Isolated nucleic acid fragment, for plant lipid compsn. modification comprises nucleic acid sequence encoding fatty acid desaturase or related enzyme with high aminoacid identity to specific polypeptide	specification					8			1, 2, 3		fatty acid desaturase can come from algae (specification)	Kara
US20080076166A1	Method For Producing Polyunsaturated Fatty Acids In Transgenic Organisms	Producing polyunsaturated fatty acid compounds in transgenic organisms comprises introducing nucleic acid sequences coding for desaturase and elongase activities into the organism	19	7		23								Kara
EP1487985B1	TRANSGENIC PLANTS EXPRESSING ENZYMES INVOLVED IN FATTY ACID BIOSYNTHESIS | TRANSGENE PFLANZEN, DIE FETTSÄUREBIOSYNTHESE ENZYME EXPRIMIEREN | ENZYMES D'EXPRESSION DE PLANTES TRANSGENIQUES IMPLIQUEES DANS LA BIOSYNTHESE D'ACIDES GRAS	Nucleic acid molecules which comprises sequences encoding enzymes involved in the biosynthesis of n-3 fatty acids, particularly docosahexanoic acid or variants useful for the production of food stuffs containing n-3 fatty acids	9			14		8					Genetic modification of algae to biodiesel	Neha

US7579517B2	Methods for increasing oil content in plants	Increasing the total oil content of plants, useful e.g. in human or animal nutrition, by expressing a yeast transgene encoding glycerol-3-phosphate dehydrogenase	specification		1			1, 15					increased oil content in a plant (could be algae); BASF	Ross
US7795414B2	Sugar and lipid metabolism regulators in plants	Novel isolated lipid metabolism protein nucleic acid useful for modifying or increasing lipids or oil and/or fatty acids, cofactors, carbohydrates, and enzymes in microorganisms and plants				Y		3			1		genetic transformation to increase lipid production; transgenic plant; BASF	Emily
US7871804B2	Method for producing polyunsaturated long-chain fatty acids in transgenic organisms	To produce polyunsaturated long chain fatty acids, for use in foodstuffs or cosmetics or pharmaceuticals, nucleic acids are introduced in transgenic organisms coded for specific polypeptides	specification			1		y	2				BASF; lipid biosynthesis	Class
US7893320B2	Method for producing multiple unsaturated fatty acids in plants	Preparing polyunsaturated fatty acids in transgenic plants, useful e.g. in pharmaceuticals and nutrition, by transforming plants with sequences encoding specific desaturases	specification			5			y				transgenic plant; use of algal genes in land crops; red algae is eukaryotic; BASF	Sanjana
WO2010104763A1	BIOFUEL PRODUCTION IN PROKARYOTES AND EUKARYOTES | PRODUCTION DE BIOCARBURANT DANS DES PROCARYOTES ET EUCARYOTES	New isolated polynucleotide useful for producing genetically modified organisms for producing terpenes e.g. fusicoccadiene, capable of transforming photosynthetic bacterium, yeast, alga or vascular plant	1			Y		1					terpenes = essential oils in plants; Sapphire	Emily

US20100120111A1	METHOD OF PRODUCING HYDROCARBON BIOFUELS USING GENETICALLY MODIFIED SEAWEED	Producing liquid hydrocarbon biofuel, by isolating genetic material in Botryococcus braunii encoding cells to produce hydrocarbons, cloning into seaweed, extracting hydrocarbons from genetically modified seaweed and processing	1, 14, 20		1, 14, 20			1, 14, 20						Ross
US20050262588A1	Thioesterase-related nucleic acid sequences and methods of use for the production of plants with modified fatty acid composition	New palmitoyl-acyl carrier protein thioesterase nucleic acid, useful for modifying the lipid composition in a host cell or a plant, and for producing a plant having seeds with reduced palmitic, stearic or oleic acid levels	specification			24		24			24			Sanjana

3.E. Spreadsheet for Patent Documents Unable to be Coded as either Relevant or Irrelevant

Publication Number	OriginalTitle	DWPI Title	Algae	Oleaginous	Biodiesel/biofuel	Lipid Biosynthesis	Photosynthesis	Genetic transformation	Eukaryotic	Prokaryotic	Gene SEQ	Use of genetically modified host	Notes	Reviewed By
CN101892091A	Method for expressing FAEES and producing biodiesel in new type body through recombined algae		1		1, 3	1, 2		2					machine translated	Ernest
US20020045232A1	Production of conjugated linoleic and linolenic acids in plants	Nucleic acids which encode a conjugase and its related enzyme a delta desaturase to be used for the large scale production of conjugated linoleic acid and linolenic acid in plants						6, 9, 11	7, 10, 12		1, 3		doesn't specify algae	Anna
US20110003360A1	DELTA-6 DESATURASE AND USES THEREOF	New delta 5 desaturase or delta 6 desaturase polypeptides, useful for producing polyunsaturated fatty acids, desaturates polyunsaturated fatty acids at carbon 5 and carbon 6, respectively						17	11	8, 9, 13, 14, 17			desaturation of PUFAs, talks about fungus, not algae	Anna
EP1794290A1	SYNTHETASE ENZYMES | SYNTHETASE-ENZYME | SYNTHETASES	Novel transgenic cell e.g. yeast or plant cell comprising nucleic acid molecule encoding polypeptide having acyl-CoA synthetase activity, useful for esterification of long chain fatty acid substrate	Y			Y							no claims, but abstract looks relevant	Kara

		to coenzyme A to form acyl-CoA												
US20090191599A1	ENGINEERED LIGHT-HARVESTING ORGANISMS	New engineered cell comprises at least two engineered nucleic acids, e.g. light capture nucleic acid and NADPH pathway nucleic acid, useful for producing carbon products, e.g. biological sugars, and hydrocarbon products			41									Kara

Patent Document Analysis

4.A. Relevant Technology Patent Documents

The following subsections within 4.A. present patent documents categorized as relevant technology. These patent documents were coded green in the Master Spreadsheet (Section 3D). There were a total of 62 patent documents that were coded into the relevant technology category.

4.A.1 Priority Country v. Patent Family Count

The following table and graph show priority country designations of all relevant patent documents. Priority country designations indicate the route a patent document enters national stage prosecution and determines priority data. Four priority country designations represented all relevant patent documents: CN = China, EP = European Patent Office, US = United States, and WO = PCT. Therefore, priority country information may be used to glean geographical patenting trends.

Priority Country	Patent Family Count
US	40
WO	18
EP	3
CN	1

Table 5: Priority Country v. Patent Family Count

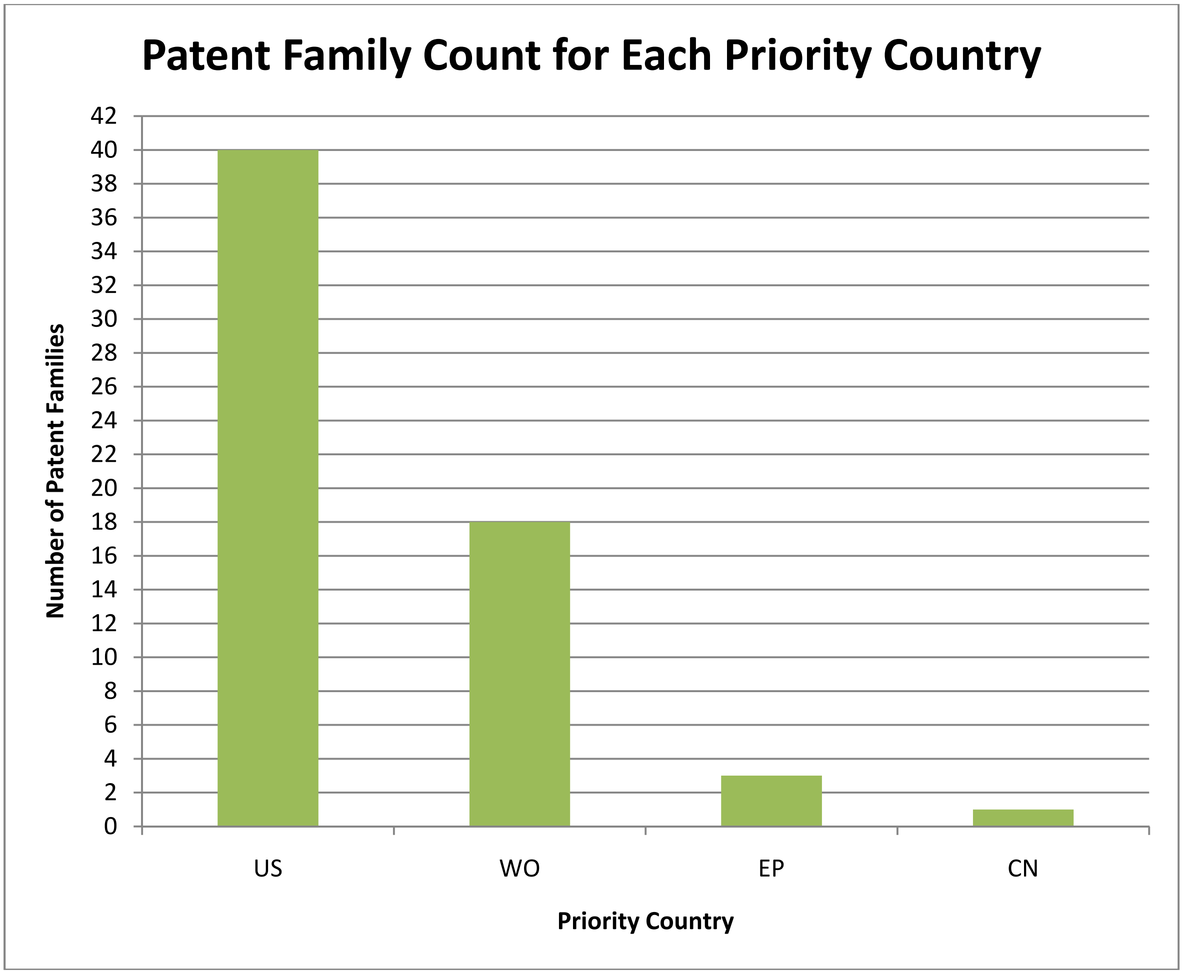


Figure 8: Priority Country v. Patent Family Count

4.A.2 Publication Year v. Patent Document Count

The following tables and graphs show the publication trends of patent documents worldwide that are relevant to production of biodiesel from algae. Analysis of relevant patent documents shows an increase in publication in this technology since 2009. Interestingly, publications from the 1980s until 2008 were almost negligible. This increase may be a result of the growing need for an alternative fuel source. The reduction in publication in 2011 is a result of not having completed the year and patent documents in the process of being published.

Publication Year	Document Count
2011	10
2010	25
2009	12
2008	3
2007	1
2005	1
2003	1

2001	1
2000	1
1999	1
1997	1
1984	1

Table 6: Publication Trends of Relevant Technology Patent Documents Worldwide for the Last 20 Years

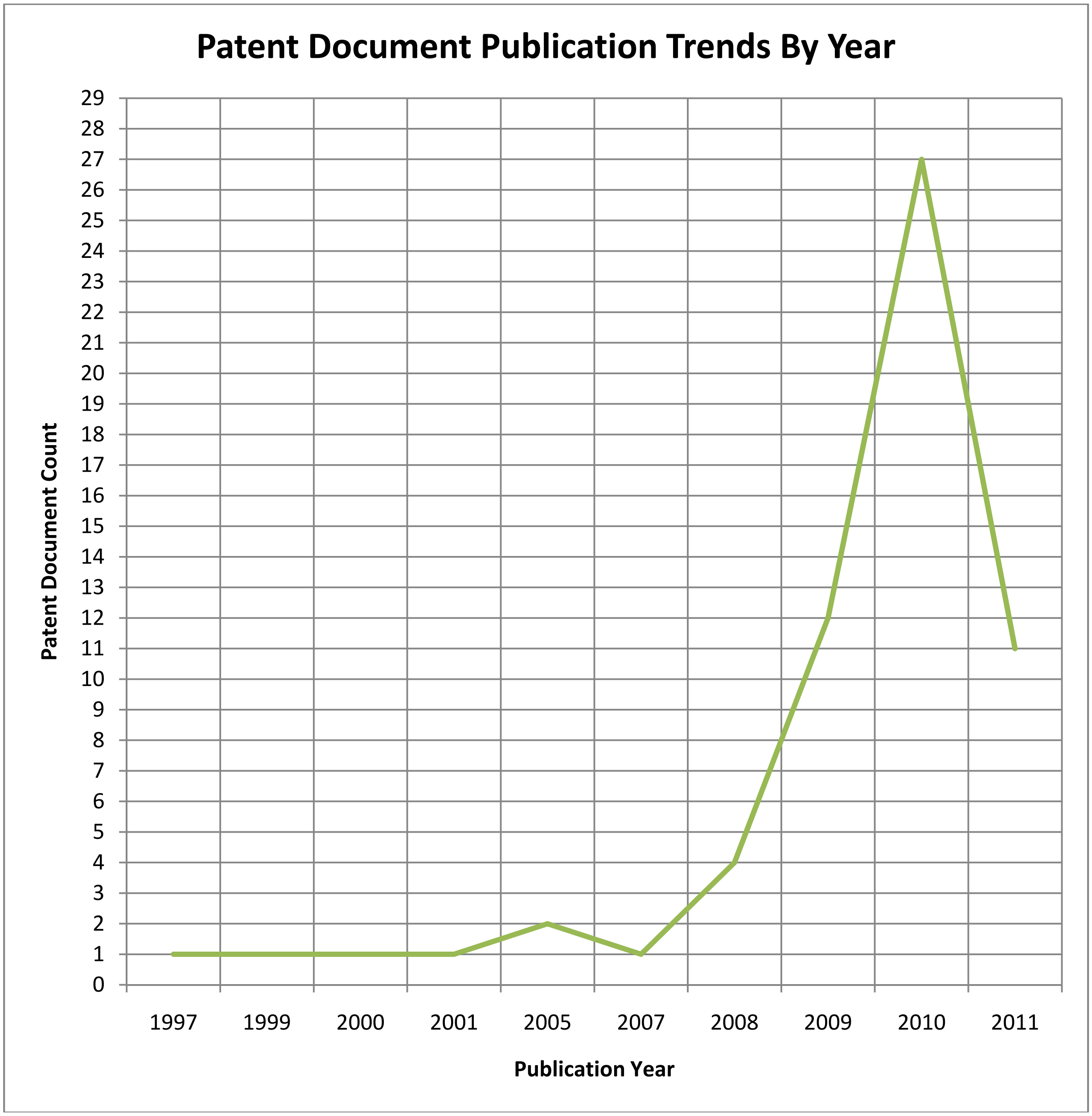


Figure 9: Publication Trends of Relevant Technology Patent Documents Worldwide for the Last 20 Years

4.A.3 Application (Filing) Date v. Patent Document Count

The following analytics are based on 62 relevant patents. These relevant patent documents show a sharp increase in application filings in 2009 and a continuously higher amount through 2010 and 2011 compared to pre-2009 filings. This increase may be the result of an increased public need for alternative fuels, or higher amounts of venture capital funding for algae biodiesel research.

