AN INDUSTRIAL SCALE PLATFORM FOR ENZYMES AND OTHER PROTEINS
Safe harbor statement

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EXECUTIVE SUMMARY
Business overview

- Dyadic is a global biotechnology company
- Founded in 1979 by Mark Emalfarb, Chairman, President and CEO
- Headquartered in Jupiter, Florida with main R&D operations in The Netherlands
- Efficient business model of:
  - Funded R&D and milestone payments
  - Licensing fees and royalties, and
  - Sale of enzyme products
- Breakeven cash flow and profitability projected in 2012 with minimal capital requirements
- Uses patented and proprietary C1 fungal expression technology and other fungal technologies to discover, develop, manufacture and sell enzymes and other proteins, together with its customers and partners
- 36 full-time employees including 25 dedicated to R&D activities
- Broad patent portfolio of 12 US and 58 foreign patents and 13 pending US and 38 pending foreign patents encompassing gene expression using Dyadic’s C1 technology
Dyadic’s leadership team

Mark A. Emalfarb
Chairman, President and CEO
Dyadic since 1979
Background: Dyadic founder

Adam J. Morgan, Esq.
Vice President General Counsel & Business Development, Secretary
Dyadic since 2009
Background: Attorney, bus. dev., licensing

Michael J. Faby, CPA
Vice President and Chief Financial Officer
Dyadic since 2009
Background: Accounting

Richard H. Jundzil
Vice President Operations
Dyadic since 2003
Background: Operations and quality

Thomas M. O’Shaughnessy
Vice President Sales & Marketing
Dyadic since 2010
Background: Chemical sales and marketing

Wim van der Wilden, Ph.D.
General Manager, Dyadic Netherlands
Dyadic since 2002
Background: Biology and biochemistry

Jan Wery, Ph.D.
Science Director, Dyadic Netherlands
Dyadic since 2007
Background: Yeast genetics
Executive Summary:

INTRODUCTION TO PROTEINS
Proteins are part of every living organism

<table>
<thead>
<tr>
<th>What is a protein?</th>
<th>What does a protein do?</th>
<th>Types of proteins by function</th>
</tr>
</thead>
<tbody>
<tr>
<td>❖ Proteins are biochemical compounds that are the foundation of living systems</td>
<td>❖ Virtually every process and product in living cells depend on proteins</td>
<td>❖ <strong>Enzymes</strong> – Catalysts that facilitate chemical reactions. They are the biggest and most</td>
</tr>
<tr>
<td>❖ Proteins are long, folded chains of smaller molecules called amino acids</td>
<td>❖ Proteins do everything from activating essential chemical reactions, to carrying</td>
<td>important group of proteins, and responsible for all metabolic reactions in living cells.</td>
</tr>
<tr>
<td>❖ There are 20 different types of amino acids, which can be combined in an almost</td>
<td>messages between cells, to fighting infections, to making cell membranes, tendons,</td>
<td>❖ <strong>Immunoglobulin or Antibodies</strong> – Involved in the organism’s immune response to neutralize</td>
</tr>
<tr>
<td>infinite numbers of ways to produce different proteins</td>
<td>muscles, blood, bone and other structural materials</td>
<td>large foreign molecules of an infection. Antibodies act as enzymes including proteins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>responsible for the clotting of blood (fibrin and thrombin).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ <strong>Hormones</strong> – Responsible for the regulation of many processes in organisms. Usually</td>
</tr>
<tr>
<td></td>
<td></td>
<td>quite small and can be classified as peptides (e.g. insulin).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ <strong>Signaling proteins</strong> – Involved in the signaling translation process. Usually they</td>
</tr>
<tr>
<td></td>
<td></td>
<td>significantly change conformation in presence of some signaling molecules. These proteins</td>
</tr>
<tr>
<td></td>
<td></td>
<td>can act as enzymes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ <strong>Motor proteins</strong> – Can convert chemical energy into mechanical energy. Actin and myosin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>are responsible for muscular motion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ <strong>Receptors</strong> – Responsible for signal detection and translation into other types of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>signals (incl. rhodopsin, a light detecting protein).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ <strong>Storage proteins</strong> – Contain energy, which can be released during metabolism processes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in the organism (Egg ovalbumin and milk casein). Almost all proteins can be digested and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>used as a source of energy and building material by other organisms.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ <strong>Transport proteins</strong> – Transport or store other chemical compounds and ions (Hemoglobin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>is responsible for oxygen transport in blood).</td>
</tr>
</tbody>
</table>

Dyadic enables the commercialization of enzymes and other proteins
Enzymes and other proteins are part of everyday life.

Examples of enzymes and other commercial proteins

- **Wastewater treatment**
  - Environmentally-friendly treatment of organic and toxic waste
  - **Enzyme market size $50mn**

- **Biopharmaceuticals**
  - Used to fight diseases such as rheumatoid arthritis and diabetes
  - **Enzyme market size $800mn**

- **Food and beverage**
  - Improves flavor/quality
  - Facilitates digestion, improves nutritional value and reduces potential allergic reactions
  - **Enzyme market size $1bn**

- **Textiles/Leather**
  - Used in the production of fabrics for clothing, furniture and other household items
  - Replaces conventional chemical methods
  - **Enzyme market size $350mn**

- **Bio-based chemicals**
  - Reduce use of petroleum-based products
  - Reduce pollution and improve product safety
  - **End market size $10bn**

- **Cosmetics and personal care**
  - Enhance quality/properties of toiletry products
  - Increase the moisturizing factor of ingredients in cosmetics
  - Reduce usage of chemical load
  - **Active ingredient market size $550mn**

- **Pulp & paper**
  - Used for bleaching, refining, de-inking and the removal of adhesives
  - **Enzyme market size $50mn**

- **Biofuels**
  - Reduce use of petroleum-based products
  - Large existing food-based ethanol market
  - Developing cellulosic biofuel market positioned for rapid growth
  - **Food-based market size $600mn**
  - **Cellulosic market size $5bn**

- **Animal health & nutrition**
  - Improve the digestibility of dietary components
  - **Enzyme market size $600mn**

- **Detergents**
  - Enhance detergents’ characteristics such as cleaning ability, color fading prevention and performance at gentler washing
  - Less energy needed for cleaning
  - **Enzyme market size $750mn**

- **Nutraceuticals**
  - Dietary supplements, herbal products, processed foods
  - **End market size $20bn**

Source: Freedonia Group, Frost & Sullivan, Verenium press releases, equity research, company estimates

Note: Market size numbers represent latest available current global estimates, unless otherwise indicated

1 US market size only; 2 Total market for bio-based chemicals; 3 Projected 2022 cellulosic biofuels enzyme market
How enzymes and other proteins are produced

**Genes**
- Over 300 billion known genes
- New genes continuously discovered and developed every year
- Gene libraries are used by companies to identify characteristics of interest
- Find genes to make the enzyme or protein of interest

**Cells**
- Cell or organism is the place where the protein (e.g., enzyme) is made
- Fungus, bacteria, mammalian, yeast, algae
- C1 is a host organism

**Proteins**
- Proteins (e.g., enzymes) perform particular functions
- Over 4mm known proteins
- Over 1mm additional proteins were discovered and developed in the past 2 years
- Virtually unlimited product opportunities
How enzymes and other proteins are commercialized

**Discovery**
- Through genomics and proteomics R&D programs, discover enzymes and other proteins

**Expression**
- Transform a gene into a protein in the living cell

**Optimization**
- Overexpression
- Insert more copies of the same gene into the cell
- Screen to find the best production candidate
- Additional testing at larger volumes
- Fermentation optimization

**Production**
- Reliably produce large volumes at low cost with high yields
- Formulation, stabilization and packaging

**Sales/Marketing**
- Direct channel to manufacturers
- Licensing or other forms of partnerships

**Common bottlenecks in protein expression and scale-up**
- Making enough to conduct a trial
- Making it at low enough cost

<table>
<thead>
<tr>
<th>Quantity</th>
<th>mg</th>
<th>multiple gm</th>
<th>tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td># of proteins</td>
<td>1,000’s of genes</td>
<td>3-6 candidates</td>
<td>1-2 candidates</td>
</tr>
<tr>
<td>Host</td>
<td>research host</td>
<td>research host</td>
<td>production host</td>
</tr>
</tbody>
</table>

C1 functions as both the research *and* production host
C1 enables commercial scale-up of enzymes & other proteins