Application Year	**Patent Document Count**
1983	1
1995	1
1999	1
2000	2
2001	1
2002	1
2003	1
2004	4
2005	1
2006	3
2007	8
2008	4
2009	19
2010	15

Table 7: Patent Document Count v. Application Year

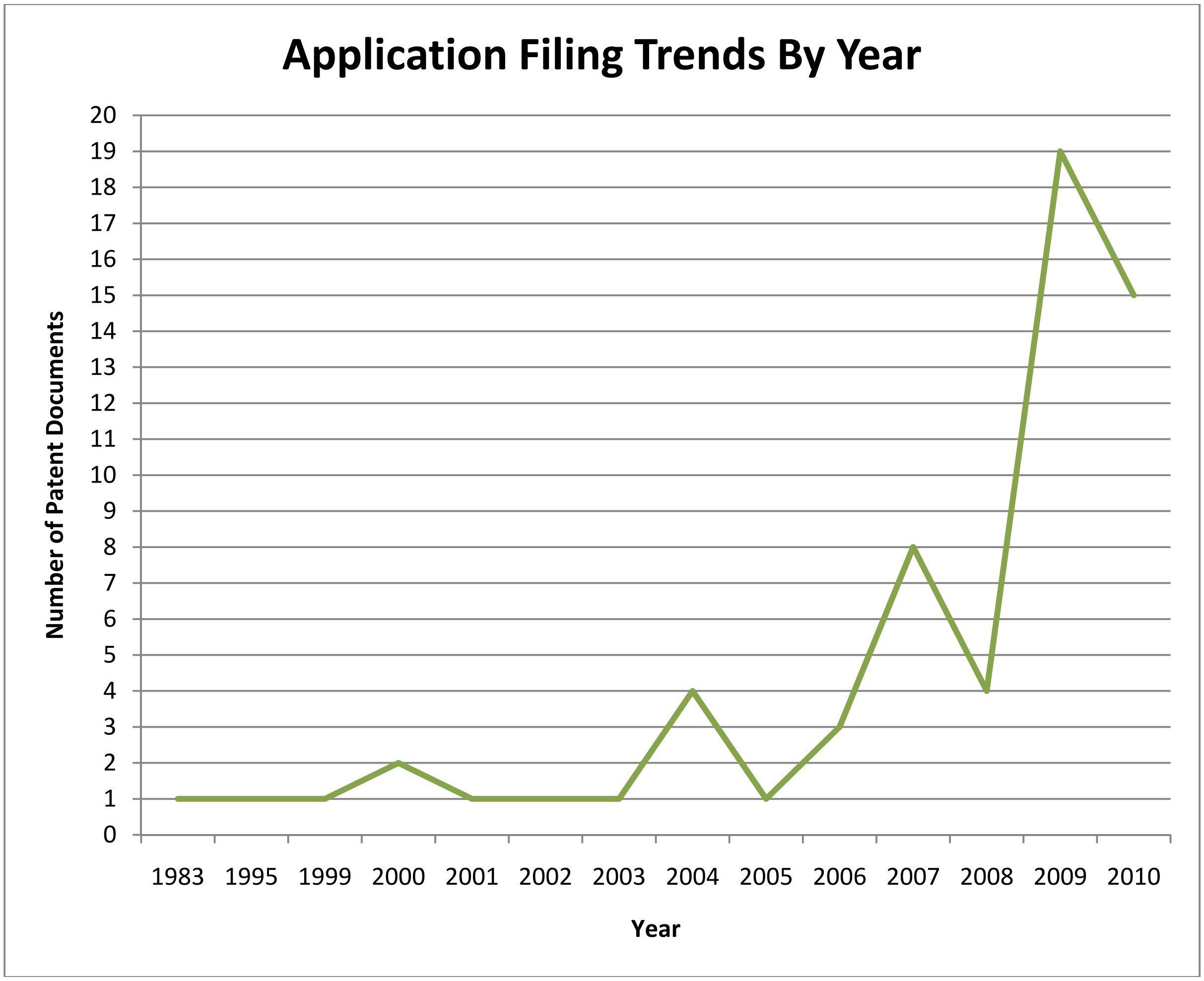


Figure 10: Patent Document Count v. Application Year

4.A.4 U.S. Classification v. Patent Document Count

U.S. classification information is only available for patents issued by the United States Patent and Trademark Office. The following analytics are based on the 40 U.S. patents categorized as relevant. The remaining documents were not analyzed because they are not categorized by U.S. classifications. The 40 U.S. documents fall into eight U.S. Classes with the top three classes being 435, 536, and 800. When further divided into U.S. sub-classifications, the top five sub-classifications are 435/134, 435/320.1, 435/257.2, 536/023.2, and 800/281. The definition of these U.S. classifications and sub-classifications are shown in Appendix D. Table 88 and Figure 11, a bar graph, show the eight 3-digit U.S. classes of the 40 relevant patent documents from the U.S. Table 9 and Figure 12, a bar graph, show the Top 20 U.S. classes and subclasses of the 40 relevant U.S. patent documents.

U.S. Class (3-digit)	Patent Document Count
435	36
536	17

800	15
554	7
044	4
530	3
424	1
426	1

Table 8: 3-Digit U.S. Classes for the 40 Relevant Patent Documents

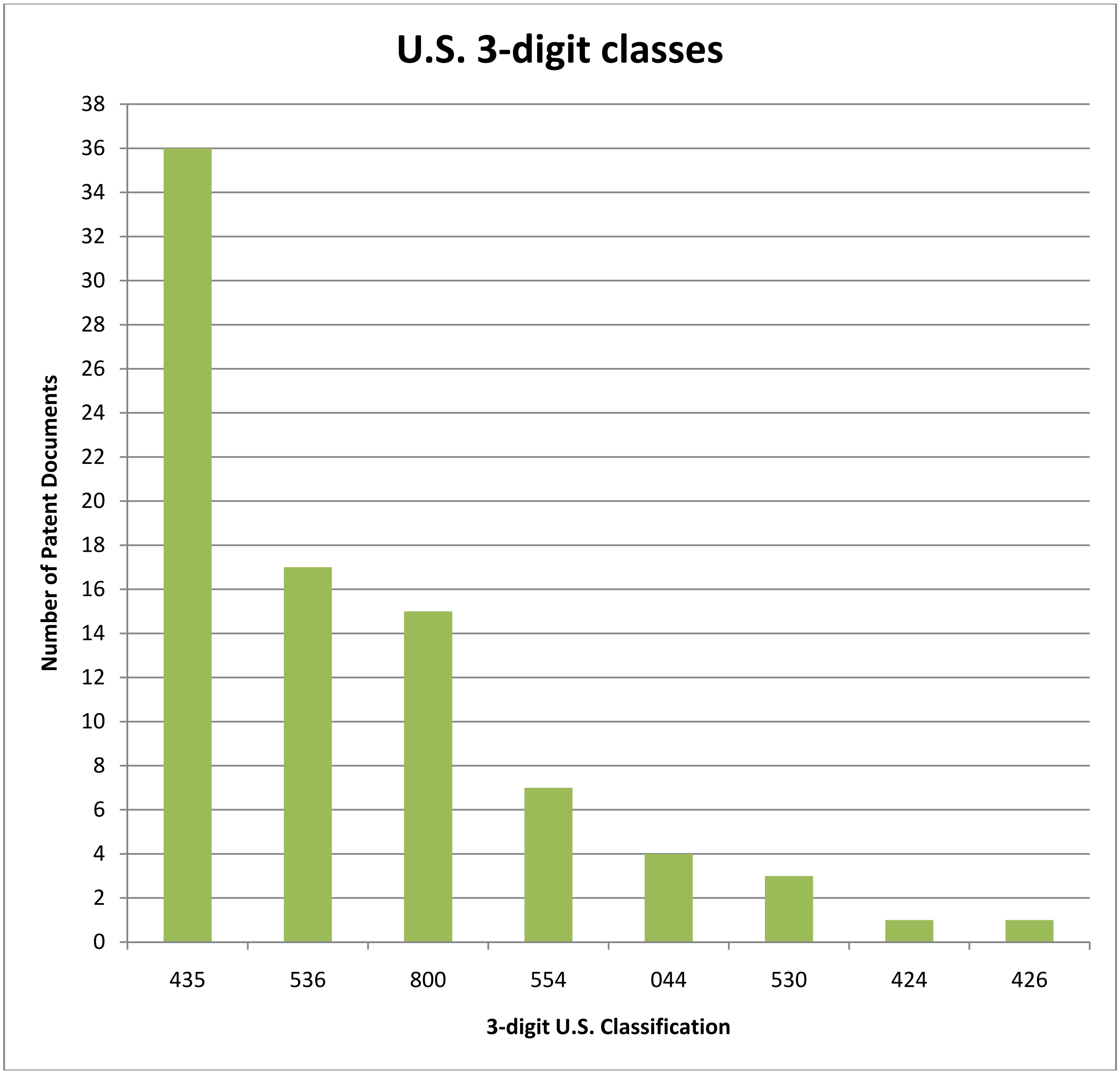


Figure 11: Eight 3-Digit U.S. Classes of the 40 Relevant U.S. Patent Documents

U.S. Class	Patent Document Count
435/134	17
435/320.1	14
435/257.2	12
800/281	11
536/023.2	10
435/471	9
435/252.3	8
800/298	8
435/419	6
435/468	5
435/193	5
435/069.1	4
430/006	4
800/295	3
435/166	3
536/023.1	3
435/254.2	3
554/001	3
435/190	3
536/023.6	3
800/278	3
800/312	3
800/320.1	3

Table 9: Top 20 U.S. Classifications and Sub-classifications for the 40 relevant U.S. Patent Documents

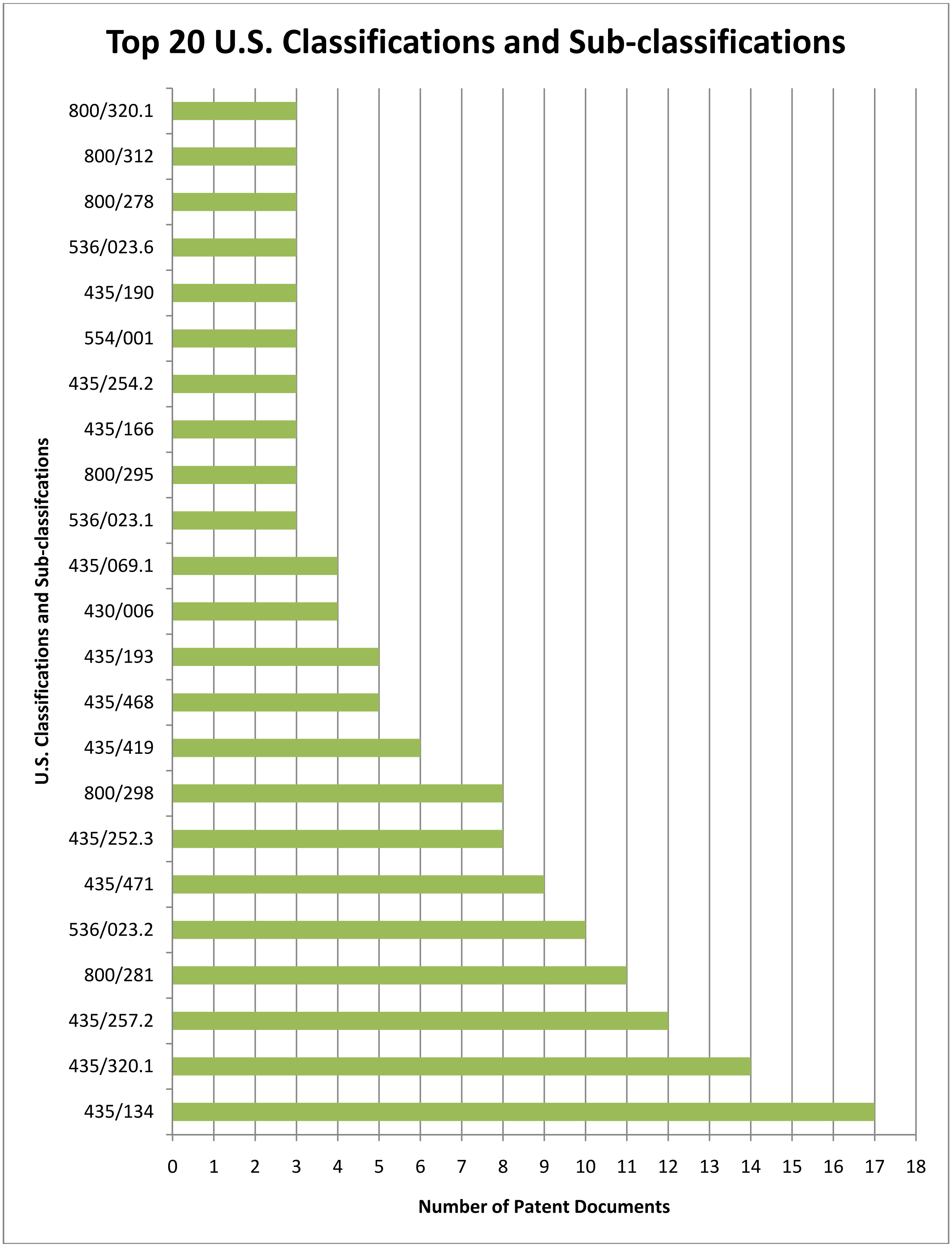


Figure 12: Bar Graph of the Top 20 U.S. Classifications and Sub-classifications of the 40 Relevant Patent Documents

4.A.5 IPC Classification v. Patent Document Count

Pursuant to the 1971 Strasbourg Agreement, the World Intellectual Property Organization (WIPO) established the International Patent Classification system (IPC) for classifying patents hierarchically according to the technology to which they pertain.[136] The IPC classifies patents into eight sections with approximately 70,000 subdivisions, each of which is continuously revised and represented by a string of Arabic numerals and Latin letters.[137] Patent-issuing authorities, patent search firms, patent practitioners, inventors, and others use the IPC as an indispensible tool in the search for prior art.[138]

Table 10 and Figure 13 represent the top-twenty IPC codes for the sixty-two relevant patent records. Section C (chemistry) occupied nineteen of the top-twenty classifications along with one classification from section A (human necessities). Subclass C12, which includes biochemistry, microbiology, enzymology, and genetic engineering,[139] was overwhelmingly the most-used classification.

International Patent Classification	Patent Document Count
C12N001582	26
C12P000764	22
C12N000112	17
C07H002104	13
A01H000500	12
C07H002100	12
C12N000113	12
C12N001563	10
C12N001574	9
C12N000121	8
C12N000902	8
C12N000910	8
C12N000510	8
C12N000900	6
C12N000120	5
C12N000119	4
C12N001500	4
C12N001552	4
C12Q000168	4
C12P000500	4

Table 10: Top 20 IPCs for the 62 Relevant Patent Documents

[136] WORLD INTELLECTUAL PROP. ORG., http://www.wipo.int/classifications/ipc/en/ [hereinafter WIPO].
[137] *Id.*
[138] *Id.*
[139] *See id.*, http://www.wipo.int/ipcpub/#refresh=page&notion=scheme&version=20110101&symbol=C.

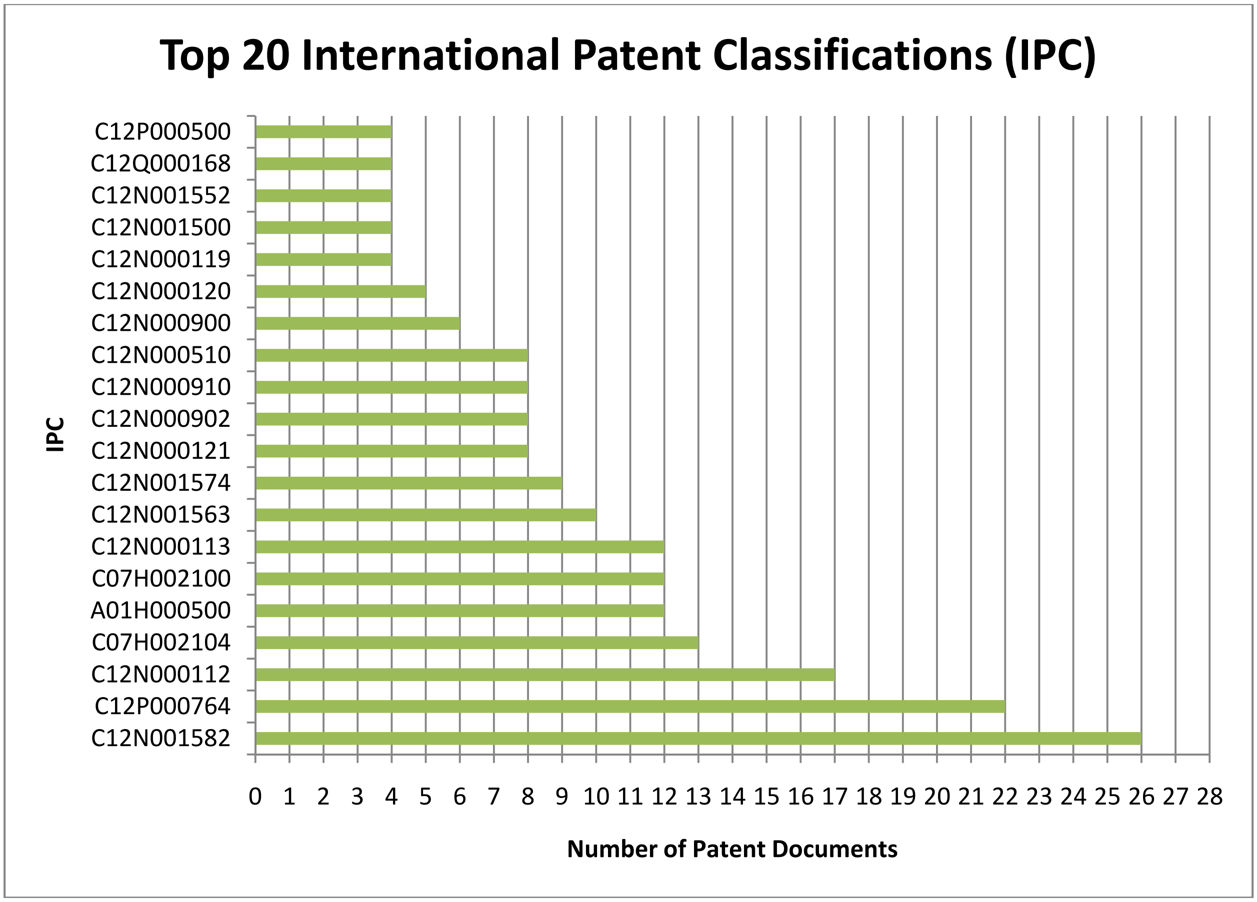


Figure 13: Patent Document Count v. Top 20 IPCs for the 62 Relevant Patent Documents

4.A.6 Derwent (DWPI) Class v. Patent Document Count)

DWPI classification information is available for all of the 62 relevant patent documents. Table 11 shows the top 20 DWPI classes that the 62 patent documents fall into. The top DWPI class is class D16. 60 out of the total of 62 patent documents fall under class D16. The definitions of the Derwent classes listed in the table below are defined in Appendix E.