Discovery
1. Finding the gene
2. Limited optimization
3. Producing economically

Expression/Optimization
1. Large number of available genes
2. Limited optimization

Production/Commercialization
1. High cost / risk

Use C1 production host for gene discovery
C1 offers compatible gene expression
C1 shortens commercialization timelines, lowers costs and reduces R&D risk

Commercialization timeline
Executive Summary:

DYADIC’S CAPABILITIES
### Dyadic’s strengths

<table>
<thead>
<tr>
<th>1</th>
<th>World-class enabling technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>■ 17 years of R&amp;D has created a highly developed C1 platform with full molecular toolkit to develop and manufacture enzymes and other proteins</td>
</tr>
<tr>
<td></td>
<td>■ Enables the introduction of enzymes and other proteins with shortened development timelines</td>
</tr>
<tr>
<td></td>
<td>■ Improves quality of enzymes and other proteins</td>
</tr>
<tr>
<td></td>
<td>■ Lowers manufacturing costs</td>
</tr>
<tr>
<td></td>
<td>■ Lowers risk and increases margins</td>
</tr>
<tr>
<td></td>
<td>■ R&amp;D and management team with decades of industrial biotechnology experience</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Scarce asset and protected IP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>■ One of three leading fungal platforms for enzyme production in the global bioenergy and bio-based chemicals markets</td>
</tr>
<tr>
<td></td>
<td>■ Only commercially exploited thermophilic fungal expression system (enzymes operate at high-temperature conditions over a broad pH range)</td>
</tr>
<tr>
<td></td>
<td>■ <em>Freedom to operate</em> — robust patent portfolio of 70 existing and 51 pending patents</td>
</tr>
<tr>
<td></td>
<td>■ Proprietary and patented genes, promoters, strains and enzyme library</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>Proven at commercial scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>■ Almost two decades of commercial enzyme production at up to 150,000 liter scale</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4</th>
<th>Broad applications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>■ Many addressable industrial enzyme markets are based on newly emerging technologies and poised for rapid growth</td>
</tr>
<tr>
<td></td>
<td>■ The flexible C1 technology platform enables Dyadic to develop and produce enzymes and other proteins for almost all end markets</td>
</tr>
<tr>
<td></td>
<td>■ Fully developed, C1 enzymes and other proteins can be highly competitive in the largest and most diverse end markets</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5</th>
<th>Existing licenses with near-term commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>■ Significant revenue growth expected from agreements with 6 multi-national, industry leading companies to commercialize products in animal health &amp; nutrition, food, biofuels and other industrial enzyme and protein markets</td>
</tr>
<tr>
<td></td>
<td>■ Extensive and growing business development pipeline</td>
</tr>
</tbody>
</table>
# C1’s advantages over other filamentous fungi

## Key considerations

<table>
<thead>
<tr>
<th>C1 advantages</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low cost</strong></td>
<td></td>
</tr>
<tr>
<td>Low-cost raw materials</td>
<td>Reduced costs make commercial processes more economically viable and competitive</td>
</tr>
<tr>
<td>Low density fermentation</td>
<td></td>
</tr>
<tr>
<td>Low energy input</td>
<td></td>
</tr>
<tr>
<td>High productivity</td>
<td></td>
</tr>
<tr>
<td><strong>Lower risk</strong></td>
<td></td>
</tr>
<tr>
<td>Single host organism used throughout – no need for separate research and production hosts</td>
<td>Greater probability of moving successfully from discovery to commercialization</td>
</tr>
<tr>
<td>Proven industrial scalable, productive host organism</td>
<td>Shorter time to market</td>
</tr>
<tr>
<td><strong>Expanded commercial potential</strong></td>
<td></td>
</tr>
<tr>
<td>C1-produced enzymes are active in broader pH and temperature ranges than comparable enzymes produced by organisms used by competition</td>
<td>Wider potential markets to address vs. competition</td>
</tr>
<tr>
<td></td>
<td>Applicable to biofuels, bio-based chemicals and industrial markets</td>
</tr>
</tbody>
</table>
2 Strong IP portfolio

Exclusive Rights and Freedom to Operate

- Dyadic is the sole owner of the C1 fungus and technology
- C1 is the first and only commercially available thermophilic fungal expression system
- Broad patent claims are issued covering C1
- **C1 is not subject to Trichoderma's multiple complex third party patent issues**
- Dyadic has freedom to operate—freedom to operate is extremely important to a biotech company
- Molecular toolkit for overexpressing or deleting genes of interest (e.g., promoters, vectors and secretion signals)
- Dyadic has patented strains, molecular tools and genes as a result of its R&D

Business Model Allows for Expansive Licensing

- Business model of out-licensing the C1 technology
- All deals are non-exclusive with respect to the use of Dyadic’s C1 technology in their respective licensed fields
- Licensee retains ownership of its genes and the enzymes produced from those genes when using the C1 technology

<table>
<thead>
<tr>
<th># of issued US patents</th>
<th># of pending US patents</th>
<th># issued foreign patents</th>
<th># pending foreign patents</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>13</td>
<td>58</td>
<td>38</td>
</tr>
</tbody>
</table>

High barriers to entry for third parties due to Dyadic's patents, know-how and trade secrets developed over decades of research
## C1 commercialization history

<table>
<thead>
<tr>
<th>Year production began</th>
<th>Manufacturing site</th>
<th>Company</th>
<th>Country</th>
<th>Fermenter size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>FermPro/Martek (now DSM)</td>
<td>Dyadic</td>
<td>USA</td>
<td>150,000L</td>
</tr>
<tr>
<td>2000</td>
<td>Polfa Tarchomin</td>
<td>Dyadic</td>
<td>Poland</td>
<td>50,000L</td>
</tr>
<tr>
<td>2009</td>
<td>EnMex</td>
<td>Dyadic</td>
<td>Mexico</td>
<td>30,000L</td>
</tr>
<tr>
<td>2011</td>
<td>Antibioticos</td>
<td>Abengoa</td>
<td>Spain</td>
<td>50,000L</td>
</tr>
<tr>
<td>2011</td>
<td>Fermic</td>
<td>Codexis</td>
<td>Mexico</td>
<td>25,000L</td>
</tr>
<tr>
<td>2011</td>
<td>Iogen</td>
<td>Codexis</td>
<td>Canada</td>
<td>150,000L</td>
</tr>
</tbody>
</table>

Proven scalability up to 150,000 liters for nearly two decades
Dyadic’s historical financial results

Total revenue consists of sales of enzymes, research services and receipt of license fees.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Revenue ($)MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010A</td>
<td>$8.4M</td>
</tr>
<tr>
<td>2011A</td>
<td>$10.2M</td>
</tr>
<tr>
<td>2012 (9-30-12)</td>
<td>$12.9M</td>
</tr>
</tbody>
</table>
Dyadic’s industrial enzymes business...

2011 Industrial enzyme sales

- Starch: 7%
- Biofuels: 2%
- Food: 7%
- Pulp & paper: 11%
- Textiles: 15%
- Animal feed: 58%

$7.4mm total 2011

Historical industrial enzyme sales ($mm)

- 2009A
- 2010A
- 2011A
- 2012 (9.30-12)

The industrial enzyme business provides credibility, liquidity and access to potential licensing partners. Expanding R&D, sales, marketing and distribution resources will greatly accelerate growth.
... is poised to commercialize new, high-value enzymes

**Situation and opportunity overview**

- Dyadic has an active customer base, with many customer relationships spanning over 15 years
- Today, Dyadic is ready to leverage the C1 technology that has been developed and refined over the past 20 years to develop higher value enzymes and other proteins
- Key assets are now in place to be leveraged for development and commercialization of new innovative enzymes for industrial markets:
  - A powerful C1 expression host capable of producing a wide range of enzymes and other proteins at commercial scale
  - An expressed enzyme library of more than 80 different types of enzymes which can also be leveraged into multiple product applications and be used in tests and applications trials
  - More than 20 years of documented R&D provides the information and tools necessary to produce a vast pipeline of potential commercial products
  - Key research and license partners who have further developed the C1 technology for their benefit as well as the benefit of Dyadic

**Dyadic's resources and technology are ready to be leveraged for rapid growth in industrial enzyme production**
## 4. Broad enzyme applications

<table>
<thead>
<tr>
<th>Market size</th>
<th>Growth</th>
<th>Market size</th>
<th>Growth</th>
<th>Market size</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3 billion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>16%</td>
<td>$10 billion (end market)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>high growth</td>
<td>$600mm</td>
<td>7%</td>
</tr>
<tr>
<td>$1 billion</td>
<td>7-9%</td>
<td>$50mm (N. America only)</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$350mm</td>
<td>(4%)</td>
<td>$550mm&lt;sup&gt;3&lt;/sup&gt;</td>
<td>5%</td>
<td>$50mm (US only)</td>
<td>8%</td>
</tr>
<tr>
<td>$750mm</td>
<td>5%</td>
<td>$20bn (end market)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>high growth</td>
<td>$800mm (US only)</td>
<td>10%&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Source: Freedonia, Frost & Sullivan, Verenium press releases, equity research, company estimates

Note: Market size numbers represent latest available current global estimates, unless otherwise indicated.

<sup>1</sup> Projected 2020 cellulosic biofuels enzyme market; <sup>2</sup> Total estimated market size; <sup>3</sup> Global market for active ingredients in cosmetics and personal care; <sup>4</sup> Represents overall pharmaceutical growth
Dyadic’s C1 enzymes enable the new sugar economy

<table>
<thead>
<tr>
<th>Crops / Biomass</th>
<th>Sugar production</th>
<th>Biofuels / Bio-based chemicals</th>
<th>Key product examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food sources</strong></td>
<td></td>
<td><strong>Fermentation organisms</strong></td>
<td>Ethanol</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Butanol</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fatty acid (diesel)</td>
</tr>
<tr>
<td>Today</td>
<td></td>
<td>Yeasts</td>
<td>Jet fuel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fungi</td>
<td>1,3-Propanol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bacteria</td>
<td>Succinic acid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Algae</td>
<td>Isoprene</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Polylactic acid</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lubricants</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Detergent alcohols</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alkanes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other chemicals</td>
</tr>
<tr>
<td><strong>Non-food sources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tomorrow: Cellulosic Sugars</td>
<td></td>
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</tbody>
</table>

Dyadic’s C1 enzymes enable a wider range of production processes to convert biomass into fermentable sugars for use in producing biofuels and bio-based chemicals.
5 Dyadic’s primary partnerships

<table>
<thead>
<tr>
<th>Company</th>
<th>Rights to C1</th>
<th>Fields (end markets)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ABENGOA</strong></td>
<td><strong>Non-exclusive</strong> rights to improve, modify and use C1 in the licensed fields</td>
<td>❖ Enzymatic hydrolysis of biomass substrates in biorefining processes (e.g., using C1 to create sugar primarily for use in biofuels, bio-based chemicals and power production)</td>
</tr>
<tr>
<td><strong>CODEXIS</strong></td>
<td><strong>Non-exclusive</strong> rights to improve, modify and use C1 in the licensed fields</td>
<td>❖ Biofuels (limited to Shell as Codexis’ exclusive partner)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ Pharmaceutical intermediates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ Bio-based chemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ Air treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>❖ Sugars</td>
</tr>
<tr>
<td><strong>sanofi pasteur</strong></td>
<td><strong>Non-exclusive</strong> R&amp;D collaboration</td>
<td>Biopharmaceuticals (specific types of vaccines)</td>
</tr>
</tbody>
</table>
Dyadic’s primary partnerships (cont’d)

<table>
<thead>
<tr>
<th>Company</th>
<th>Rights to C1</th>
<th>Fields (end markets)</th>
</tr>
</thead>
</table>
| Major animal health & nutrition company      | **Non-exclusive** research collaboration and rights to use customized C1 strain in licensed field | **Animal health and nutrition**  
(production of a specific product line) |
| Market leading food and enzyme company       | **Non-exclusive** research collaboration and rights to use customized C1 strain in licensed field | **Food**  
(production of a specific enzyme) |
| Leading animal health & nutrition company    | **Non-exclusive** research collaboration and rights to use customized C1 strain in licensed field | **Animal health and nutrition**  
(production of a specific enzyme) |

Significant revenue growth expected from 6 existing agreements  
Funded research in existing and new markets validate and improve the C1 technology  
All transactions provide non-exclusive access to the company’s C1 platform
C1 OVERVIEW
What is C1?

- A robust and versatile fungal platform for gene discovery, expression and the production of enzymes and other proteins
- Based on the *Myceliophthora thermophila* fungus, a soil-borne saprophyte that secretes cellulases and proteases
- Developed in the early 1990’s through a fortuitous UV-induced mutation and continuously bioengineered since
- Addresses the critical bottlenecks of protein discovery, development, scale-up and commercialization
- Enables new product introduction with less time, cost and risk
- Broad platform capabilities validated through 17 years of R&D and 15 years of product sales and partnerships with key players
- Successfully manufactured a variety of commercial products at industrial scale (up to 150,000 liters) in 5 countries over 17 years
The evolution of C1

1992:
- Discovered C1 wild type strain which naturally produced neutral cellulase enzymes

1995/96:
- Fortuitous mutation of a C1 strain led to development of a high cellulase (HC) C1 strain with unique morphology
- Can produce high protein levels under low viscosity

2005-2008:
- Sequenced and annotated the C1 genome
- Development of low cellulase (LC) protein production platform
- Enabled the commercial production of "pure" enzymes and other proteins

2009 - Present:
- Developed comprehensive enzyme library
- Produced first commercial product using LC C1
- Expressed 7 different genes simultaneously / continued further improvements
- GRAS status acknowledged by FDA
- Developed strains for biofuel enzyme production

Development of a world-class protein production technology

1997 - 2007:
- Developed molecular toolkit for optimizing C1-based recombinant protein production for commercialization of enzymes and other proteins
- Produced variety of commercial products using the HC C1 platform technology
- Developed a variety of low protease C1 strains
- Successfully expressed human therapeutic proteins in C1
- High throughput robotic screening developed and patented
Major scientific collaborations

Moscow State University
Zeist, The Netherlands
Manitowoc, Wisconsin
Jupiter, Florida

Kluyver Centre
Wageningen University
Fibre-XM program
Bio-Mimetic project

European Commission
EUREKA
Sigma
Disco
NEMO for bioethanol
Scientific media recognition

Biofuels International, March 2012

“In 2011, a consortium of several worldwide renown organizations suggested that the use of thermostable enzymes offers economic advantages in the production of many chemicals and biomass-based fuels. Unfortunately, most of the commercially available enzymes which are produced by fungi like Trichoderma and Aspergillus are not sufficiently thermostable...The reported findings confirm previous results obtained by enzyme manufacturer Dyadic, which was the first company to successfully develop a thermophilic fungal production platform.”

Nature Biotechnology, October 2011

“The best studied and most widely used cellulases and hemicellulases are produced by Trichoderma, Aspergillus...and they are most effective over a temperature range from 40°C to ~50°C. At these temperatures, complete saccharification of biomass polysaccharides...requires long reaction times...One way to overcome these obstacles is to raise the reaction temperature...However, implementing higher reaction temperatures requires the deployment of enzymes that are more thermostable...Thermostable enzymes and thermophilic cell factories may afford economic advantages in the production of many chemicals and biomass-based fuels.

Industrial Biotechnology, June 2011

“The search for novel and/or improved industrial enzymes and enzyme production systems is intensifying as market demand increases. One such new system was developed based on a recently discovered fungal isolate, C1...The filamentous fungus C1 was developed into a mature technology and protein-production platform. C1’s inherent richness of genes encoding industrially relevant enzymes and its high-producing characteristics have been a proven starting point for the development of different C1 strains producing enzymes and enzyme mixtures.”