DWPI Class-Main	Patent Document Count
A94	1
A97	4
B02	2
B04	20
B05	4
C03	3
C06	30
D13	10
D16	60

D21	3
D23	21
E15	1
E17	12

Table 11: Top 20 DWPI Classes for the 62 Relevant Patent Documents

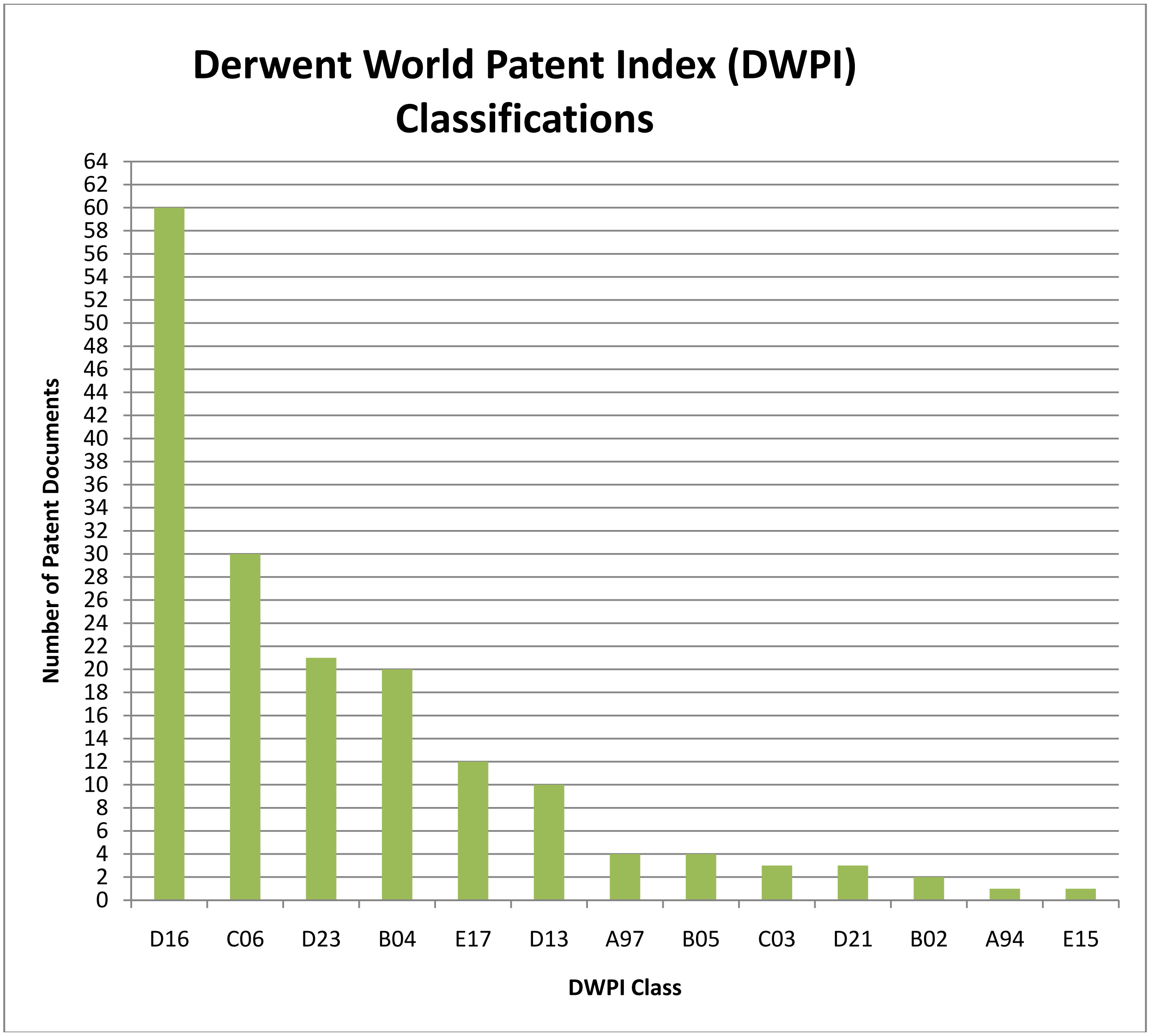


Figure 14: Bar Graph of the Top 20 DWPI Classes for the 62 Relevant Patent Documents

4.A.7 Derwent Manual Code v. Patent Document Count

The Derwent Manual Code is a custom taxonomy given by the Derwent World Patent Index. The number refers to the novel use and features of the claimed invention. Here there is a fairly steep drop off after the first few classifications and the trend then levels out. The "D05" which makes up the top 5 codes are prevalent in the areas of recombination, genetic engineering, and biofuels.

Derwent Manual Code	Patent Document Count
D05H12E	26
D05C	22
D05H12A	18
D05H16B	16
D05H14	15
C04E08	14
B04E08	11
E11M	11
C04A0800E	11
B04E04E	10
B04F0400E	10
C04F0400E	10
C04F08A0E	10
C04E03E	9
H06B07	9
B04E02E	8
D05H14B3	8
C04B01B	8
C04F0900E	8
C04E99	8

Table 12: Patent Document Count v. Derwent Manual Codes

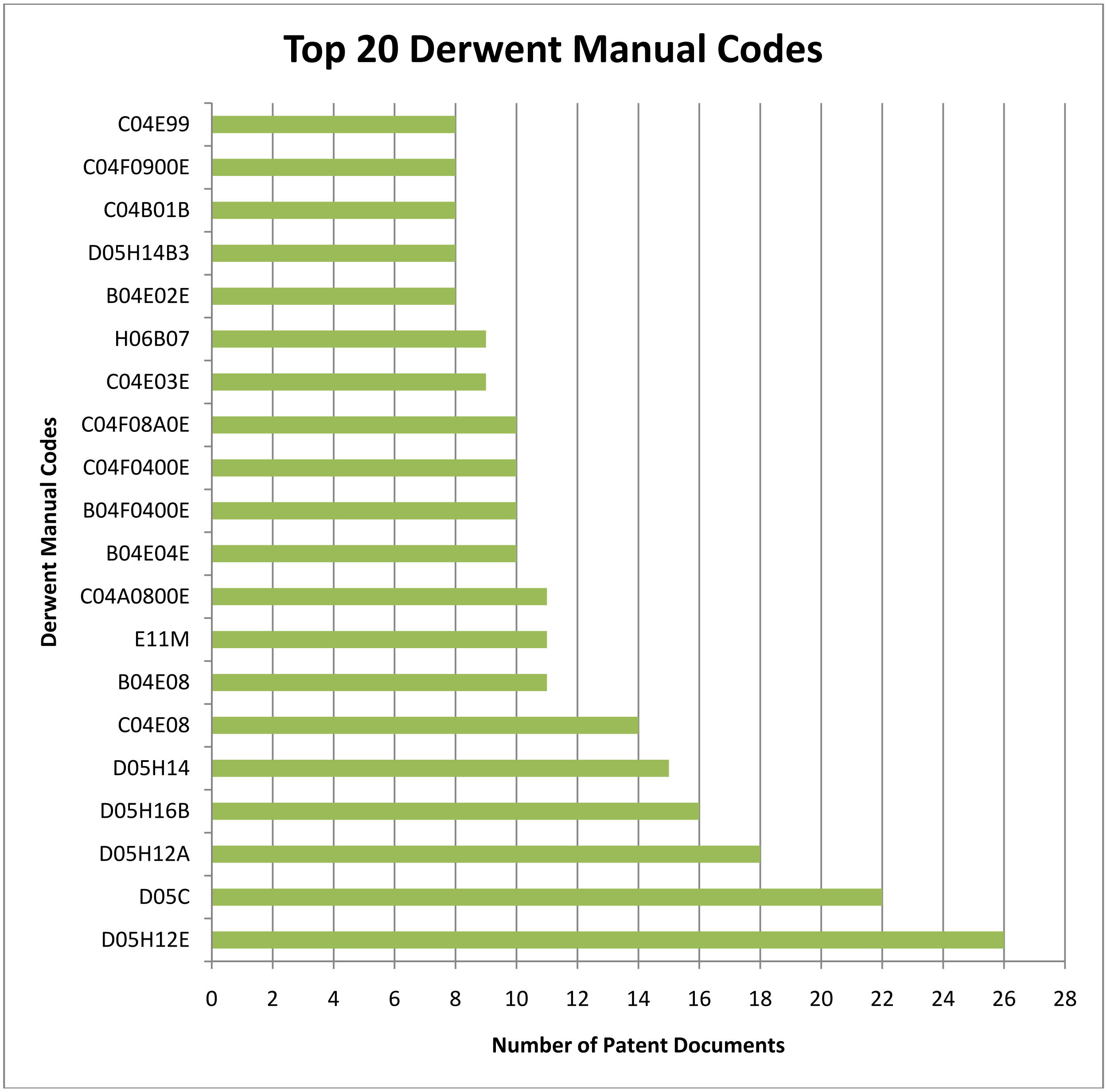


Figure 15: Derwent Manual Code v. Patent Document Count

4.A.8 Assignees v. Patent Document Count

All relevant patent documents were matched with corresponding assignees. All assignee information was obtained from Thomson Innovation or USPTO Assignee searches. At least thirty-one unique assignees owned all sixty-two relevant patent documents. However, assignee information was unavailable for four patent documents, labeled "Unknown Assignees." Table 13 reports all assignees associated with relevant patents. Figure 16 reports assignees with at least two relevant patent documents in their portfolio. Mean relevant patent documents per assignee is 2, the standard deviation is 1.67.

Assignee	Patent Document Count
BASF Plant Science GmbH	8
E.I du Pont de Nemours and Co.	5
Martek Biosciences Corp.	5
University of California	4
Aurora Biofuels Inc.	3
Michigan State University	3
Solazyme Inc.	3
Kuehnle AgroSystems Inc.	2
Monsanto Co.	2
Sapphire Energy Inc.	2
Targeted Growth Inc.	2
Abbott Laboratories	1
Amoco Corp.	1
Arizona State University	1
Dow Agrosciences LLC	1
LS9 Inc.	1
Maxygen Inc.	1
Ohio State University	1
OrganoBalance GmbH	1
Phycal LLC	1
Rosetta Genomics Ltd.	1
Rosetta Green LTD	1
Synthetic Genomics	1
Texas A&M University	1
The Donald Danforth Plant Science Center	1
TransAlgae Ltd.	1
University of Texas	1
University of York	1
Washington State University	1
Zhengzhou University	1

Table 13: Patent Document Count v. Assignees

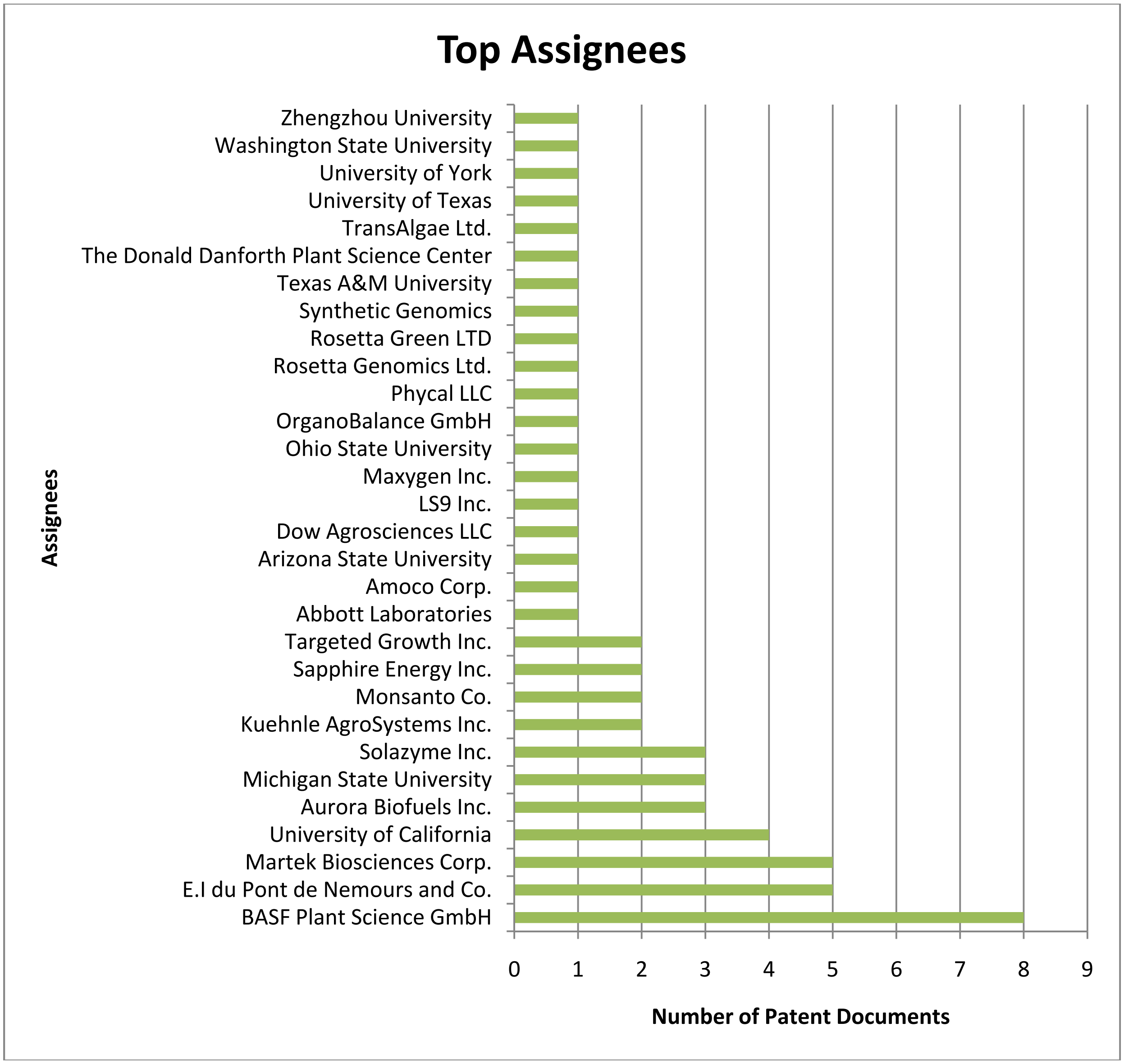


Figure 16: Assignee v. Patent Document Count

4.A.9 Inventors v. Patent Document Count

The following is a chart showing the relationship between the inventor of a technology and the number of relevant patents documents on which they are present as an inventor. As can be seen, there is very little difference between the top inventor (4 patents) and the last inventor (2 patents).