Numerous publications have validated Dyadic’s C1 technology
Leveraging the protein production puzzle

Dyadic provides a proven path towards commercialization of a wide range of enzymes
Enzymatic potential of C1

A large number of genes putatively encoding **industrially important** enzymes discovered:

- ~150 proteases
- ~700 oxido-reductases
- ~75 lipases / esterases.
- ~250 Carbohydrate-active enzymes (CAZy)

**C1 is a rich source of industrial relevant enzymes**
C1 has more enzyme-encoding genes than competing systems (for biofuels and bio-based chemicals)

<table>
<thead>
<tr>
<th>Genes encoding</th>
<th>Number in C1</th>
<th>Number in Trichoderma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endo-glucanases, Cellobiohydrolases, β-glucosidases</td>
<td>~ 20</td>
<td>~ 11</td>
</tr>
<tr>
<td>Cellulose binding domains (CBM1-type)</td>
<td>~ 46</td>
<td>~ 11</td>
</tr>
<tr>
<td>Xylanases/Xylosidases</td>
<td>~ 18</td>
<td>~ 6</td>
</tr>
<tr>
<td>Arabinofuranosidases/arabinases</td>
<td>~ 8</td>
<td>~ 5</td>
</tr>
<tr>
<td>Esterases (Axe, Fae)</td>
<td>~ 18</td>
<td>~ 4</td>
</tr>
<tr>
<td>Cellulase boosters (GH61)</td>
<td>~ 26</td>
<td>~ 3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>~ 116</strong></td>
<td><strong>~ 40</strong></td>
</tr>
</tbody>
</table>

Source: Literature and JGI database searches

C1 is a more recent and more robust system rapidly being adopted by major players
Integrated discovery process

**Discovery process**

- Isolate or synthesize DNA
- Clone DNA fragments
- Transfer DNA to C1
- Screen different C1 strains to find optimal host
- Integrate more gene copies into optimal host
- Produce protein of interest

**Host organism**

- DNA source (from Dyadic or customer)
- Discovery host
- Production host

C1’s integrated discovery system significantly shortens the R&D timeline, reduces R&D risk and increases the probability of success.
**C1’s molecular toolbox facilitates expression**

<table>
<thead>
<tr>
<th>Tools</th>
<th>Description</th>
<th>In C1 library</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Host strains</strong></td>
<td>◆ Different strains of the C1 platform are used to overexpress genes of interest</td>
<td>◆ Over 30 different host strains</td>
</tr>
<tr>
<td></td>
<td>◆ Strains include variations better suited for producing commercial products or purer enzymes (e.g., low cellulase and protease activity)</td>
<td></td>
</tr>
<tr>
<td><strong>Commercial strains</strong></td>
<td>◆ Strains used for production of commercial products</td>
<td>◆ 6 commercial strains</td>
</tr>
<tr>
<td><strong>Gene promoters</strong></td>
<td>◆ DNA sequence that drives the expression of genes of interest</td>
<td>◆ 2 strong promoters that are active under carbon limitations</td>
</tr>
<tr>
<td></td>
<td>◆ 1 strong starch inducible promoter</td>
<td>◆ 1 strong glucose promoter</td>
</tr>
<tr>
<td><strong>Gene terminators</strong></td>
<td>◆ DNA sequence that terminates the expression of genes of interest</td>
<td>◆ 2 efficient gene transcription terminators</td>
</tr>
<tr>
<td><strong>Basic expression vectors</strong></td>
<td>◆ A DNA construct that contains all elements needed to express the genes of interest, to be transferred into the target cell</td>
<td>◆ 18 different expression vectors</td>
</tr>
<tr>
<td><strong>Gene expression vectors C1 enzyme library</strong></td>
<td>◆ A collection of vectors—each vector contains a gene that encodes for an enzyme in the C1 enzyme library</td>
<td>◆ &gt;80 expression vectors that have been transferred into C1 LC strains, each over-expressing the enzymes encoded by these genes</td>
</tr>
</tbody>
</table>
### Tools (cont’d)

<table>
<thead>
<tr>
<th>Tools</th>
<th>Description</th>
<th>In C1 library</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal peptides / protein carriers</strong></td>
<td>◆ Protein sequences for the secretion of target proteins</td>
<td>◆ 1 efficient signal peptide</td>
</tr>
<tr>
<td></td>
<td>◆ A gene introduced into a cell that confers a trait suitable for selection</td>
<td>◆ 3 auxotrophic markers</td>
</tr>
<tr>
<td><strong>Selection markers</strong></td>
<td>◆ Vectors to disrupt specific genes</td>
<td>◆ Over 25 different types, including 2 auxotrophic markers and 10 proteases</td>
</tr>
<tr>
<td><strong>Gene knock-out vectors</strong></td>
<td>◆ Database containing the genome sequence and gene annotations</td>
<td>◆ Full genome sequence and automatically annotated genes</td>
</tr>
<tr>
<td><strong>Genome database</strong></td>
<td>◆ Gene expression data specific for protein production</td>
<td>◆ Several strong promoters identified</td>
</tr>
<tr>
<td><strong>RNA sequencing data</strong></td>
<td>◆ Protocols, etc.</td>
<td>◆ Large collection of knowledge, methods and protocols for fungal genetics, molecular biology, enzymology, biochemistry, fermentation and downstream processing</td>
</tr>
</tbody>
</table>

Dyadic has the complete toolkit to express genes, and produce and secrete proteins encoded by those genes
Development of protein hyper-producing strains

Mutagenesis overview

- **C1**
  - Wild type
  - UV mutagenesis

- **UV13-6**
  - Cellulase over producer
  - NTG* mutagenesis

- **NG7C-19**
  - De-repressed cellulase production
  - UV mutagenesis
  - High cellulase, low viscosity (mycelial fragmentation)

Performance comparison between wild strain and HC

![Graph comparing viscosity and protein yield between NG7C-19 and HC](image-url)
C1 — Strain development

From these two strains, Dyadic has generated more than 30 host strains.

- **C1**
  - Wild type
  - UV mutagenesis

- **UV13-6**
  - Cellulase over producer
  - NTG* mutagenesis

- **NG7C-19**
  - De-repressed cellulase production
  - UV mutagenesis

- **HC**
  - High cellulase, low viscosity (mycelial fragmentation)
  - UV mutagenesis

- **LC**
  - Protease-deficient
  - UV mutagenesis

- **LCprt**
  - LCprt with major protease gene alp1 disrupted
  - alp1 knock-out

- **HCprt**
  - Protease-deficient
  - UV mutagenesis

- **HCprt Δalp1**
  - HCprt with major protease gene alp1 disrupted
  - alp1 knock-out

Discovery → Expression → Optimization → Commercialization
C1-LC technology enables efficient production of purer enzymes

- High performance under broad operating conditions
- High levels of protein expression
- Commercial scale (i.e. 60g / l)
- Further fermentation improvements expected

- Genome fully sequenced and annotated
- >80 enzymes expressed in LC strains
- Majority of enzymes have been characterized
- Applicability to several end-markets

- Very powerful in current state
- Potential just beginning to be explored
Two recent examples of LC engineered strains

Analyze market need
- Food, starch, alcohol & brewing
- Pulp & paper
- Personal care & cosmetics
- Biofuels

Animal nutrition & health
- Textiles & leather
- Detergents
- Wastewater
- Nutraceuticals

C1 LC Strain

End product
- Next generation feed enzymes
- Leading Grain enzyme
- Nutraceuticals
Dyadic’s LC Strain (also called the “white strain”) is an additional expression tool which can be used to produce high levels of purer enzymes and other proteins. The LC Strain was developed through sustained efforts at Dyadic Netherlands to produce significantly less background proteins in order to provide a clean background host for targeted production. The LC strain allows for more efficient and economical industrial scale production of highly targeted enzymes and proteins at greater purity levels.

Development of Low Cellulase (LC) strain

- Baseline HC C1-strain (column A):
  - High cellulytic activities
  - Diverse enzyme mixture
  - Up to 100 g/L total protein

- Low cellulase (LC) C1 background strain (column B):
  - Almost no cellulytic activities
  - Very few endogenous secreted proteins
  - Better suited for enzyme characterization

- Up to ~80% target protein (3 examples—column C through E)
  - Column E shows the expression of two different genes simultaneously in one cell

Purer enzymes and other proteins provide the desired performance without undesirable side effects.
Highly expressed enzymes using C1-LC strain

Examples: Soon to be launched commercial enzymes

- One LC-host expresses dedicated enzyme mixture
- Composition can be easily adapted for various applications
- High production levels
- Large scale fermentations pending
- Considerable room for fermentation optimization

Enzyme 1 (20 g/L)
Enzyme 2 (12 g/L)
Enzyme 3 (15 g/L)

Knowledge of enzyme properties in combination with the LC strain host system leads to rapid development of high margin enzyme mixtures targeted to various applications
## Enzyme characterization