Inventor	Patent Document Count
Petra Cirpus	4
Craig A. Weaver	3
James G. Wetz	3
Joerg Bauer	3

Ernst Heinz	3
Bertrand Vick	3
Ross Zirkle	2
Narendra S. Yadev	2
Andreas Renz	2
Thorsten Zank	2

Table 14: Patent Document Count v. Inventor

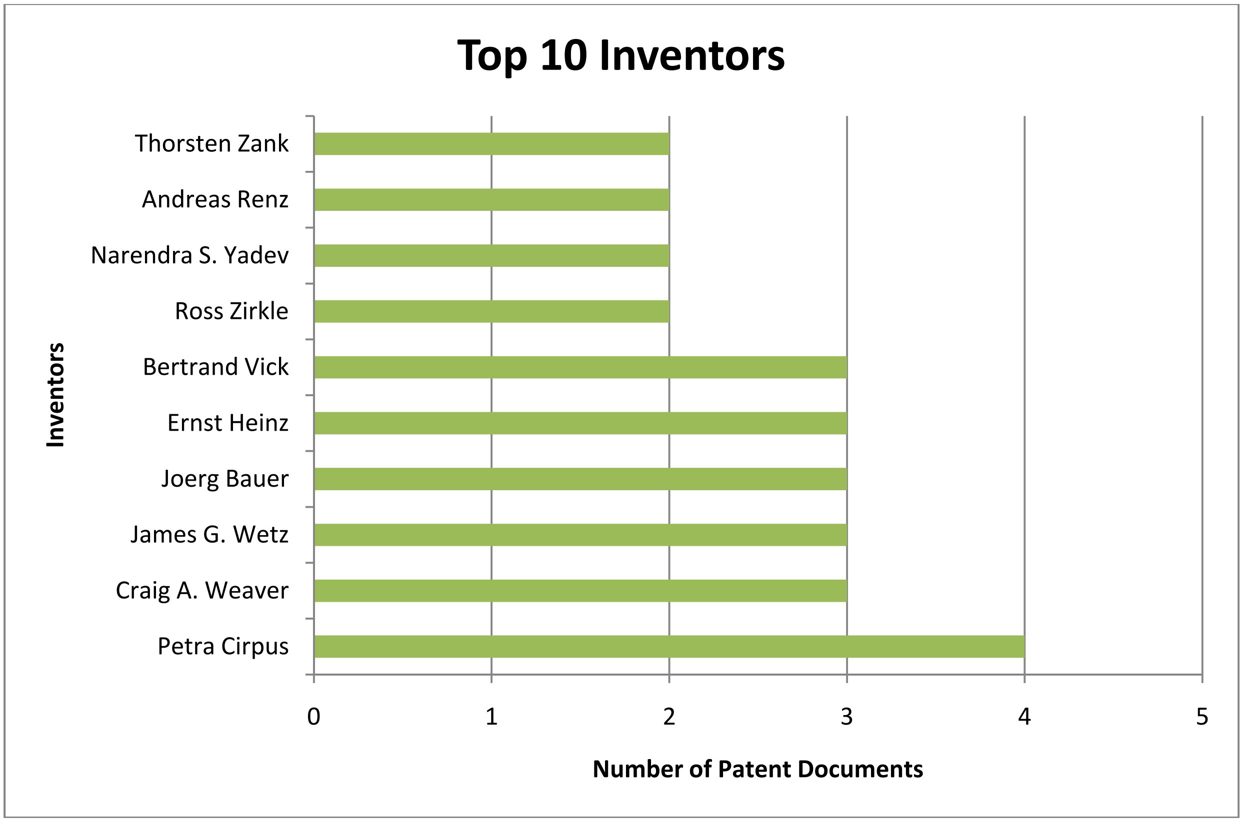


Figure 17: Patent Document Count v. Inventor

4.A.10 Themescape Map

An added feature of Thomson Innovation, is the ability to create Themescape maps. Documents with similar content are near each other in the content map, forming peaks, and the number of documents in a region is indicated by the height of the peaks in the landscape. Tall peaks indicate many documents, while small peaks indicate fewer documents. The relationship between the topics in the documents is drawn as the distance between peaks. Peaks that are located near each other have more similar topics than peaks that are located farther away. A Themescape map summarizing the title, abstract and claims of the Relevant Technology patents is found in Figure 18 and a Themescape map summarizing the Derwent title and abstract of the Relevant Technology patents is found in Figure 19.

Figure 18: Relevant Documents Themescape Map - Title Abstract Claims

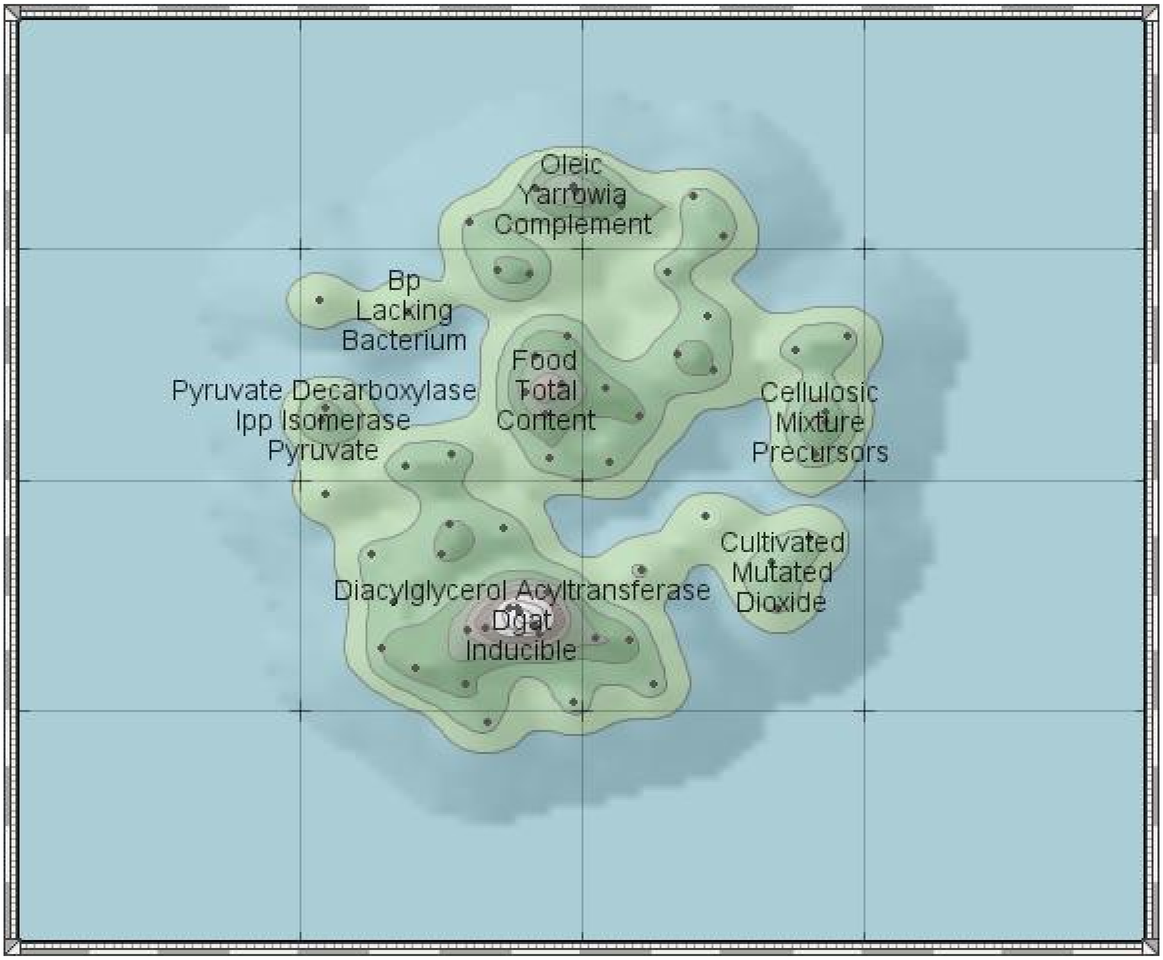


Figure 19: Relevant Documents Themescape Map - DWPI Title Abstract

VIII. Appendices

APPENDIX A: Non-Patent Literature

1. GuanHua Huang, Feng Chen, Dong Wei, XueWu Zhang, Gu Chen, *Biodiesel Production by Microalgal Biotechnology*, 87 APPLIED ENERGY 38–46 (2010).

Abstract:

"Biodiesel has received much attention in recent years. Although numerous reports are available on the production of biodiesel from vegetable oils of terraneous oil-plants, such as soybean, sunflower and palm oils, the production of biodiesel from microalgae is a newly emerging field. Microalgal biotechnology appears to possess high potential for biodiesel production because a significant increase in lipid content of microalgae is now possible through heterotrophic cultivation and genetic engineering approaches. This paper provides an overview of the technologies in the production of biodiesel from microalgae, including the various modes of cultivation for the production of oil-rich microalgal biomass, as well as the subse- quent downstream processing for biodiesel production. The advances and prospects of using microalgal biotechnology for biodiesel production are discussed."

2.Randor Radakovits, Robert E. Jinkerson, Al Darsins, Matthew C. Posewitz, *Genetic Engineering of Algae for Enhanced Biofuel Production*, 9(4) EUKARYOTIC CELL 486–501 (Apr. 2010).

Abstract:

"There are currently intensive global research efforts aimed at increasing and modifying the accumulation of lipids, alcohols, hydrocarbons, polysaccharides, and other energy storage compounds in photo- synthetic organisms, yeast, and bacteria through genetic engineering. Many improvements have been realized, including increased lipid and carbohydrate production, improved H2 yields, and the diversion of central metabolic intermediates into fungible biofuels. Photosynthetic microorganisms are attracting considerable interest within these efforts due to their relatively high photosynthetic conversion efficiencies, diverse metabolic capabilities, superior growth rates, and ability to store or secrete energy-rich hydro carbons. Relative to cyanobacteria, eukaryotic microalgae possess several unique metabolic attributes of relevance to biofuel production, including the accumulation of significant quantities of triacylglycerol; the synthesis of storage starch (amylopectin and amylose), which is similar to that found in higher plants; and the ability to efficiently couple photosynthetic electron transport to H2 production. Although the application of genetic engineering to improve energy production phenotypes in eukaryotic microalgae is in its infancy, significant advances in the development of genetic manipulation tools have recently been achieved with microalgal model systems and are being used to manipulate central carbon metabolism in these organisms. It is likely that many of these advances can be extended to industrially relevant organisms. This review is focused on potential avenues of genetic engineering that may be undertaken in order to improve microalgae as a biofuel platform for the production of biohydrogen, starch derived alcohols, diesel fuel surrogates, and/or alkanes."

3. Brian J. Schmidt, Xiefan Lin-Schmidt, Austin Chamberlin, Kourosh Salehi-Ashtiani, Jason A. Papin, *Metabolic Systems Analysis to Advance Algal Biotechnology*, 5 Biotech. J. 660–670 (2010).

Abstract:

"Algal fuel sources promise unsurpassed yields in a carbon neutral manner that minimizes resource competition between agriculture and fuel crops. Many challenges must be addressed before algal biofuels can be accepted as a component of the fossil fuel replacement strategy. One significant challenge is that the cost of algal fuel production must become competitive with existing fuel alternatives. Algal biofuel production presents the opportunity to fine-tune microbial metabolic machinery for an optimal blend of biomass constituents and desired fuel molecules. Genome-scale model-driven algal metabolic design promises to facilitate both goals by directing the utilization of metabolites in the complex, interconnected metabolic networks to optimize production of the compounds of interest. Network analysis can direct microbial development efforts towards successful strategies and enable quantitative fine-tuning of the network for optimal product yields while maintaining the robustness of the production microbe. Metabolic modeling yields insights into microbial function, guides experiments by generating testable hypotheses, and enables the refinement of knowledge on the specific organism. While the application of such analytical approaches to algal systems is limited to date, metabolic network analysis can improve understanding of algal metabolic systems and play an important role in expediting the adoption of new bio-fuel technologies."

4. Inna Khozin-Goldberg, Zvi Cohen, *Unraveling Algal Lipid Metabolism: Recent Advances in Gene Identification*, 93 BIOCHEMIE 91–100 (2011).

Abstract:

"Microalgae are now the focus of intensive research due to their potential as a renewable feedstock for biodiesel. This research requires a thorough understanding of the biochemistry and genetics of these organisms' lipid biosynthesis pathways. Genes encoding lipid-biosynthesis enzymes can now be identified in the genomes of various eukaryotic microalgae. However, an examination of the predicted proteins at the biochemical and molecular levels is mandatory to verify their function. The essential molecular and genetic tools are now available for a comprehensive characterization of genes coding for enzymes of the lipid-biosynthesis pathways in some algal species. This review mainly summarizes the novel information emerging from recently obtained algal gene identification."

5. Qiang Hu, Milton Sommerfeld, Eric Jarvis, Maria Ghirardi, Matthew Posewitz, Michael Seilbert, Al Arzins, *Microalgal Triacylglycerols as Feedstocks for Biofuel Production: Perspectives and Advances*,54 THE PLANT J. 621–639 (2008).

Abstract:

"Microalgae represent an exceptionally diverse but highly specialized group of micro-organisms adapted to various ecological habitats. Many microalgae have the ability to produce substantial amounts (e.g. 20–50% dry cell weight) of triacylglycerols (TAG) as a storage lipid under photo-oxidative stress or other adverse environmental conditions. Fatty acids, the building blocks for TAGs and all other cellular lipids, are synthesized in the chloroplast using a single set of enzymes, of which acetyl CoA carboxylase (ACCase) is key in regulating fatty acid synthesis rates. However, the expression of genes involved in fatty acid synthesis is poorly understood in microalgae. Synthesis and sequestration of TAG into cytosolic lipid bodies appear to be a protective mechanism by which algal cells cope with stress conditions, but little is known about regulation of TAG formation at the molecular and cellular level. While the concept of using microalgae as an alternative and renewable source of lipid-rich biomass feedstock for biofuels has been explored over the past few decades, a scalable, commercially viable system has yet to emerge. Today, the production of algal oil is primarily confined to high-value specialty oils with nutritional value, rather than commodity oils for biofuel. This review provides a brief summary of the current knowledge on oleaginous algae and their fatty acid and TAG biosynthesis, algal model systems and genomic approaches to a better understanding of TAG production, and a historical perspective and path forward for microalgae-based biofuel research and commercialization."

APPENDIX B: Patents Unable to be Coded as Relevant or Irrelevant

The following is a list of patents that were unable to be coded as either irrelevant or relevant in regards to the genetic transformation of algae for use in the production of biodiesel. A short explanation as to why they were unable to be coded is also included.

I. CN101892091A
   a. Original Title: Method for Expressing FAEES and producing biodiesel in new type body through recombined algae
   b. Machine translated
II. US20020045232A1
   a. Original Title: Production of conjugated linoleic and linolenic acids in plants
   b. DWPI Title: Nucleic acids which encode a conjugase and its related enzyme a delta desaturase to be used for the large scale production of conjugated linoleic acid and linolenic acid in plants
   c. Method for producing fatty acids in plans by genetic transformation. Technology may be relevant to algae, but unsure.
III. US20110003360A1
   a. Original Title: Delta-6 Desaturase and Uses Thereof
   b. DWPI Title: New delta 5 desaturase of delta 6 desaturase polypeptides, useful for producting polyunsaturated fatty acids, desaturases polyunsaturated fatty acids at carbon 5 and carbon 6, respectively
   c. Method for producing a vector to be used in genetic transformation of a host cell. Algae is not specifically mentioned.
IV. EP1794290A1
   a. Original Title: Synthetase Enzymes
   b. DWPI Title: Novel transgenic cell e.g. yeast or plant cell comprising nucleic acid molecule encoding polypeptide having acyl-CoA synthetase activity, useful for esterification of long chain fatty acid substrate to coenzyme A to form acyl-CoA
   c. No claims, but abstract looks relevant
V. US20090191599A1
   a. Original Title: Engineered Light-Harvesting Organisms
   b. DWPI Title: New engineered cell comprises at least two engineered nucleic acids, e.g. light capture nucleic acid and NADPH pathway nucleic acid, useful for producing carbon products, e.g. biological sugars, and hydrocarbon products
   c. Host cell used is a bacteria, but the technology may also be relevant to algae.

APPENDIX C: Description of Patent Databases & Platforms Used in this Report

Platform Name – Thomson Innovation

I. General Information
   a. Thomson Innovation is a Thomson Reuters product
   b. Data Coverage
      i. US Grants & Applications
      ii. European Grants & Applications
      iii. German Grants & Applications
      iv. German Utility Models
      v. WIPO/PCT Applications
      vi. British Applications
      vii. French Applications
      viii. Japanese Grants & Applications
      ix. Chinese Utility Models & Applications
      x. Korean Grants & Applications
      xi. INPADOC
      xii. Derwent World Patents Index
      xiii. Non-Patent Literature
      xiv. Business Information and News

II. Searches and Views
   a. Quick/Number searching and Boolean searching are available
   b. Corporate tree shows a user how an Assignee name fits into a corporate hierarchy which takes into account mergers and acquisitions and then lets you search for patents by selecting Assignee names from that corporate hierarchy
   c. Cross Search enables you to search the Patent, Literature and Business content sets in a single search
   d. Patent images can be viewed in both high and low resolution
   e. Saved Searches saves queries for frequently used searches. Searches can be saved directly from a result set. Two or more existing Saved Searches can be merged
   f. Users can create Alerts for later automated searches
   g. Work files save, organize, annotate and share personalized lists of patents. Work files can save up to 20,000 patent documents. Users can share Work Files with coworkers or clients.
   h. Data Extract exports key bibliographic fields in common formats

III. Analysis and Mapping
   a. Charts & Graphs
   b. Thomson Innovation provides a collection of standard templates, each one designed to illustrate a different aspect of your list of records
   c. Citation maps
      i. Using citation mapping, you analyze your own patent and choose to look at forward only citations to focus just on other patents citing yours
      ii. To support the patent's validity, you use citation mapping to review the reference cited in your client's patent, as well as the references cited by those, to establish the state of the art at the time of the invention

d. Text Clustering
    i. Clustering organizes results in a hierarchical format for easy drill-down to enable refinement of search strategies and identification of new links between subject matter and assignees
e. Themescape Maps
    i. Themescape creates content maps from Thomson Innovation full text patent data, enhanced patent data from DWPI, and scientific literature content
    ii. Common conceptual terms are displayed in a two-dimensional map, with peaks representing a concentration of documents and showing the relative relationship of one record to another
    iii. The thematic topographical map enables "at a glance" assessments and is searchable

Platform Name – Westlaw

I. General Information
  a. Westlaw is a Thomson Company product
  b. Flexible pricing plans (i.e., large company or single attorney)
  c. The Westlaw database contains full text information of patents before 1972, whereas other services just have bibliographic information

II. Searching
  a. The value-added services can be accessed from the "Patent Practitioner" tab of the user's account after login. This tab includes links useful to facilitate research in patent literature, cases, statutes and regulations, court records and litigation tracking. It also provides information on recent developments, litigation practice guides, prosecution practice guides, and forms
  b. "KeyCite" covers all patent granted by the USPTO since 1976. "KeyCite" also offers access to reissued patents, defensive publications, and statutory invention registrations. To view KeyCite information for a document, users can click a status flag on the document or click "Full History" or "Citing References" links on the "Links" tab
  c. Citing references provide relevant previous patent literatures
  d. Citing references are available for US patents only
  e. Provides access to the Derwent World Patent Index as well as relevant sources, including cases and statutes, patents and patent treatises, and post issuance information, such as KeyCite for patents
  f. Includes a link to Delphion which provides access to the full text of US and European patents and patent applications, PCT applications, and abstracts from Japanese patents and patent applications
  g. Has ability to search full-text patent documents, each has a link to display the full original patent, including drawings in PDF format
  h. US patent file histories are available in PDF format, with handwritten comments and time stamps intact
  i. Using certain truncations and connectors is difficult when using the Westlaw database

j. Hybrid searches often generate a large number of irrelevant results

Platform name – TotalPatent™

I. General Information
   a. TotalPatent™ is a LexisNexis® product
   b. 2008 CODiE Award winner for "Best Online Science or Technology Service"
   c. Data Coverage
      1. Africa Regional Intellectual Property Organization (Application and Granted)
      2. Argentina (Applications and Granted)
      3. Austria(Applications, Granted and Utility)
      4. Australia (Applications and Granted)
      5. Bosnia and Herzegovina (Applications and Granted)
      6. Belgium(Applications and Granted)
      7. Bulgaria (Applications, Granted and Utility)
      8. Republic of Bolivia (Applications, Granted and Utility)
      9. Brazil (Application Granted and Utility)
      10. Canada (Application and Granted)
      11. Swiss confederation ((Application and Granted)
      12. China (Application, Granted and Utility)
      13. Chile (Application and Utility)
      14. Columbia (Application)
      15. Costa Rica (Applications)
      16. Czechoslovakia (Application and Granted)
      17. Cuba (Application and Granted)
      18. Cyprus(Application and Granted)
      19. Czech Republic ((Application and Granted)
      20. German(Application, Granted, and Utility)
      21. Denmark (Application and Granted)
      22. Dominican Republic (Application and Granted)
      23. Algeria (Application and Granted)
      24. Ecuador (Application and Utility Models)
      25. Estonia (Application and Granted)
      26. Egypt (Application)
      27. Finland (Application and Granted)
      28. Great Britain (Application and Granted)
      29. Gulf States (Granted)
      30. Hellenic Republic (Applications, Granted and Utility)
      31. Gautemala (Applications)
      32. Hong Kong (Application and Granted)
      33. Honduras (Applications)
      34. Croatia (Application and Granted)
      35. Hungary (Application, Granted and Utility)
      36. Indonesia(Application and Granted)
      37. Ireland (Application and Granted)

38. Israel (Application)
39. India (Application and Granted)
40. Italy (Application, Granted and Utility)
41. Japan (Application, Granted and Utility)
42. Kenya (Applications)
43. Korea (Application, Granted and Utility)
44. Morocco (Applications)\
45. Monaco (Applications)
46. Moldova (Applications, Granted and Utility)
47. Mongolia(Application)
48. Malta (Applications)
49. Malwai (Applications)
50. Mexico(Applications, Granted and Utility)
51. Malaysia (Applications and Granted)
52. Nicaragua(Applications)
53. Netherlands((Application and Granted)
54. Norway (Applications and Granted)
55. New Zealand (Applications)
56. African Intellectual Property Organization (Applications)
57. Panama (Applications)
58. Peru (Appplications and Utility)
59. Phillipines (Applications, Grated and Utility)
60. Poland(Applications, Grated and Utility)
61. Portugal (Applications, Grated and Utility)
62. Paraguay (Applications)
63. Romania(Applications and Granted)
64. Russia(Applications)
65. Sweden(Applications and Granted)
66. Singapore (Applications)
67. Slovak (Applications and Granted)
68. San marino(Applications and Granted)
69. USSR (Appliations)
70. El Savador (Applications)
71. Tajikistan (Applications, Granted and Utility)
72. Turkey (Applications and Utility)
73. Trinidad (Granted)
74. Taiwan(Granted and Utility)
75. Ukraine(Application, Granted and Utility)
76. US (Applications, Granted, utility, Design and Plant Applications)
77. Uruguay (Applications)
78. WIPO (Applications)
79. Yugoslavia (Applications and Granted)
80. South Africa(Applications)
81. Zambia (Applications)
82. Zimbabwe (Applications)

II. Searches

a. The searching is Semantic Searching, which enables query creation and improves search results by using semantics, the science of meaning in language.
b. Quick/Number searching and Boolean searching are available
c. Saved Searches saves queries for frequently used searches. Searches can be saved directly from a result set. Two or more existing Saved Searches can be merge
d. Users can create Alerts for later automated searches
e. Work files save, organize, annotate and share personalized lists of patents. Work files can save up to 20,000 patent documents. Users can share Work Files with coworkers or clients.
f. Data Extract exports key bibliographic fields in common formats
g. Notes feature allows users to make comments accessible to people across the entire user group
h. Searching subsidiary companies is also available.

III. Analysis
  a. Allows analysis of charts and graphs
  b. Visualization and comparison tools available. Two fields can be selected to analyze the results
  c. Saved folders can be analyzed.

Platform Name – PatentLens

I. General Information
  a. It is a project of Cambia.
  b. It includes sequences (DNA, RNA and Protein) extracted from patent documents.
  c. The platform was last updated may 2, 2010.
  d. It includes full text of over 8 million patents and applications
  e. It uses NCBI's Blast software to search sequences that are specifically listed in US.
  f. Allows sequence searching in specification and claims of patents
  g. Similarity of sequences is determined by E-value
  h. This platform is a free resource.

II. Data coverage
  1. US
  2. EPO
  3. Australia
  4. INPADOC

APPENDIX D: Definitions of US Classifications[140]

The U.S. Patent Classification System is a categorization of all U.S. patent and other technical documents by common subject matter. Each subject matter division includes a class and a subclass. The Manual of Classification is an ordered listing of all the valid classifications. Classes and subclasses have titles providing a general description of their contents, and definitions providing a more specific description. A definition may contain an explanation of the class or subclass, a glossary, search notes, references to subclasses within a class, and references to other classes and subclasses. The U.S. system contains about 450 classes and about 150,000 subclasses. The classification code is express with 2 numbers separated by a forward slash, for example, 435/134. The first number, 435, represents the class of the invention. The number following the slash, 134, is the subclass of the invention within the preceding class. Patents will always have both a class and a subclass. More explanation and definitions of U.S. patent classifications can be found at, http://www.uspto.gov/web/patents/classification/.

<u>Classifications assigned to patent documents coded as relevant for this report include:</u>

Class 435: Chemistry: Molecular Biology and Microbiology

- 435/006 = Involving nucleic acid
- 435/069.1 = Recombinant DNA technique included in method of making a protein or polypeptide
- 435/134 = Fat; fatty oil; ester-type wax; higher fatty acid (i.e., having at least seven carbon atoms in an unbroken chain bound to a carboxyl group); oxidized oil or fat
- 435/166 = Preparing hydrocarbon
- 435/193 = Transferase other than ribonuclease
- 435/252.3 = Transformants (e.g. recombinant DNA or vector or foreign or exogenous gene containing, fused bacteria, etc.)
- 435/254.2 = Yeast; media therefore
- 435/254.22 = Candida
- 435/257.2 = Transformants
- 435/320.1 = Vector, per se (e.g., plasmid, hybrid plasmid, cosmid, viral vector, bacteriophage vector, etc.)
- 435/325 = Animal cell, per se (e.g., cell lines, etc.); composition thereof; process of propagating, maintaining or preserving an animal cell or composition thereof; process of isolating or separating an animal cell or composition thereof; process of preparing a composition containing an animal cell; culture media therefore
- 435/419 = Plant cell or cell line; per se, contains exogenough or foreign nucleic acid
- 435/468 = Introduction of a polypeptide molecule into or rearrangement of a nucleic acid within a plant cell
- 435/471 = Introduction of a polynucleotide molecule into or rearrangement of nucleic acid within a microorganism (e.g., bacterial, protozoa, bacteriophage, etc.)

Class 536: Organic Compounds

- 536/023.1 = DNA or RNA fragments or modified forms thereof (e.g., genes, etc.)
- 536/023.2 = Encodes an enzyme

[140] http://www.uspto.gov/web/patents/classification/.

- 536/023.6 = Encodes a plant polypeptide

Class 554: Organic Compounds

- 554/001 = Fatty compounds having an acid moiety which contains the carbonyl of a carboxylic acid, salt, ester, or amide group bonded directly to one end of an acyclic chain of at least seven (7) uninterrupted carbons, wherein any additional carbonyl in the acid moiety is (1) part of an aldehyde or ketone group, (2) bonded directly to a noncarbon atom which is between the additional carbonyl and the chain, or (3) attached indirectly to the chain via ionic bonding

Class 800: Multicellular living organisms and unmodified parts thereof and related processes

- 800/278 = Met hod of introducing a polynucleotide molecule into or rearrangement of genetic material within a plant or plant part
- 800/281 = The polynucleotide alters fat, fatty oil, ester-type wax, or fatty acid production in the plant
- 800/295 = Plant, seedling, plant seed, or plant part, per se
- 800/298 = Higher plant, seedling, plant seed, or plant part (i.e., angiosperms or gymnosperms)
- 800/320.1 = Maize

APPENDIX E: Definitions of IPC Classifications

International Patent Classification System[141]

- The World Intellectual Property Organization (WIPO) administers the International Patent Classification (IPC) system. IPCs are organized hierarchically and divide technology into eight sections (A through G) with approximately 70,000 subdivisions.
- An IPC is typically expressed as, for example, C12N 15/82, but may also appear as C12N001582.
    - The first letter, C, specifies a Section.
    - The number following the Section indicator, 12, specifies a Class.
    - The letter N specifies a Subclass.
    - The number 15 specifies a Main Group.
    - The number following the slash, 82, specifies a Subgroup.
- WIPO publishes the authentic IPCs versions in English and French languages. Chinese, Croatian, Czech, Dutch German, Hungarian, Japanese, Korean, Polish, Romanian, Russian, Serbian, and Spanish versions are also available.
- More information is available at the WIPO website, http://www.wipo.int/classifications/ipc/en/.

Classification Codes Applicable to this Report[142]

- Section A: Human necessities
    - A01H: New plants or processes for obtaining them; plant reproduction by tissue culture techniques.
        - A01H 5/00 Undifferentiated human, animal or plant cells, e.g. cell lines; Tissues; Cultivation or maintenance thereof; Culture media therefor

- Section C: Chemistry; Metallurgy
    - C07H: Sugars; derivatives thereof; nucleosides; nucleotides; nucleic acids
        - C07H 21/00: Compounds containing two or more mononucleotide units having separate phosphate or polyphosphate groups linked by saccharide radicals of nucleoside groups, e.g. nucleic acids
        - C07H 21/04: with deoxyribosyl as saccharide radical

    - C12N: Micro-organisms or enzymes; compositions thereof; propagating, preserving, or maintaining micro-organisms; mutation or genetic engineering; culture media
        - C12N 1/12: Unicellular algae; Culture media therefor
        - C12N 1/13: modified by introduction of foreign genetic material
        - C12N 1/19: modified by introduction of foreign genetic material
        - C12N 1/20: Bacteria; Culture media therefor
        - C12N 1/21: Bacteria; Culture media therefor
        - C12N 5/10: Cells modified by introduction of foreign genetic material, e.g. virus-transformed cells

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141 WIPO, http://www.wipo.int/classifications/ipc/en/ (last visited Apr. 24, 2011).

142 WIPO, http://www.wipo.int/ipcpub/#refresh=page (version 2011.01) (last visited Apr. 24, 2011).

    - C12N 9/00: Enzymes, e.g. ligases; Proenzymes; Compositions thereof; Processes for preparing, activating, inhibiting, separating, or purifying enzymes
    - C12N 9/02: Oxidoreductases
    - C12N 9/10: Transferases
    - C12N 15/00: Mutation or genetic engineering; DNA or RNA concerning genetic engineering, vectors, e.g. plasmids, or their isolation, preparation or purification; Use of hosts therefor
    - C12N 15/52: Genes encoding for enzymes or proenzymes
    - C12N 15/63: Introduction of foreign genetic material using vectors; Vectors; Use of hosts therefor; Regulation of expression
    - C12N 15/74: Vectors or expression systems specially adapted for prokaryotic hosts other than E. coli, e.g. Lactobacillus, Micromonospora
    - C12N 15/82: Use of eukaryotes as hosts for plant cells

- C12P: Fermentation or enzyme-using process to synthesize a desired chemical compound or composition or to separate optical isomers from a racemic mixture
    - C12P 5/00: Preparation of hydrocarbons
    - C12P 7/64: Fats; Fatty oils; Ester-type waxes; Higher fatty acids, i.e. having at least seven carbon atoms in an unbroken chain bound to a carboxyl group; Oxidised oils or fats

- C12Q: Measuring or testing processes involving enzymes or micro-organisms; compositions or test papers therefor; processes of preparing such compositions; condition-responsive control in microbiological or enzymological processes.
    - C12Q 1/68: involving nucleic acids

APPENDIX F: Derwent Classifications[143]

Description of Derwent Patent Classifications

- The Derwent World Patent Index (DWPI) classification system categorizes patent documents using a simple classification system for all technologies; consistently applied to all patents by Thomson Scientific subject experts, enabling effective and precise searching in a particular area of technology.
- International Patent Classification (IPC) is an internationally recognized classification system controlled by the World Intellectual Property Organization (WIPO) and assigned to patent documents by various patent offices.
- Where possible Thomson indicated next to the class the equivalent IPC in an abbreviated form (e.g., A47, F23-5). However, this should be used only as a guide since there are areas where the DWPI classes are assigned intellectually by Thomson's subject experts, and no strict correspondence is claimed.