<table>
<thead>
<tr>
<th>pH and temperature range of C1 xylanases (select examples)</th>
<th>Xyl-A</th>
<th>Xyl-B</th>
<th>Xyl-C</th>
<th>Xyl-D</th>
<th>Xyl-E</th>
<th>Xyl-F</th>
<th>Xyl-G</th>
<th>Xyl-H</th>
<th>Xyl-I</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH range (&gt;50% activity)</td>
<td>4.5-8.5</td>
<td>3.5-5.5</td>
<td>4.5-8.0</td>
<td>3.0-8.0</td>
<td>4.5-7.5</td>
<td>4.0-7.0</td>
<td>4.5-8.5</td>
<td>4.0-8.0</td>
<td>3.5-6.5</td>
</tr>
<tr>
<td>Temperature range (°C, &gt;50% activity)</td>
<td>50-80</td>
<td>30-80</td>
<td>35-80</td>
<td>30-90</td>
<td>50-75</td>
<td>40-70</td>
<td>40-80</td>
<td>30-90</td>
<td>55-90</td>
</tr>
</tbody>
</table>
Dyadic has multiple ways to optimize production

- Inserting multi-gene copies coupled with fermentation process optimization leads to high yield, low cost products
- Improved productivity by approximately five fold in 1 year
- ~40 g/L of target protein of EgB was produced
Dyadic has an extensive C1 enzyme library

Overview of enzyme library

- Library contains a collection of more than 80 enzymes, each produced by a single C1 LC host
- The enzymes have been extensively biochemically characterized
- The enzymes show a great diversity of activities
- Dyadic continues to expand the enzyme library by expressing the genes of selected enzymes in a special C1 LC host
- Dyadic has ongoing activity in collaborative projects, as well as third party validations for many of these enzymes, including an ongoing European project that will lead to new classes of enzymes
- This information can be used to develop highly efficient biofuel, animal health & nutrition, pulp & paper, as well as food & beverage enzyme mixtures (among other potential uses)

Examples of enzymes in the library

<table>
<thead>
<tr>
<th>Category</th>
<th># C1 LC strains per category</th>
<th>End-market application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulases and hemicellulases</td>
<td>62</td>
<td>Biofuels, animal feed, food, pulp &amp; paper, wastewater</td>
</tr>
<tr>
<td>Pectinases</td>
<td>15</td>
<td>Food &amp; beverage, textiles</td>
</tr>
<tr>
<td>Amylases</td>
<td>1</td>
<td>Food &amp; beverage, detergents</td>
</tr>
<tr>
<td>Proteases</td>
<td>1</td>
<td>Food, detergents, wastewater, personal care</td>
</tr>
<tr>
<td>Chitinases</td>
<td>1</td>
<td>Biopesticides</td>
</tr>
</tbody>
</table>

Total 80

C1’s extensive enzyme library has great potential in many end markets
Application of enzyme library

**Gene overexpression using C1’s enzyme library**

- A C1 strain was developed that can increase the activity level of the most important enzyme in a commercial product by more than 4-fold, as compared to the enzyme produced by another microorganism.
- Dyadic’s enzyme library was used to identify enzymes that have complementary or synergistic effects.
- A C1 enzyme was identified that, at only a 5% level, boosted the activity of the commercial enzyme by a factor of 4.25.
- Next step: Overexpress the gene encoding the C1 enzyme in strain A.
- The resulting strain will produce a mix of enzymes which will show substantially higher activity at lower production costs.

**Overview**

- Combining the C1 enzyme library with the C1 expression system enables the production of better performing, lower cost enzymes.
Broad operating conditions for greater productivity (cont’d)

<table>
<thead>
<tr>
<th>Discovery</th>
<th>Expression</th>
<th>Optimization</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trichoderma</strong></td>
<td><strong>Aspergillus</strong></td>
<td><strong>Dyadic’s C1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Viscosity (centipoises)</strong></td>
<td>200-1,000</td>
<td>1,500–2,000</td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

Properties of C1 vs. other fungal systems

- **Low viscosity**
  - C1 exhibits a low-viscosity morphology in submerged culture compared to other commercial enzyme-producing fungi
  - The inherent low-viscosity phenotype of C1 HC and LC strains offers advantages in commercial scale fermentation which results in higher production levels with lower energy input
  - Easily-scalable system, which decreases time from R&D to commercialization and increases probability

- **Fermentation media**
  - Standard low cost industrial fermentation media
  - Uses industrial starch as main carbohydrate source
  - Can also produce enzymes and other proteins using agricultural waste streams (e.g., molasses)

- **High productivity**
  - C1 has demonstrated high productivity at up to 150,000 liter scale at facilities in five countries

C1’s low viscosity and flexible fermentation conditions enable high productivity at low cost resulting in an easier path towards commercialization
C1 has an excellent safety profile

**Generally Recognized as Safe (GRAS) status acknowledged by the FDA**
- Generally Recognized as Safe (GRAS) Notification for C1-cellulase accepted with no questions asked by FDA on September 29, 2009¹
- GRAS Notification letter is a public statement by FDA acknowledging Dyadic’s safety determination for the intended uses of C1
- GRAS Notification letters are broadly recognized in the food and consumer products industries as the safety standard

**C1 strain**
- Pathogenicity and toxigenicity data: strain is non-infectious and no known toxins are produced
- Peer-reviewed scientific literature have confirmed—no known pathogenicity
- No mycotoxins found

**C1-Enzyme preparation**
- In vivo feeding trials:
  - 14 day dose study in rats
  - 13 week subchronic rat study
- Genotoxicity testing:
  - AMES bacterial mutagenesis
  - Chromosomal aberration test
  - Genetic mutation test
- **No adverse effects observed**
- **No foreign DNA**
- **Safety confirmed**

¹ FDA GRAS Notice No. 000292, see http://www.accessdata.fda.gov/scripts/fcn/fcnDetailNavigation.cfm?rpt=grasListing&id=292
Production of heterologous proteins

<table>
<thead>
<tr>
<th>Source</th>
<th>Enzyme/protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fungal</td>
<td>Xylanases, amylase, cellulase, endo-polygalacturonase, oxidase, phytase</td>
</tr>
<tr>
<td>Bacterial</td>
<td>Xylosidase, cellulase, esterase</td>
</tr>
<tr>
<td>Bacterial-directed evolution</td>
<td>Phytase(^1), animal feed enzyme</td>
</tr>
<tr>
<td>Mammalian</td>
<td>Proteases</td>
</tr>
<tr>
<td>Human</td>
<td>Immunoglobulin IgG1</td>
</tr>
<tr>
<td>Viral</td>
<td>Vaccine components</td>
</tr>
</tbody>
</table>

Heterologous enzymes/proteins from a variety of organisms have been produced
C1 platform takeaways

**C1 platform technology**
- An engine for growth which can be programmed to efficiently produce most enzymes and other proteins at commercial scale (e.g., enzymes which degrade or modify the fibers in the cell walls of plants)
- Optimized to produce enzymes and other proteins from genes contained in the C1 genome as well as from other genomes

**Research and development**
- The C1 platform technology is the result of more than 20 years of research and development by Dyadic and its scientific partners
- Dyadic's team of highly skilled scientists and network of scientific organizations are highly trained and experienced in the use of the C1 technology
- Continued research can further improve the C1 technology's ability to discover, develop and manufacture enzymes and other proteins for targeted markets

**Enzyme library**
- The library of more than 80 individual lignocellulose degrading enzymes produced by C1 are a fertile source for future high purity products in many industries
- Minimizes undesirable side activities that may delay or prevent commercialization

**Enzyme mixtures**
- In addition to its more than 80 single enzymes, Dyadic has a variety of other C1 strains which produce enzyme mixtures (consisting of up to 7 different enzymes produced from one C1 cell) which can be used as the baseline strain to which single enzymes can be added for greater performance

**Commercial strains**
- In addition to C1 strains Dyadic has commercially relevant strains of *Trichoderma* and *Aspergillus* which have been used to commercially produce cellulase, hemicellulase and amylase enzymes at up to 150,000 liters

Dyadic has the assets necessary to develop and commercialize a vast pipeline of commercial enzymes
BUSINESS OVERVIEW
## Dyadic business overview

<table>
<thead>
<tr>
<th>Research and licensing</th>
<th>Industrial enzymes</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Non-exclusive license agreements for use of C1 technology (including upfront, milestone and royalty payments)</td>
<td>- Sale of C1-based enzymes and other proteins for multiple industries including biofuels and animal feed</td>
</tr>
<tr>
<td>- R&amp;D agreements funded by third parties for development of C1-based products</td>
<td>- Sale of over 20 product offerings including xylanases, cellulases, beta-glucanases and proteases</td>
</tr>
<tr>
<td>- Leveraging C1 enzyme library into additional revenue</td>
<td>- Current end markets include animal health &amp; nutrition, pulp &amp; paper, food and starch, and textiles</td>
</tr>
</tbody>
</table>