Classification Codes (applicable to this report)

- **A94:** Semi-finished materials – fibres, films, foams.
  - This is a subclass of A8/9 – (Polymers and Plastics) Applications.
- **A97:** Miscellaneous goods not specified elsewhere – including papermaking, gramophone records, detergents, good and oil well applications.
  - This is a subclass of A8/9 – (Polymers and Plastics) Applications.
- **B02:** Fused ring heterocyclics.
  - This is a subclass of B- Pharmaceuticals.
- **B04:** Natural products and polymers. Including testing of bodily fluids (other than blood typing or cell counting), pharmaceuticals or veterinary compounds of unknown structure, testing of microorganisms for pathogenicity, testing of chemicals for mutagenicity or human toxicity and fermentative production of DNA or RNA. General compositions.
  - This is a subclass of B- Pharmaceuticals
- **B05:** Other organics – aromatics, aliphatic, organo-metallics, compounds whose substituents vary such that they would be classified in several of B01 – B05.
  - This is a subclass of B- Pharmaceuticals
- **C03:** Other organic compounds, inorganic compounds and multi-component mixtures. Polymers and proteins.
  - This is a subclass of C – Agricultural Chemicals.
- **C06:** Biotechnology – including plant genetics and veterinary vaccines.
  - This is a subclass of C – Agricultural Chemicals.
- **D13:** Other foodstuffs and treatment – including preservation of food, milk, milk products, butter substitutes, edible oils and fats, non-alcoholic beverages, artificial sweeteners, food additives and animal feed.
  - This is a subclass of D1 – Food and Fermentation.
- **D16:** Fermentation industry – including fermentation equipment, brewing, yeast production, production of pharmaceuticals and other chemicals by fermentation,

[143] *Derwent World Patent Index*, THOMSON CORPORATION, http://science.thomsonreuters.com/m/pdfs/mgr/derwentclass.pdf.

microbiology, production of vaccines and antibodies, cell and tissue culture and genetic engineering.
    - This is a subclass of D1 – Food and Fermentation.
- **D21:** Preparations for dental or toilet purposes – including filling alloys, compositions for dentures or dental impressions, anti-caries chewing gum, plaque disclosing compositions, toothpastes, cosmetics, shampoos, topical anti-sunburn compositions and toilet soaps (A61K).
    - This is a subclass of D2 – Cosmetics, Disinfectants and Detergents.
    - A61K is the corresponding IPC.
- **D23:** Oils, fats and waxes – including fatty acids, essential oils, but excluding butter (substitutes) and montan wax (C11B, C).
    - This is a subclass of D2 – Cosmetics, Disinfectants and Detergents.
    - C11b, C are the corresponding IPCs.
- **E13:** Heterocyclics
    - This is a subclass of E1 – General Organic.
- **E15:** Alicyclics.
    - This is a subclass of E1 – General Organic.
- **E17:** Other aliphatics
    - This is a subclass of E1 – General Organic.
- **E19:** Other organic compounds general – organic compounds of unknown or indefinite structure; general mixtures of many types; organic reactions (e.g. nitration, resolution) when applied generally.
    - This is a subclass of E1 – General Organic.
- **E36:** Dye precursors excluding E21-E, E24-B.
    - This is a subclass of E3 – General Inorganic
- **G02:** Inks, paints, polishes – polymer-based paints and inks are also classified in Section A (C09D, F, G).
    - This is a subclass of G – Printing, Coating, and Photographic.
    - C09D, F, G are corresponding IPCs.
- **H04:** Petroleum processing – including treating, cracking, reforming, gasoline preparation – biosynthesis based on hydrocarbon feedstocks is included (C10G).
    - This is a subclass of H – Petroleum.
    - C10G is the corresponding IPC.
- **H06:** Gaseous and liquid fuels – including pollution control. Chemical aspects of catalytic exhaust systems for cars are included as well as liquid or gaseous fuels of non-petroleum origin, e.g. methanol or ethanol-based fuels. Combustion improvement additives for liquid fuels are included (C10L).
    - This is a subclass of H – Petroleum.
    - C10L is the corresponding IPC.
- **H07:** Lubricants and lubrication – this excludes self-lubricating surfaces e.g. PTFE coated surfaces and lubrication systems in general. The section includes lubricants of non-petroleum origin e.g. silicone oils (C10M).
    - This is a subclass of H – Petroleum.
    - C10M is the corresponding IPC.
- **H09:** Fuel products not of petroleum origin – excluding coal handling, preparation or mining, but including coking, briquetting, peat processing synthesis, gas production, coal

gasification. Combustion improvement additives for coal, peat and other non-hydrocarbon based fuels are included in this Section together with coal liquefaction and desulphurisation.
    - This is a subclass of H – Petroleum.

- **P13:** Plant culture, dairy products (A01G, H, J).
    - This is a subclass of P1 – Agriculture, Food, Tobacco.
    - A01G, H, J are the corresponding IPCs.
- **P14:** Animal care (A10K, L, M)
    - This is a subclass of P1 – Agriculture, Food, Tobacco.
    - A01K, L, M are the corresponding IPCs.

APPENDIX G: Patent Families

"If there are several applications or publications for an individual invention (in other countries) claiming the same priority or priorities, we talk about a "patent family." All of these "family members" are related to one another by common priority numbers with associated priority dates. The concept of the patent family first emerged through the Paris Convention on the Protection of Intellectual Property in 1883, while automated systems enabling patent family searching became available through the establishment of the IIB in The Hague in 1947and INPADOC in Vienna in 1972. Since then, patent searching has evolved due to exponential improvements in computing and communication technology.

The term patent family can be defined in a number of ways depending on the relationship between a patent document and its priority or priorities within the meaning of the Paris Convention. The differences only become obvious when the structure of a patent application is complex, i.e. when applications are filed in several countries. Such applications may cite various earlier applications as priorities, or the diverse patent offices involved in the grant process may accept or refuse different patent claims. This results in patents which have different scopes of protection.

An important point when using any database to retrieve information on patent families is that there is never any guarantee that you will find all the corresponding patent documents that exist. Database producers do what they can to ensure completeness, but they can never guarantee it."[144]

The "Extended" (INPADOC) Patent Family

"The biobliographic and legal status databases form the basis of the EPO's raw data resources (INPADOC). In February 2008 the biobliographic data included about 60 million bibliographic data sets from almost 80 different countries. The legal status database contains a collection of more than 50 million legal events from 48 countries.

From the beginning, the concept was to cover as many countries and as many publication levels as possible. One of the strongest motives for the integration of INPADOC into the EPO was the wish to combine the particular strengths of INPADOC with the EPO's existing in-house biobliographic database, "DOC-DB."

Following integration of the two databases in the 1990s, the raw data behind both databases is now the same. And since esp@cenet draws on the same pool of data as raw data resources (INPADOC) and DOC-DB, it contains the same documentation.

However, the philosophy of the "extended" (INPADOC) patent family is quite different, and so are the results of family searches. Unlike the "also published as" feature in esp@cenet, which only shows "equivalents," i.e. almost identical documents, an INPADOC family search should retrieve all documents relating in any way to the root document.

[144] EUROPEAN PATENT OFFICE, *Patent Families* (Feb. 29, 2008), http://www.epo.org/patents/patent-information/about/families.html.

Features of INPADOC

When using INPADOC via one of the commercial database host services, it bears all the esp@cenet features, plus the following:

- Standardization of applicant and inventor names
- References to abstracts from Chemical Abstracts and Thomson Scientific Abstracts are made within the patent family
- By including the legal status database additional information is available and additional family links can be established
- National application numbers, international application numbers and domestic relations are included in the family search

For both of the EPO's raw data resources (INPADOC) and esp@cenet, even where no priority has been claimed by the patent application, artificial or "intellectual" links are built in systematic way for the complete PCT minimum documentation. The same is done for older documents (pre-1968) for which the priority information is not complete.

Definition of the "extended" (INPADOC) patent family

All the documents directly or indirectly linked via a priority document belong to one patent family. In the case shown below, documents D1 to D5 belong to the same patent family, P1.

FAMILY P1

Document D1	Priority P1		
Document D2	Priority P1	Priority P2	
Document D3	Priority P1	Priority P2	
Document D4		Priority P2	Priority P3
Document D5			Priority P5

As mentioned above, national patent application numbers, international application numbers and domestic relations are included in the family search.

In the "extended" (INPADOC) patent family, it does not matter where you start the search. It can be an application number, a priority application number or a publication number.
If the search starts with a publication number, all application numbers, domestic application numbers, priority numbers and international application numbers are used to retrieve additional documents. For all documents found in this step, step one is repeated. This iteration process ends only when no more new documents can be found.

Raw data resources (INPADOC) also use some additional sophisticated rules for certain countries, for example, if publication numbers are used instead of priority numbers in the original documents. This happened rather frequently for older documents, where the priority claims were not treated as carefully as they are now.

The inclusion of legal status information in the patent search also sometimes retrieves additional links, e.g. for divisional applications, continuations, continuations in part or national publications of first filings of PCT (international) applications, where the priority links are often missing.

Limitations of the family search in raw data resources (INPADOC) have to rely on the correctness of the data supplied by the co-operating patent offices and the extent to which it is up to date. In particular, delays in the delivery of bibliographic data can vary significantly depending on the country concerned and the time period covered. Before relying on the completeness of a patent family, users should check where there are gaps or delays in certain areas. You can find this kind of information in the PFS and PRS statistics on the internet, which are updated weekly and contain indications of missing or delayed document series. See raw data resources (INPADOC) useful tables and statistics. To be absolutely sure about the actual status of a patent, users are recommended to contact the appropriate patent issuing authority direct.
Particular care has to be taken in the case of European patents which have entered into the national phase. Here the completeness and accuracy of data can vary significantly from country to country. A good overview of the volume and kind of "post-grant" information available in raw data resources (INPADOC) can be found in the raw data resources (INPADOC) FAQ. For most of the EPO member states, information about the validation, lapse, etc., of European patents is given as part of the legal status information, and as mentioned before is less consistent due to the different quality of data available. Starting from week 50/2007, additional post-grant 172 information is taken from the fee administration system and included in the legal status part of the database.

Example of an "extended" (INPADOC) patent family

The same example is used as for the esp@cenet patent family previously (US5402857). See the example as a PDF document.

As you can see, the iterative INPADOC search retrieves 81 document records, of which esp@cenet displayed only five. The information available includes 323 legal status events (not shown in the example above). This higher recall of documents reflects not only the different philosophies of the two systems, but also the fact that INPADOC displays all publication levels within one country as separate family members."[145]

Thomson Scientific WPI Patent Family (DWPI)

"Patent Families in the Thomson Scientific World Patents Index (WPI) draw together patents covering the same invention. Their relationship is defined by the priority or application details claimed by each document. Thus, in its simplest form, a new document (D1) claiming a unique priority (P1) will be assigned to be the ―basic‖ of its own, new patent family in Thomson Scientific WPI.

Subsequently, if a second document (D2) also claiming priority P1 is received by Thomson Scientific this will be added (as an ―equivalent‖) to the patent family already containing document D1. Other documents claiming priority P1 will also be added to this family as

[145] *Id.*

—equivalents as they are included in the database. Thus, a patent family may contain anything from a single document to 10 or more. Each patent family represents a single record in the Thomson Scientific WPI database.

The basic document is the first member of a patent family that appears in Thomson Scientific WPI, so it may not necessarily be the first one published for that invention. Differences in the speed that patenting authorities supply data to Thomson Scientific, and in the processing time for documents from different countries may affect which document appears in Thomson Scientific WPI first and becomes basic.

Patents often claim more than a single priority and these must match before any equivalent is added to a family. This means that if a basic document (D3) claims priorities P2, P3 & P4, a subsequent document (D4) claiming priorities P2 & P3 will be added to the family as an equivalent, whereas patent D5 which claims priorities P2, P3 and a unique priority (P5) will form the basis of a new, but related patent family. In cases such as this, the accession number of any related family is included in the cross-reference field of each relevant Thomson Scientific WPI record.

Divisions and continuation patents maintain the same status as the original specification. This means that if GB1 is a basic, and GB2 is divisional to GB1, then GB2 will also be a basic (in its own family). However, if GB1 is equivalent to another document already in the Thomson Scientific WPI database, then GB2 will also join this family as an equivalent. It should be noted that family relationships will be defined by the order in which patents appear in Thomson Scientific WPI.

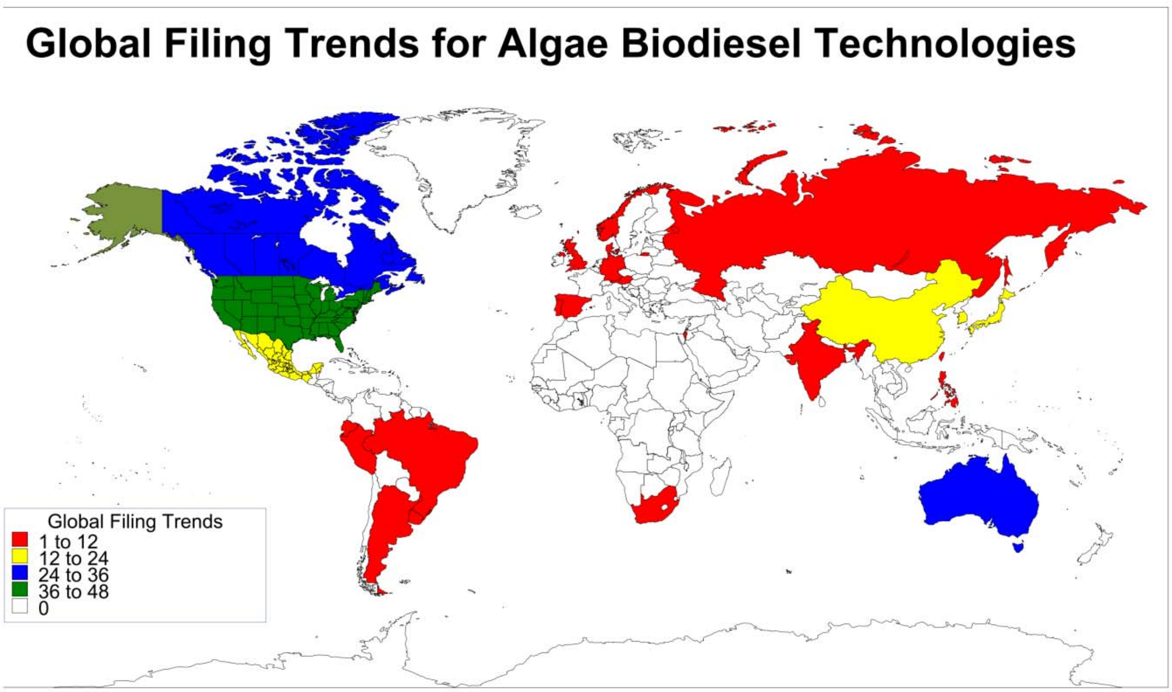
Thomson Scientific also puts a lot of resources into including patents in families even when no foreign priority is claimed, e.g. when an application has been made beyond the 12 months defined by the Paris Convention. Thomson Scientific identifies these "non-convention" equivalents by the presence of foreign nationals and addresses in the Inventor field in the absence of priority data other than the local filing details. Equivalency is determined through a time-consuming manual check of inventors, subject matter, etc.

In this way Thomson Scientific attempts to make patent families in Thomson Scientific PI as comprehensive as possible. However, because of the incidence of multiple priorities, and patent divisions and continuations (especially continuing applications in US documents), it is important to retrieve all related families through their common priorities in order to have a comprehensive overview of patent family relationships."[146]

[146] *Id.*

APPENDIX H: PCT World Map

The following pictures depict world maps of the coded patents. Table 4 and Figure 6 show the filing trends of patents families on a country-by-country basis. The patent families were obtained by using the INPADOC and DWPI families feature available on Thomson Innovation ® and the "Extended Families" feature on LexisNexis Total Patents™. The patents filed in WIPO and EPO are not shown in the figure below.



APPENDIX I: Authors' Resumes

SPOORTHY GUDAVALLI

Email:	90 Centre Street	Phone:
spoorthy.gudavalli@law.unh.edu	Concord, NH 03301	(832) 334-9780

EDUCATION

University of New Hampshire School of Law, Franklin Pierce Center for Intellectual Property, Concord, NH
Juris Doctor Candidate, May 2012
Honors: Diversity Scholarship Recipient
Activities: Legal Skills Teaching Assistant
Career Services Advisory Board
Phi Alpha Delta
Student Intellectual Property Law Association

The University of Texas at Austin, Austin, TX
B.S. Biomedical Engineering (Cellular and Bio-Molecular Engineering), May 2009
Honors: August Kunz Academic Scholar
Activities: President, Pratham Austin
Co-Founder, Longhorns Speak – Discussion through Dialogue
Peer Assistance Leader, Women in Engineering

EXPERIENCE

Upcoming — **Fletcher Yoder, Intellectual Property Law Firm,** Houston, TX
Legal Internship with a firm that has expertise in the Biomedical Industry

Fall 2010 – Spring 2011 — **International Technology Transfer Institute Clinic**, Concord, NH
Pharmaceutical Patent Mining Project for the World Health Organization (WHO) and the World Intellectual Property Organization (WIPO)
Developed a methodology to assess patent status of medicines on WHO's "Essential Medicine List." Presented findings in Geneva, Switzerland at a joint technical symposium between WHO, WIPO, and WTO (World Trade Organization) called "Access to Medicines, Patent Information and Freedom to Operate."