### Key personnel

- Adam Morgan – VP General Counsel & Business Development
- Wim van der Wilden – General Manager, Dyadic Netherlands
- Jan Wery – Science Director, Dyadic Netherlands
- Thomas M. O’Shaughnessy – VP Sales & Marketing
- Richard H. Jundzil – VP Operations
- Sales representatives in the Americas, EU, and Asia

### Location

- Jupiter, FL – HQ & research lab
- Wageningen, The Netherlands – Research lab
- Greensboro, NC – Research lab
- Jupiter, FL – HQ & research lab
- Wageningen, The Netherlands – Research lab
- Greensboro, NC – Research lab

### Partners

- [CODEXIS](#)  
- [ABENGOA](#)  

Leading food company  
Two leading animal health & nutrition companies

### Global customer base

- Two leading animal health & nutrition companies
- Leading food company
Efficient business model

Licensing (including royalties)

- Cost to license rights depends on a number of variables including:
  - Field of use and size of the market
  - Nature and extent of what the customer can do with C1
- Cost of license typically reflects a percentage of overall revenue or value that the customer will realize through the use of C1 technology in producing and selling products:
  - Upfront or access fee, typically paid upon signing of agreement
  - Milestone payments, when certain key events occur (e.g., opening a commercial facility, first commercial sale)
  - Royalties, paid based on licensee’s net sales of products which utilize the licensed technology
- This licensing model has allowed Dyadic to minimize its capital investment by partnering with companies that have greater resources to invest in developing and commercializing Dyadic’s technology

R&D

- Dyadic provides R&D services which utilize its C1 platform technology and/or access to the C1 library
- R&D creates customized C1 fungal strains that can produce the desired enzyme or protein from the gene provided by the customer
- Upon completion of research, customer can utilize resulting C1 strain to produce enzymes at its own facilities under a non-exclusive license
- This non-exclusive license allows Dyadic to continue to license C1 to others in the same or different fields while the licensee maintains exclusive rights to the specific C1 strain produced by the research they funded as well as the enzymes produced from that specific strain
- Total costs of the research project is determined based on the number of genes the customer wishes to express through C1 and the nature and extent of enzyme or protein optimization
- R&D projects can range from a few months to several years

<table>
<thead>
<tr>
<th>Upfront or access fee</th>
<th>Depending on field of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milestone payments</td>
<td>Upon commercializations, plant openings, or production targets met</td>
</tr>
<tr>
<td>Royalties</td>
<td>Depending on industry and profitability of the licensee</td>
</tr>
</tbody>
</table>

Revenue per full time equivalent (FTE) scientist

Dyadic’s efficient business model integrates product sales with R&D services and licensing rights to C1
## Research & development – Dyadic Netherlands

### Overview
- Located in Wageningen, The Netherlands
  - 20 employees — 6 with Ph.D.’s
  - Centre of excellence for Life Sciences research
- Dyadic’s research & development subsidiary
  - Participation in a number of funded international projects
  - Member of the Industrial Platform of the Kluver Centre for Genomics of Industrial Fermentation
  - Partner in The Eurofung Project (European scientific and industrial network on fungal research)

### Capabilities
- Core competencies in:
  - Molecular Biology
  - Fermentation Technology
  - Enzymology
  - Biofuel application technology
- Collaborates with strategic partners to:
  - Provide on-site enzyme production
  - Assist partners in producing customized C1 fungal strains for the manufacturing of large quantities of diverse enzymes and other proteins at high yields and low cost

### R&D services
- Overexpression and commercial production of heterologous and homologous proteins using fungal expression systems for multiple industry applications
- Access to enzymes produced by Dyadic’s fungal strains
- Development of tailor-made C1 strains for application in biofuels and bio-based chemicals production processes based on selected waste streams
- Development of enzyme cocktails tailored to the needs of the customer
Dyadic’s US R&D and Applications labs

<table>
<thead>
<tr>
<th>Jupiter, Florida lab</th>
<th>Greensboro, North Carolina lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>❖ Dyadic’s Jupiter, Florida lab is focused on analytical analysis such as enzyme activity assays and protein characterization</td>
<td>❖ Dyadic’s Greensboro, North Carolina lab is focused on applications testing for textiles and pulp &amp; paper, including product development, optimization and screening</td>
</tr>
<tr>
<td>❖ Biofuels R&amp;D includes the following activities:</td>
<td>❖ Primary pulp &amp; paper applications are:</td>
</tr>
<tr>
<td>✷ Lignocellulosic biomass saccharification</td>
<td>✷ Refining – virgin and recycled (OCC)</td>
</tr>
<tr>
<td>✷ Small scale enzyme purification</td>
<td>✷ Deinking wastepaper – MOW, ONP</td>
</tr>
<tr>
<td>✷ Optimization of product formulations</td>
<td>✷ Bleaching – Kraft SW and HW</td>
</tr>
<tr>
<td>✷ Evaluation of competitor products and formulations</td>
<td>❖ Primary textile applications are:</td>
</tr>
<tr>
<td>❖ Scientists also conduct quality assurance, product stability studies and provide technical sales support</td>
<td>✷ Denim washing (stone washing)</td>
</tr>
<tr>
<td></td>
<td>✷ Bio-finishing – surface hair removal</td>
</tr>
<tr>
<td></td>
<td>✷ Bio-scouring – reduce alkali, water</td>
</tr>
</tbody>
</table>
Toll fermentation manufacturing

Overview
- Producing enzymes with Mexican toll manufacturer since 2009
- Non-exclusive relationship
- US and European tolling options
- Specific enzymes produced include xylanases, cellulases, beta-glucanases, proteases and amylases
- More than 200 batches at 25 cubic meter scale producing over 5,000 cubic meters of fermentation broth since 2009

Capabilities
- 4 x 30m³ fermenters (25m³)
- 1 x 60M³
- 2 x 1M³ (1,000L) pilot scale
- Kosher certified
- Halal certified
- ISO 9000 certified
- HACCP
- Aspergillus
- Bacillus
- C1
- Trichoderma

Prior toll fermentation manufacturing
- 150,000 liter fermenters at FermPro/Martek (now DSM) from 1994 to 1999
- Three 50 cubic meter fermenters at Polfa Tarchomin in Poland from 2000 to 2008
Warehousing and logistics

<table>
<thead>
<tr>
<th>Warehousing</th>
<th>Packaging and shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Three warehousing locations operated by third parties</td>
<td></td>
</tr>
<tr>
<td>✓ Americas (Charlotte, North Carolina, USA)</td>
<td></td>
</tr>
<tr>
<td>✓ Europe (Tilburg, NL)</td>
<td></td>
</tr>
<tr>
<td>✓ Asia (Hong Kong)</td>
<td></td>
</tr>
<tr>
<td>✓ Packaging—25 kg, 240 kg and 1,200 kg standard pack sizes</td>
<td></td>
</tr>
<tr>
<td>✓ Bonded warehouses and cold storage</td>
<td></td>
</tr>
<tr>
<td>✓ Shipment lead times less than 2 weeks with proper projections</td>
<td></td>
</tr>
</tbody>
</table>

Global footprint

- Charlotte, NC
- Greensboro, NC
- Tlalnepantla, MX
- Tilburg, NL
- Wageningen, NL
- Hong Kong

- Toll manufacturing (3rd party)
- Warehouse (3rd party)
- Corporate headquarters
- R&D centers
CELLULOSIC BIOFUELS AND BIO-BASED CHEMICALS
Cellulosic ethanol market—27bn gallons per year by 2022

**Market overview**

- Cellulosic biofuels represent a major opportunity for C1’s enzyme platform
- Huge potential market with room for disruptive technologies to capture significant market share
- Based on analyst estimates and global biofuels renewal standards, the cellulosic biofuels market is expected to reach **27bn gallons per year** by 2022

**Cellulosic ethanol market forecasts**

- **North America**
- **Brazil**
- **Europe**
- **Asia**

**U.S Renewable Fuel Standards (RFS2) estimates**

- The original RFS1 program required 7.5bn gallons of renewable fuel to be blended into gasoline by 2012
- Under RFS2 the program was expanded to include diesel, target 9bn gallons by 2008 and 36bn gallons by 2022
- RFS2 will achieve significant reductions of greenhouse gas emissions and encourage the development and expansion of the U.S renewable fuels sector
- Carbon credits are tradable certificates with the right to emit one tonne of carbon dioxide or another equivalent
- Biofuels will enable companies to reduce their carbon footprint and sell these credits

Source: US Department of Energy, equity research estimates
C1 is one of only three leading enzymatic platforms

Production process

- **Feedstock**
- **Pretreatment**
- **Enzymatic Hydrolysis**
- **Sugar fermentation**
- **Distillation**
- **Upgrading**

<table>
<thead>
<tr>
<th>Company</th>
<th>Enzymatic Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abengoa</td>
<td>Dyadic / C1 enabled</td>
</tr>
<tr>
<td>Codexis</td>
<td></td>
</tr>
<tr>
<td>BP</td>
<td>Trichoderma enabled</td>
</tr>
<tr>
<td>DuPont</td>
<td>Novozymes</td>
</tr>
<tr>
<td>Clariant / Süd Chemie</td>
<td>DSM enabled</td>
</tr>
</tbody>
</table>
| POET / DSM               | Chemgen
                          KL Energy
                          MBI
                          Amyris
                          Gevo
                          LS9
                          Butamax |
Bio-based chemicals overview

### Market overview
- Sustainability concerns and a drive for higher-performance products have led to a major global push for the development of bio-based chemicals as a replacement and supplement to the existing market for chemicals.
- Bio-based chemicals are produced from biomaterials and other renewable sources.
- A growing number of bio-based chemicals, such as the biodegradable bioplastic PLA (polylactic acid) that derives from corn, are already in commercial production; the longer-term plan is to use lower-cost lignocellulosic feedstocks.
- For biochemical-conversion technologies, a major R&D focus is on improving pretreatment technology for breaking hemicellulose down to component sugars and developing more cost-effective enzymes and other biocatalysts for breaking cellulose down to its component sugar.
- Dyadic is positioned to leverage its C1 integrated technology platform in this developing field.
- C1 technology can be used to facilitate both parts of the bio-based chemical production process: (1) producing the enzymes that convert biomass into fermentable sugars; and (2) potentially acting as an expression host to consume the fermentable sugars and produce the bio-based chemicals.

### End markets

<table>
<thead>
<tr>
<th>Chemical/Plastic</th>
<th>Size of traditional end market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phthalate (replacement)</td>
<td>$11 billion</td>
</tr>
<tr>
<td>Polyols/Polyurethane</td>
<td>$11 billion</td>
</tr>
<tr>
<td>Solvents</td>
<td>$40 billion</td>
</tr>
<tr>
<td>Acrylic Acid</td>
<td>$14.5 billion</td>
</tr>
<tr>
<td>Succinic Acid</td>
<td>$7.5 billion</td>
</tr>
<tr>
<td>1, 4-Butanediol</td>
<td>$3 billion</td>
</tr>
</tbody>
</table>

Source: Company estimates

C1 enables both the production and consumption of fermentable sugars to produce bio-based chemicals
C1 advantages over Trichoderma for cellulases

- Genetic make-up
  - More genes with potential to encode for lignocellulosic enzymes (e.g., C1 has 26 cellulase booster genes (GH 61 enzymes) vs. only 3 GH 61 genes in the Trichoderma genome)

- Unique morphology
  - Easier to screen and transfer genes and cultures

- Low viscosity
  - Higher yields with lower energy input
  - Greater uniformity in fermentation process
  - Greater flexibility of raw materials

- Wider pH and temperature range
  - Enzymes have broader applications
  - Potential to reduce costs in the breakdown of cellulosic biofuels—higher temperatures reduce reaction times in biomass degradation, thus improving the economics

- Broad patent ownership
  - Broad patents related to C1 are owned by Dyadic
  - Less litigation risk from crowded playing field of overlapping Trichoderma patents

- Screening of unknown enzymes
  - One strain can be used throughout the entire process (unconfirmed whether other systems can do the same)
  - Dyadic has issued US and European patents for the use of C1, *Trichoderma* and *Aspergillus* for high throughput screening of unknown or improved enzymes
C1 has more enzyme-encoding genes than competing systems (for biofuels and bio-based chemicals)

<table>
<thead>
<tr>
<th>Genes encoding</th>
<th>Number in C1</th>
<th>Number in Trichoderma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endo-glucanases, Cellobiohydrolases, β-glucosidases</td>
<td>~ 20</td>
<td>~ 11</td>
</tr>
<tr>
<td>Cellulose binding domains (CBM1-type)</td>
<td>~ 46</td>
<td>~ 11</td>
</tr>
<tr>
<td>Xylanases/Xylosidases</td>
<td>~ 18</td>
<td>~ 6</td>
</tr>
<tr>
<td>Arabinofuranosidases/arabinases</td>
<td>~ 8</td>
<td>~ 5</td>
</tr>
<tr>
<td>Esterases (Axe, Fae)</td>
<td>~ 18</td>
<td>~ 4</td>
</tr>
<tr>
<td>Cellulase boosters (GH61)</td>
<td>~ 26</td>
<td>~ 3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>~116</td>
<td>~ 40</td>
</tr>
</tbody>
</table>

Source: Literature and JGI database searches

**Overview**

- *Trichoderma* is an older, established enzyme-producing host, being further developed by Novozymes and DuPont (Genencor) for biofuels and bio-based chemicals
- C1 is already equaling *Trichoderma* in a shorter period of time with fewer resources, and outperforming it at higher pH and temperature ranges
- C1 may have even greater potential in encoding for lignocellulosic enzymes (e.g., C1 has 26 GH61 genes as compared to 3 GH61 genes in Trichoderma)

C1 is a newer, more robust system rapidly being adopted by major players (e.g., Abengoa, Codexis)
C1 enzymes perform at wide pH and temperature ranges

**pH comparison**

<table>
<thead>
<tr>
<th>Glucose yield (g/L)</th>
<th>24 hrs</th>
<th>72 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td>5.0</td>
<td>4.5</td>
<td>5.0</td>
</tr>
<tr>
<td>5.5</td>
<td>4.5</td>
<td>5.5</td>
</tr>
<tr>
<td>6.0</td>
<td>4.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*C1 enzymes operate in the highest pH range vs. competitors*

**Temperature comparison (°C)**

<table>
<thead>
<tr>
<th>Glucose yield (g/L)</th>
<th>24 hrs</th>
<th>72 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>37</td>
<td>50</td>
</tr>
<tr>
<td>55</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

*C1 enzymes thrive under higher temperatures*

Research shows that use of heat-resistant enzymes offers economic advantages in the production of many bio-based chemicals and biofuels.
C1 enzymes remain effective at higher pH levels

C1 strains have higher yield

Pre-treated corn stover

<table>
<thead>
<tr>
<th>Enzyme loading</th>
<th>pH5 C1-G7</th>
<th>pH6 C1-G7</th>
<th>pH5 Cellic Ctec2</th>
<th>pH6 Cellic Ctec2</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wood pulp

<table>
<thead>
<tr>
<th>Material</th>
<th>C1-G7</th>
<th>Ctec2</th>
<th>No enzyme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardwood strips</td>
<td>68%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardwood stock</td>
<td>66%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine rejects</td>
<td></td>
<td>36.5%</td>
<td>&gt;36%</td>
</tr>
<tr>
<td>Hardwood stock bleach</td>
<td>70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood fiber</td>
<td></td>
<td>90.2%</td>
<td></td>
</tr>
<tr>
<td>No.5 pm reject</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T=50°C, pH=6.5, equal enzyme dose, % indicates glucose conversion yield

At pH of 6.0 or greater, C1 has little or no competition
C1 enzymes perform in acid, neutral and alkaline conditions

**Paper sludge at high dry matter loading and high alkalinity**

- Alkalinity of paper sludge prevented competitors’ Trichoderma enzymes from liquefaction and saccharification
- Chemicals present did not significantly inhibit G7

C1 has the flexibility to perform at multiple pH levels
C1 lignocellulosic enzymes are more thermophilic

**Broad temperature profiles**

- Ability to add enzyme in early stage after thermo-pretreatment
- Less processing time
- Lower viscosity of biomass at high temperature

At high temperatures, C1 has little or no competition
Dyadic’s *AltenaFuel® CMAX3™* outperforms Cellic® CTec3

**July 2012 laboratory testing results**

![Graph showing saccharification yield at pH 5 and pH 6](image)

Experimental conditions: pH = 5.0 (unless stated otherwise); T = 55 °C; pretreated corn stover (10% dry matter); C1 and Cellic®CTec enzymes were used at equal protein loadings (*Cellic® CTec2* and *Cellic® CTec3* are produced and owned by Novozymes).
## Significant improvements beyond CMAX3 — details