Fall 2010 — **Patent Drafting Project, Stephen S. Hodgson, Attorney at Law**, Houston, TX
Drafted a patent application in the field of Electrical and Mechanical Engineering; engaged in extensive prior art searches while drafting claims, patent drawings and specifications.

Summer 2010 — **Summer Legal Internship, New Hampshire Insurance Department,** Concord, NH
Drafted legal memorandums and New Hampshire insurance statutes; investigated and managed an insurance fraud case; explored possible trademark infringement by an outside law firm.

Fall 2008 – Spring 2009 — **Senior Design Project, Department of Biomedical Engineering, University of Texas,** Austin, TX
Explored and tested biomaterials for tailored biodegradability; developed and tested a prototype for industrial use; researched prior art to manage patent infringement issues.

Summer 2008 — **Summer Internship, Office of Technology Commercialization, University of Texas,** Austin, TX
Assisted with projects in patent prosecution, federal invention reporting, and patent compliance; worked with patent licensing agents; documented patent disclosures.

Fall 2006 — **Undergraduate Researcher, Biomedical Informatics Laboratory, University of Texas,** Austin, TX
Assisted in developing a breast cancer detection system for clinical use; analyzed data from multiple experiments and helped refine a quantitative assessment methodology.

SKILLS

Relevant Courses: Patent Law, Patent Prosecution I&II, IP Management, Technology Licensing, Mining Patent Information in the Digital Age, Managing Knowledge Assets in the University, Trademarks, Fundamentals of Intellectual Property.
Patent Searching Experience: Thompson Innovation, Dialog, TotalPatent, Espacenet, USPTO & USPTO Pair
Computer Programming: C++, MATLAB, LabView, SolidWorks (CAD)
Fluent in Telugu: A language spoken in South India
Hobbies: Classical Indian Music Vocalist, Reading Food Blogs, Watching Documentaries

ERNEST A. KAWKA

E-mail: kawka.ernest@gmail.com | 5B Kimball Street Concord, NH 03301 | Phone: (570) 630-0398

EDUCATION

UNIVERSITY OF NEW HAMPSHIRE SCHOOL OF LAW (f/k/a Franklin Pierce Law Center), Concord, NH **Juris Doctor** Candidate, May 2012

Journals: Associate Editor, *University of New Hampshire Law Review*

Specialized IP and Entrepreneurial Law Courses: Patent Law; Patent Mining; Patent Application Drafting I & II; Pharmaceutical Patent Law; Securities Regulation: Public and Private Securities Markets; Business Associations

UNIVERSITY OF SCRANTON, Scranton, PA

M.A. in Chemistry, May 2009

Master's Thesis: Designed, built and quantified novel photometric scheme for the measurement of colloidal silver nanoparticles.

UNIVERSITY OF SCRANTON, Scranton, PA

B.S. in Biochemistry (patent bar eligible), May 2007

LEGAL EXPERIENCE

May 2011 to Aug. 2011 — **WORLD INTELLECTUAL PROPERTY ORGANIZATION**, Geneva, Switzerland

Specialized agency of the United Nations with a focus on promoting innovation, technology, and industry.

Legal Intern – Global Challenges Division

Executing a project relating to pharmaceutical compounds listed on the World Health Organization's Model List of Essential Medicines (MLEM).

June 2010 to Aug. 2010 — **NOVO NORDISK**, Princeton, NJ

Biopharmaceutical company with a major focus on diabetes treatments.

Legal Intern – Intellectual Property

Drafted patent applications and USPTO Office Action replies in the course of ongoing domestic and foreign patent cases. Conducted prior art searches and helped to prepare clearance opinions. Compiled and executed patent portfolio analysis for federal regulatory and internal use.

Technology focus: Insulin and human growth hormone compounds.

SCIENTIFIC AND ENTREPRENEURIAL EXPERIENCE

June 2007 to June 2009 — **SANOFI PASTEUR**, Swiftwater, PA

The vaccines division of Sanofi-Aventis Group.

Environmental & Quality Control Regulatory Analyst

Helped validate new vaccine manufacturing facility. The facility obtained FDA approval in an expedited timeframe and thereby was able to bring the first H1N1 vaccine to market during 2009 flu pandemic.

Aug. 2008 to June 2009 — **RTK ANALYTICAL, INC.**, Scranton, PA

Chief Technology Officer and Co-Founder

Start-up founded in 2008 to commercialize analytical instrument technologies for medical and military applications that I helped to invent at the Univ. of Scranton. RTK achieved a successful exit event by licensing the patent.

Nov. 2003 to May 2007 — **GENAEYA CORPORATION**, Honesdale, PA
Founder and sole owner
Created and developed a small freight transportation brokerage service company. The company grew into a $400,000/year business and then closed when fuel prices made the business model unsustainable.

PEER-REVIEWED SCIENTIFIC PUBLICATIONS

D.A. Rusak, **E.A. Kawka** and E.B. Trexler, "Investigation of a Null-Measurement of Optical Absorbance Using a Pulse-Width Modulated Light-Emitting Diode," Rev. Sci. Instrum. 81, 016107 (2010).

PATENTS

Named inventor on U.S. Patent Application No. 13/007,962 (filed Jan. 17, 2011), "Method and Apparatus for Null-Measurement of Optical Absorption Using Pulse Width Modulation."

LANGUAGES

Fluent in Polish (spoken and written)

WORK STATUS

I am a U.S. and Polish citizen, so I am eligible for working permits in all European Union countries.

INTERESTS

Trap and skeet shooting; fly-fishing.

James Klobucar

54 Beacon Street
Concord, NH 03301
(608) 289-5694
james.klobucar@law.unh.edu

Bar Admissions

United States Patent and Trademark Office (March 2011)

Education

University of New Hampshire School of Law (formerly Franklin Pierce Law Center), Concord, New Hampshire
Juris Doctor candidate, 2011

Cornell College, Mount Vernon, Iowa
Bachelor of Arts, Chemistry, Biochemistry & Molecular Biology 2008
Study Abroad: San Salvador, Bahamas February 2008
College Activities

- Phi Alpha Delta Pre-Law Fraternity
- College Republicans
- Student Athletic Advisory Committee
- Cornell Sportsmen: **Treasurer** 2007-2008, founding member
- Football 2004-2005
- Track & Field 2004-2008
  Team MVP, Team Captain, All-Conference, Conference Champion, NCAA All-American

Work Experience

Senior Independent Study

- **Genetics Laboratory:** I worked with plasmid DNA isolation, agarose gel eletrophoresis, restriction endonuclease digestion, DNA sequencing, and the sequence analysis of Fire Coral.
- **Biochemistry Laboratory:** I worked with the isolation and enzymatic regulation of pyruvate kinase, experimental design and data analysis, and enzyme activity assay.

Legal Assistant/IP Consultant. LegalAnthem, LLC. Lakewood, NJ November 2010-Present

- Website testing
- Legal research and obtain intellectual property rights

Legal Extern. University of Utah-Technology Commercialization Office. Salt Lake City, UT August 2010-December 2010

- Full-time extern for first semester of 3L year
- Negotiate/write license agreements and material transfer agreements, conduct prior art searches, conduct legal research, file trademarks

Track & Field Coach – Volunteer. Concord H.S., Concord, NH March 2009-Present

- Coach athletes at practices and attend meets – 20 hours per week

Skills & Interests

Language: Conversational Spanish
Activities: Running, Fishing, Skiing

Ross K. Krutsinger

USPTO Reg. No. 67,393

56 Beacon St. Concord, NH 03301; (603) 545-9392

rkrutsinger@comcast.net

SUMMARY

Adaptable IP law specialist with scientific, creative, and business acuity: strong legal and engineering academic records; experience with semiconductors, chemical technologies, and entrepreneurism.

EDUCATION

University of New Hampshire School of Law (formerly **Franklin Pierce Law Center**), Concord, NH

Juris Doctor, candidate May 2011

Master of Laws in Intellectual Property, candidate May 2011

- *Recipient*, Merit Scholarship and Trustees' Merit Scholarship
- *Board Member/Notes & Comments Editor*, IDEA: The Intellectual Property Law Review
- *Teaching Assistant*, Tort Law, Fall Semester 2009
- *Member*, AIPLA, ABA, LES, IIPO, Phi Alpha Delta
- Attended the Pierce Law/WIPO Comprehensive Patent Cooperation Treaty Seminar
- Attended the 2009 E-Law Summer Institute, IP Summer Institute, Int'l Crim. Justice Institute

University of Colorado, Boulder, CO

B.S. Chemical Engineering *with honors*, May 1994

- Dean's List and recipient of J. H. Baily Memorial Scholarship for academic excellence
- **University of Queensland**, Brisbane, Australia, engineering study abroad, Jan.–Dec. 1992
- *Member*, Golden Key Honor Society, Omega Chi Epsilon Chemical Engineering Honor Society, Tau Beta Pi Engineering Honor Society, Alpha Epsilon Delta Premedical Honor Society
- Independent study: reverse osmosis water desalination with polysulfone membranes
- Independent study: start up and evaluation of stirred tank reactor system

LEGAL EXPERIENCE

Seyfarth Shaw, LLP, Boston, MA

Law Clerk/Patent Agent — *Jan. 2011 – Present*

IP Extern — *Aug. 2010 – Dec. 2010*

IP litigation and patent prosecution in the chemical/pharmaceutical, mechanical, and computer arts. Assignments include infringement, invalidity, and freedom-to-operate analyses; legal research; and drafting patent claims, applications, responses to Office actions, client letters, and memoranda.

International Technology Transfer Institute, Concord, NH — *Spring Semester 2011*

Biodiesel Patent Landscape Clinic

Prepare and analyze a global patent landscape report for genetically-modified algae for biodiesel production. Search for patent documents relevant to lipid biosynthesis, photosynthesis, and lipid secretion; analyze to determine filing trends, key players in the technology, classification, and more.

Waddey & Patterson, PC, Nashville, TN

IP Law Clerk — *June – Aug. 2010*

Patent prosecution in the chemical/pharmaceutical and mechanical arts, trademark prosecution, and litigation support. Assignments included drafting responses to Office actions and appeal briefs, conducting freedom to operate and patentability searches, and legal research.

TECHNICAL EXPERIENCE

Astralux, Inc., Boulder, CO
Research Technician & Safety Officer — *May 1999 – Oct. 2002*
Developed wide band gap semiconductor devices using silicon carbide, gallium nitride, and silicon; processed wafers in a clean room lab using lithography, reactive ion etch, thermal evaporation, electron microscopy, and vacuum systems; measured luminescence and evaluated surfaces of etched and bonded wafers; designed lithography masks; searched patents and literature; contributed to four publications.

Eltron Research, Inc., Boulder, CO
Research Associate & Safety Officer — *Apr. 1995 – May 1999*
Developed technology in electrochemistry, catalysis, fuel cells, and materials science; conducted experiments with valuable species recovery, water purification, chemical sensors, aluminum nitride boules, and conversion of methane to synthesis gas; drew technical figures, machined flow-cells, built high-temperature furnaces; assessed lab safety using OSHA guidelines; contributed to two publications.

BUSINESS EXPERIENCE

R. A. M. Restorations and Modifications, Inc., Franklin, TN
Co-Founder & Vice President (Self-employed) — *Feb. 2004 – June 2008*
Co-founded a company for purchasing, renovating and selling homes for profit. Created budgets, planned projects, secured and negotiated bids, taught myself construction skills and completed renovation work.

Self-Employed, Nashville, TN
Professional Musician — *Apr. 1993 – June 2008*
Networked with industry contacts and musicians to build a career as a live performer, artist, studio session musician, producer, songwriter, and teacher; organized and promoted various bands; authored three published articles; negotiated contracts, filed copyright registrations and publishing forms.

SELECTED PUBLICATIONS

Ross K. Krutsinger, *What Can the Patent Prosecution Highway Do For You?*, FRANKLIN PIERCE CENTER FOR INTELL. PROP. NEWSL. (Spring, 2010).

Ross K. Krutsinger, note, *Ouch, You're Twisting My Arm's Length: The Arm's-Length Standard in View of Xilinx, Inc. v. Comm'r and the 2009 Cost-Sharing Regulations* (May, 2010) (on file with author), *available at* http://lawlib.wlu.edu/works/734-1.pdf.

Ivan Perez-Wurfl, Ross K. Krutsinger, John T. Torvik, *4H-SiC Bipolar Junction Transistor With High Current and Power Density*, 47 SOLID STATE ELEC. 229 (Feb., 2003).

Ivan Perez-Wurfl, Ross K. Krutsinger, John T. Torvik, Bart Van Zeghbroeck, *SiC Bipolar Transistors for RF Applications*, INT'L SEMICONDUCTOR DEVICE RESEARCH SYMP. (2001).

John T. Torvik, Ross K. Krutsinger, Bart Van Zeghbroeck, Ted A. Winningham, Ken Douglas, William Wesch, *Formation of Hybrid SiC/Si and SiC/SiO_2/Si Wafers by Oxygen Implantation, Wafer Bonding and Etching*, ELEC. MATERIALS CONF., Symp. Q (2001).

John T. Torvik, Ross K. Krutsinger, Bart Van Zeghbroeck, *Electrical and Optical Characterization of Wafer Bonded 4H/6H-SiC and SiC/Si N-P Heterojunction Diodes*, ELEC. MATERIALS CONF., Symp. Q (2001).

Ella F. Spiegel, Anthony F. Sammells, Ross K. Krutsinger, F.D. Smith, *Removal of Low Levels of Ammonium Ion From Spacecraft Recycled Water*, 29th INT'L CONF. ON ENVTL. SYS. (July 1999).

Michael Schwartz, James H. White, Mark G. Myers, Stera Deych, Ross Krutsinger, *The Use of Ceramic Membrane Reactors for the Partial Oxidation of Methane to Synthesis Gas*, 213 ABSTRACTS OF PAPERS OF THE AM. CHEM. SOC'Y 83-Fuel Pt. 1 (Apr. 13, 1997).

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Sanjana Mangalagiri
sanjanams@gmail.com

EDUCATION

University of New Hampshire School of Law (Formerly Franklin Pierce Law Center), Concord, NH
Juris Doctor, expected, *May 2012*
Moot Court Participant, Giles Sutherland Rich Moot Court Competition, *Spring 2011*
Teaching Assistant, Legal Research, *Fall 2010*

Relevant Coursework (to be completed by *Spring 2011*):
Fundamentals of Intellectual Property   U.S. Patent Law   Technology Licensing
Patent Searching and Mining   Patent Landscape Clinic
Patent Practice and Procedure I – Claim Drafting (Drafted 13 sets of claims on mechanical disclosures)
Patent Practice and Procedure II – Office Actions for the USPTO (Non-final and Final)

PES Institute of Technology, College of Engineering, Bangalore, India
Bachelor of Engineering, Biotechnology Engineering, *May 2008* (Patent Bar Eligible)
Relevant Coursework:
Genetic Engineering   Molecular Biology   Health and Pharmaceuticals   Bioreactor Design Immunology
Bioinformatics   Bioreaction Engineering   Microbiology

EXPERIENCE

Cornell Center for Technology Enterprise and Commercialization, Cornell University, Ithaca, NY
Summer Intern *Summer 2010*
Analyzed office actions and assisted with a response strategy to the USPTO regarding the rejection of drug patent applications filed by the university. Assisted in commercializing a project on Genetically Modified Papaya and in converting provisional applications to PCT. Worked on various technologies in life sciences ranging from anti-cancer drugs to pharmaceutical equipments and biofuel cells.

Fisheries Department, Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy
Summer Intern *Summer 2009*
Researched on “Potential Implications of Intellectual Property on Genetically Modified Fish”. A report was submitted on the same.

Cornell Center for Technology Enterprise and Commercialization, Cornell University, Ithaca, NY
Summer Intern *Summer 2008*
Performed research on the production of ethanol from fruit waste.

Indgene Labs, Bangalore, India
Intern *Jan-May 2008*
Researched and formulated an anti-obesity drug insilico. Presented a paper based on this research at an International Biotechnology Conference “Molecular Mechanisms and Systems Biology” in Bangalore, India.

Cornell Center for Technology Enterprise and Commercialization, Cornell University, Ithaca, NY
Summer Intern *Summer 2006*
Assisted in conducting prior art research and freedom to operate for patenting of synthetic strains of coat protein for Papaya Ring Spot Virus (PRSV).

PERSONAL INFORMATION AND INTERESTS

Citizenship: US
Interests: Dancing, yoga, aerobics, traveling, cooking, and reading novels

MATTHEW PREISS

12 Pond View Ave. · Westerly, RI 02891
Phone: (401)-741-5981
mrp2111@gmail.com

Education

UNIVERSITY OF RHODE ISLAND — JANUARY 2010 – PRESENT
DOCTOR OF PHILOSOPHY (PH.D.) IN CHEMICAL ENGINEERING CANDIDATE — Kingston, Rhode Island
College of Engineering

- Research Concentration: Multi-functional and Tunable Lipid-Nanoparticle Assemblies

FRANKLIN PIERCE CENTER FOR INTELLECTUAL PROPERTY — AUGUST 2008 – PRESENT (EXPECTED MAY 2011)
UNIVERSITY OF NEW HAMPSHIRE SCHOOL OF LAW — Concord, New Hampshire
JURIS DOCTOR (J.D.)
MASTER OF LAWS IN INTELLECTUAL PROPERTY (LL.M.-IP)

UNIVERSITY OF RHODE ISLAND — SEPTEMBER 2006 – MAY 2008
MASTER OF SCIENCE IN CHEMICAL ENGINEERING — Kingston, Rhode Island
College of Engineering

- Thesis Title: Technical and Economic Assessment of a Solid Oxide Fuel Cell Power Plant Utilizing Landfill Gases

COLUMBIA UNIVERSITY — SEPTEMBER 2004 – MAY 2006
BACHELOR OF SCIENCE IN BIOMEDICAL ENGINEERING — New York, New York
MINOR IN MECHANICAL ENGINEERING
School of Engineering and Applied Sciences

- Concentration: Biomechanics

PROVIDENCE COLLEGE — SEPTEMBER 2001 – MAY 2004
BACHELOR OF SCIENCE IN PHYSICS, MATHEMATICS, AND CHEMISTRY — Providence, Rhode Island

Department of Engineering-Physics-Systems

Work Experience

TEACHER'S ASSISTANT — AUGUST 2009 – PRESENT
Franklin Pierce Law Center/UNH School of Law — Concord, New Hampshire

- Courses: Legal Research and Information Literacy Class (August-December 2009), United States Patent Searching (August-December 2010), International and Foreign Patent Searching (January 2011-Present)

RESEARCH ASSISTANT — MAY 2009 – PRESENT
Franklin Pierce Law Center/UNH School of Law — Concord, New Hampshire
Intellectual Property Law Library

RESEARCH ASSISTANT — SEPTEMBER 2008 – PRESENT
Franklin Pierce Law Center/UNH School of Law — Concord, New Hampshire
International Technology Transfer Institute (ITTI)

RESEARCH ASSISTANT — JUNE 2006 – AUGUST 2008 & MAY 2010 – AUGUST 2010
University of Rhode Island — Kingston, Rhode Island
Department of Chemical Engineering

LABORATORY ASSISTANT — FEBRUARY 2002 – AUGUST 2002
Providence College — Providence, Rhode Island

PRINCIPAL AND DESIGN ENGINEER — JUNE 2001 - PRESENT
G. W. Preiss & Son, LLC, Consulting Engineers — Westerly, Rhode Island

Publications

- **Preiss, M.** & Bothun, G., *Stimuli-Responsive Liposome-Nanoparticle Assemblies*, Expert Opinion on Drug Delivery. Invited Review (submitted 2011).
- Bothun, G. & **Preiss, M.**, *Bilayer heating in magnetite nanoparticle-liposome dispersions via fluorescence anisotropy*, Journal of Colloid and Interface Science (in-press 2011)
- Kenyon, J., **Preiss, M.**, Kowalski, S., & Clark, K., Intellectual Property and Biodiesel Biomass: A Comparison of Major Agricultural and Algacultural Resources, In Margarita, S. & Gisela, M. *Biodiesel*. Invited Chapter (in-development 2011).
- **Preiss, M.** & Kowalski, K. *Algae and Biodiesel: Patenting energized as green goes commercial*, Journal of Commercial Biotechnology 16(4) 293-312 (2010).
- Cavicchi, J & **Preiss, M.** *Intellectual Property: A Global Directory of Acronyms and Abbreviations*, William S. Hein & Co. (2010).

Presentations

- Kowalski, S., **Preiss, M.**, Chiluwal, A., & Cavicchi, J., *Freedom to Operate, Product Deconstruction, and Patent Mining: Principles and Practice*, Access to Medicines, Patent Information and Freedom to Operate: A Workshop on Patent Searches and Freedom to Operate at Joint Technical Symposium by World Health Organization, World Trade Organization, and World Intellectual Property Organization; Geneva, Switzerland, February 17, 2011.

Honor Societies, Memberships, Research Skills, and Activities

- Member in Sigma Xi, the Scientific Research Society
- Member of Tau Beta Pi, the Engineering Honor Society
- Member in Rho Chi, the Pharmacy Honor Society
- Member of Phi Alpha Delta Law Fraternity, International
- Volunteer in the Louis Stokes Alliance for Minority Participation teaching science, engineering and mathematics
- Certified AutoCAD Level II – Intermediate AutoCAD Functions and Concepts
- Proficient in patent and legal research on Dialog, Thompson Innovation, U.S. Patent and Trademark Office patent database, Lexis, and Westlaw

Neha Bina Ramani

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Education

UNH SCHOOL OF LAW (formerly FRANKLIN PIERCE LAW CENTER), Concord, NH
Candidate for Masters in Intellectual Property Law — May 2011

Relevant Classes: Patent Law
Patent Practice and Procedure I and II
IP Management
Patent Mining
Technology Licensing

Activities: South Asian Law Student Association, Vice President
Intellectual Property Summer Institute – Concord, NH, June 2011

UNIVERSITY OF STRATHCLYDE, Glasgow, United Kingdom
B.S. Honors in Biochemistry and Pharmacology — May 2010

Relevant Classes: Medical Biochemistry
Molecular Genetics
Drug Receptor Interactions
Pharmacokinetics

Experience

UNH SCHOOL OF LAW, Concord, NH — Spring 2011

- *Intellectual Property Technology Transfer Institute Clinic*
  Developed a biotechnology educational report on trends of patents in Algae Bio-diesel industry. Analyzed patents to determine genetic transformation technology relevant to producing increased bio-fuel producing algae.

UNIVERSITY OF STRATHCYLDE, Glasgow, United Kingdom — Spring 2010

- *Academic Project*
  "Stem cell therapies: Is a cure for Parkinson's disease possible?"
  Created a literature review project to determine currently existing evidence for the effectiveness of the therapeutic approach. Researched scientific journals and publications, analyzed data, and predicted a favorable outcome.

HARLAN LABORATORIES, Ahmedabad, Gujarat, India — June 2009 – Sept 2009

- *Intern*
  Corresponded with clients, managed database for project deadlines and followed up with respective project heads and clients. Analyzed market surveys and literature, acted as liaison to clients, and organized client visits through India.

AHMEDABAD PASHUVIHAR VETERINARY HOSPITAL, Ahmedabad, Gujarat, India — Summers, 2003 - 2008

- *Voluntary assistant*
  Assisted veterinary doctors in cleaning and patching wounds, diagnosing disease, performing injections, administering medication

Patent Searching Experience

USPTO, Thomson Innovation, Dialog, PatentScope, Total Patents Classification search (US, IPC, ECLA)

Seminar Presentations

- *The MMR Vaccine* – A debate about the speculation over a link between the MMR vaccine and autism
- *Clinical Case Study* – A case study of the history of a patient suffering from Diabetic Ketoacidosis. This included studying the symptoms and predicting the precaution and treatment methods.

Languages and Interests

Fluent in Hindi and Gujarati.
Trained Indian Classical Singer
Interests include reading, painting, photography, paragliding, and lawn tennis

Anna E. Stanford
10 Celtic Street Floor 1, Concord, NH 03301
(256)762-7281
annaestanford@gmail.com

Education

Juris Doctor candidate, May 2012, GPA: 3.09 / 4.0
University of New Hampshire School of Law (formerly Franklin Pierce Law Center), Concord, NH
Member: American Intellectual Property Law Association (AIPLA), student member

Bachelor of Science in Molecular Biology, Minor in Business Administration, May 2009, G.P.A.: 3.18 / 4.0
Auburn University, Auburn, AL
Member: Delta Epsilon Iota Honor Society; Tau Sigma Honor Society

Experience

International Technology Transfer Institute Clinic, August 2010 – present, UNH School of Law, Concord, NH

- Patent searching project for new additions to the List of Essential Medicines for the World Health Organization in conjunction with the World Intellectual Property Organization and the World Trade Organization
- Using premium searching platforms including Thomson Innovation, Lexis TotalPatent, and DialogClassic
- Co-leading preparation of an educational report on development of technologies for biodiesel production from algae

Math *and Reading Tutor*, September 2009-present, Conant Elementary, Concord, NH

- Strengthen students' math and reading skills with one-on-one assistance

Undergraduate Lab Assistant, Microbiology Lab, May 2008-April 2009, Poultry Science Department, Auburn University, Auburn, AL

- Performed experiments for studying microorganisms which cause food-borne illnesses
- Used single nucleotide polymorphism (SNP) techniques to sequence and analyze selected pathogenic genes of *Campylobacter jejuni.* Focus was to develop a multilocus virulence sequence typing system for this bacterial pathogen. Typing system could be used for epidemiological studies of *C. jejuni* in the food chain.
- Assisted with experiments involving molecular and microbiological techniques, purification of frozen cultures using nitrocellulose filters, and preparation of PFGE plugs.

Key skills:

- Bacterial DNA extraction and purification
- PCR preparation of samples for gene sequencing and multilocus sequence typing
- PCR and gel electrophoresis for random fragment length polymorphisms of DNA
- Proficient in phase contrast and brightfield microscopy
- Preparation of liquid and solid media
- Cryostorage of bacterial isolates
- Experience with steam sterilization of labware and lab waste
- Bradford protein assays

Undergraduate Lab Assistant, Molecular Genetics Lab, May 2007- August 2007 and March 2008-May 2008, Department of Biological Sciences at Auburn University, Auburn, AL
Assisted with project studying heat-stress properties of cotton plants

Nursery School Worker, August 2006 – December 2006, Highland Baptist Church, Florence, AL

Volunteer Work

Daughters of the American Revolution, Junior Member, September 2010-present
Student Mentor, University New Hampshire School of Law, May 2010-present
Franklin County Archives, June 2009-August 2009
Clemson Area Chamber of Commerce, Clemson, SC, January 2006-March 2006

Hobbies

Yoga, indoor rock climbing, and snow skiing

EMILY C. THOMPSON

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Education

University of New Hampshire School of Law September 2009 - Present
(Formerly Franklin Pierce Law Center) Concord, NH
J.D. Candidate 2012
Activity: Class Representative for Student Intellectual Property Law Association

Northeastern University September 2004 - May 2008
Bachelor of Science in Neuroscience Boston, MA
Minor in History
Activities: Psychology Department Tutor and Resident Assistant

Experience

UNH Office for Research Partnerships and Commercialization, Durham, NH January 2011 - Present
Licensing Intern
- Work with university inventors to commercialize university inventions

Forsyth Institute Molecular Genetics Department, Boston, MA October 2008 - August 2009
Laboratory Technician
- Performed PCR, cloning and DNA sequencing techniques for oral microbe experiments
- Analyzed DNA sequence data of bacteria correlated with periodontal and other oral diseases, and canine oral microbe samples for a commercial project

Forsyth Institute Cytokine Biology Department, Boston, MA July 2008 - August 2008
Laboratory Intern
- Performed RT-PCR and immunoblotting techniques for osteoclast (bone cell) differentiation and activation research

Brigham and Women's Hospital General Clinical Research Center, Boston, MA July 2006 - June 2007
Co-op Lab Technician
- Applied electrodes and collected EEG/circadian rhythm data for sleep studies

Research

UNH School of Law International Technology Transfer Institute Clinic January 2011 – Present
Student Attorney

- Researching algae biodiesel technology for a patent landscape analysis search report

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Passed USPTO Exam April 4, 2011 (registration number available upon final USPTO approval)

EDUCATION

University of New Hampshire School of Law, Concord, NH
(Formerly Franklin Pierce Law Center)
Juris Doctor, expected, May 2011
Member, Phi Alpha Delta
Student Mentor

Tulane University, New Orleans, LA
Bachelor of Science in Engineering, Chemical and Biomolecular Engineering, May 2008
Business minor
Member, Omega Chi Epsilon

Rensselaer Polytechnic Institute, Troy, NY
Visiting Scholar – Hurricane Katrina Displaced Student
September – December 2005

EXPERIENCE

International Technology Transfer Institute, Student Attorney *January 2011 – present*
University of New Hampshire School of Law, Concord, NH
Team/Project Leader. Utilize Thomson Innovation, LEXIS TotalPatent, and MicroPatent to create a biotechnological patent landscape relating to the genetic engineering of algal species for the production of biodiesel. Analyze hundreds of patents and patent applications to determine their relevancy to algae biodiesel. Collaborate with and managed eight other student attorneys to complete the report. Organize and manage weekly clinic classes. Teach other student attorneys skills necessary to complete the report.

Raytheon IDS Legal Department, Legal Intern *May 2010 – December 2010*
Raytheon Company Integrated Defense Systems, Tewksbury, MA
Worked alongside attorneys in the Raytheon Company Integrated Defense Systems Office of General Counsel (IDS OGC), primarily with the Senior Counsel of Intellectual Property. Participated in staff meetings for both IDS OGC and Corporate Intellectual Property and Licensing (IP&L). Assisted with an analysis of the IDS patent portfolio. Became member of various invention review committees which interviewed employee inventors to determine the most effective way to protect inventions (patent, trade secret, etc). Reviewed and negotiated proprietary information agreements and software licensing agreements. Negotiated terms and conditions for IP sales. Researched various IP issues. Communicated with outside counsel in connection with IP matters (patent and trademark). Wrote internal legal memos relating to providing gratuities to foreign and domestic individuals and government officials. Became familiar with government contracting. Gained knowledge of the FAR and DFARS. Collaborated with team to create several IP related courses. Assisted ethics department with conflicts of interest checks and other investigations. Placed on an educational leave of absence (ELOA) at the end of the year.

International Technology Transfer Institute, Student Attorney *January 2010 – May 2010*
University of New Hampshire School of Law, Concord, NH
Used Thomson Innovation to create a biotechnological patent landscape relating to the diagnosis of Dengue Fever. Analyzed hundreds of patents and patent applications to determine their relevancy to the diagnosis of Dengue. Collaborated with five other student attorneys to complete the report.

Raytheon IDS Configuration Management, Engineering Intern *Summers 2008, 2009*
Raytheon Company Integrated Defense Systems, Andover, MA
Collaborated with a team to create a training package. Reviewed manufacturing shop orders to validate revisions in the design of materials. Created and updated process sheets for several programs. Placed on an educational leave of absence (ELOA) at the end of the summer.

Raytheon IDS Materials Engineering, Engineering Intern *Summer 2007*
Raytheon Company Integrated Defense Systems, Andover, MA
Supervised production on a missile defense system. Trained and certified workers in specialized areas. Completed Raytheon Six Sigma Training. Prepared and presented at meetings with senior management. Obtained Secret United States Government clearance. Placed on an educational leave of absence (ELOA) at the end of the summer.

PUBLICATIONS

University of New Hampshire School of Law Educational Report: "Patent Landscape of Algae Biodiesel: Applicable Genetic Engineering Technologies," Kara Verryt, Anna Stanford, Matthew Preiss, Ross Krutsinger, James Klobucar, Ernest Kawka, Emily Thompson, Spoorthy Gudavalli, Sanjana Mangalagiri, and Neha Remani; Spring 2011.

Franklin Pierce Law Center Educational Report: "Patent Landscape of Dengue Diagnostic Technologies," Kara Verryt, Pravin Conda, Craig T. Ajmo Jr. Ph.D, Jennifer Fadden Bryan, Amrita Chiluwal, and Trent Merrell; Spring 2010.

INTERESTS

Volunteering with Habitat for Humanity, skiing, snowboarding, dancing, gymnastics, coaching gymnasts, reading, music, traveling and spending time with family.

SELECTED TRAINING, AFFILIATIONS AND RECOGNITIONS

- American Bar Association (ABA), member
- International Trademark Association (INTA), member
- Phi Alpha Delta, member
- Omega Chi Epsilon, member
- American Institute of Chemical Engineers, member
- Society of Women Engineers, member
- Raytheon Six Sigma certified
- University of New Hampshire School of Law Academic Scholarship Recipient
- Tulane University Presidential Scholarship Recipient

APPENDIX J: MicroPatent® Summary Report for Relevant and Potentially Relevant Technology Patent Documents

(Please refer to attached DVD disc for the MicroPatent® Summary Report for Relevant Patent Documents)