### Latest results concerning robustness of CMAX3

- Less inhibited by glucose compared to Ctec3
- Less inhibited by ethanol compared to Ctec3

### Concrete plans for short term CMAX3 improvement

- Optimization with respect to cellulose hydrolysis
- Optimization with respect to xylan (C5) hydrolysis

### Plans for medium term CMAX3 improvement

- Increase ratio of productive vs. non-productive enzymes in mixture
  (e.g. LC-strain based biofuel mixture)
CMAX3 vs CTEC3

Glucose inhibition

10% PCS, T=50°C, t=72h, 10 mg/g DM

CMAX3 shows less inhibition by glucose
Significant improvements beyond CMAX3

C1 biofuel enzyme development timeline (4 years)

Customized enzyme mixtures and onsite production of C1 enzymes including CMAX will assure the most efficient lowest cost enzymes
Dyadic has multiple ways to commercialize products

C1 has the optionality between HC and LC background strains

- **A. Baseline (HC) C1-strain:**
  - High cellulolytic activities
  - Diverse enzyme mixture
  - Up to 100 g/L total protein

- **B. Low cellulase (LC) C1 strain:**
  - Almost no cellulolytic activities
  - Very few secreted proteins
  - Better suited for enzyme characterization

- **C-D.** Up to ~80% target protein (2 examples)

- **E.** The expression of two different genes simultaneously in one cell

- LC Strains were initially used for the R&D purposes: the development of a library of C1 enzymes

- The enzyme library is extremely important for the development of enzyme mixes needed for the hydrolysis of complex polymers

- Recently, LC strains are also used to produce "pure" enzymes and other proteins

Combination of HC and LC strains and the C1 enzyme library led to CMAX3 and is being used to develop the next generations of feed, food and fuel enzymes
Dyadic licensee profile: Abengoa

Company overview

- Founded in 1941 and headquartered in Seville, Spain
- Abengoa is one of the largest ethanol producers and alternative energy companies in the world
- Operates in a variety of end markets, including electricity transmission, solar, biofuels, water infrastructure and waste recycling
- Strategic alliance with Companhia Energética de Minas Gerais (CEMIG), one of Brazil’s largest electrical power companies
- In 1991, Abengoa began focusing its activities on development and innovations in the sectors of renewable energy, bio-energy, water and information technology
- Approximately 22,000 employees

Historical financial summary ($mm)

<table>
<thead>
<tr>
<th></th>
<th>2009A</th>
<th>2010A</th>
<th>2011A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>4,800</td>
<td>6,452</td>
<td>9,871</td>
</tr>
<tr>
<td>% growth</td>
<td></td>
<td>34.4%</td>
<td>53.0%</td>
</tr>
<tr>
<td>EBITDA</td>
<td>824</td>
<td>1,078</td>
<td>1,536</td>
</tr>
<tr>
<td>% margin</td>
<td>17.2%</td>
<td>16.7%</td>
<td>15.6%</td>
</tr>
</tbody>
</table>

Company segments

Engineering & Construction
- Operates globally in the energy, water and environment sector
- Provides turnkey solutions for electrical transmission and distribution lines, cogeneration power stations, solar CSP plants, biofuel plants and water infrastructure solutions
- 50% of 2011 revenues, 40% of EBITDA

Concession-type infrastructure
- Operation of solar power plants, power transmission networks and water desalination plants
- Revenues are governed by inflation-adjusted fees and power purchase agreements or regulated tariffs
- 6% of 2011 revenues, 27% of EBITDA

Industrial production
- Biofuels and industrial waste recycling
- European market leader in ethanol production and #6 in North America
- In recycling, Abengoa is the market leader in the niche markets where it operates
- 44% of 2011 revenues, 33% of EBITDA

Capacity

- 3,175mm L/year of biofuels
- 2.5mm t/year of recycling
- 970mm L/day1 of water desalination
- 1,653mm W1 installed solar-thermal power
Dyadic licensee profile: Abengoa (cont’d)

Relationship overview

- 2006: R&D program led to non-exclusive license agreement
- 2009: Non-exclusive license agreement covers use of C1 expression system for large-scale production of enzymes for use in manufacturing of biofuels, power and chemicals
- 2012: License agreement amendment to expand territories to worldwide rights; also provides Abengoa the right to produce, use and sell C1 enzymes in both first and second generation (cellulosic) biofuels and bio-based processes
- Focused on enzymes for lignocellulosic bioethanol production

Abengoa productions plans

- Biomass Pilot Plant (US) in 2007 - 0.02 Mgal/yr capacity
- Biomass Demonstration Plant (Spain) in 2008 – 1.3 Mgal/yr capacity
- Commercial Plant (Kansas, US) in 2013

Source: Abengoa presentations

Abengoa cellululosic bioethanol production projections

Abengoa cellulosic bioethanol production projections

Cellulosic ethanol production cost estimates ($/gal)

Source: Abengoa presentations
Dyadic licensee profile: Codexis

**Codexis overview**

- Founded in 2002
- Specializes in creating enzymes and microbes that help speed up chemical reactions in the pharmaceutical and biofuels space
- Operates in three main segments:
  - Pharmaceuticals
  - Biofuels
  - Bio-based Chemicals
- Codexis' biofuel program develops enzymes and other biocatalysts that accelerate the breakdown of cellulosic biomass into sugar, and then transform these sugars into cellulosic ethanol and biodiesel
- Revenues mostly from its pharmaceutical business

**Historical financial summary ($mm)**

<table>
<thead>
<tr>
<th></th>
<th>2009A</th>
<th>2010A</th>
<th>2011A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>83</td>
<td>107</td>
<td>124</td>
</tr>
<tr>
<td>% growth</td>
<td></td>
<td>28.9%</td>
<td>15.9%</td>
</tr>
<tr>
<td>EBITDA</td>
<td>(7)</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>% margin</td>
<td>NM</td>
<td>9.3%</td>
<td>4.0%</td>
</tr>
</tbody>
</table>

*Source: Company presentations, filings and website, equity research

1 Includes R&D funding

**JV between Shell and Cosan**

- On August 2010, Shell and Cosan entered into a $12bn JV to establish one of the largest ethanol production capabilities in the world ("Raízen")
- Shell contributed its equity stake in Codexis and Iogen Energy (a technology firm specializing in cellulosic ethanol production) and its distribution network; Cosan is providing sugarcane production sites
- **What this means for Codexis**: In ethanol production, about 2/3 of the sugarcane plant is discarded as cellulosic biomass. Codexis is expected to work on developing more efficient biocatalysts to convert the entire 100% of the plant into biodiesel through a direct fermentation process. Revenue generated from the project using Codexis' biocatalyst technology would be subject to royalty fees

**Codexis biofuels products**

- Main products are the CodeXyme™ Cellulase enzymes (based on C1)
- Goal is to market CodeXyme™ as the world’s best enzyme package enabling cost advantaged conversion of biomass to sugars for the production of bio-based fuels and chemicals
- Developed with the help of Dyadic’s C1 technology
Dyadic licensee profile: Codexis (cont’d)

**License overview**
- Non-exclusive license agreement
- Covers use of C1 expression system for large-scale production of enzymes in biofuels, chemicals, air treatment, wastewater, sugar and pharmaceuticals intermediate production
- Shell is the exclusive biofuels partner of Codexis
- Codexis has used approximately 110 scientists per year and has spent 45% of its R&D budget working on CodeXyme cellulase enzymes (based on C1)

**Codexis milestone expectations**

<table>
<thead>
<tr>
<th>Completed</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>CodeXyme™ Cellulase Enzymes</td>
<td>20,000L scale-up in Mexico City</td>
<td>10MT bagasse pilot with Chemtex</td>
<td>Established CMO supply chain</td>
</tr>
<tr>
<td></td>
<td>150,000L scale up with Iogen Energy in Canada</td>
<td>Commercial samples to chemical industry</td>
<td>First commercial production</td>
</tr>
<tr>
<td></td>
<td>Launch of CodeXyme™</td>
<td></td>
<td>Customer and partner agreements</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commercial production</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Customer and partner agreements</td>
</tr>
</tbody>
</table>
Dyadic licensee profile: Codexis (cont’d)

Codexis public materials—Investor presentation

**Progress in CodeXyme™ Cellulase**

*Codexis has delivered *significant improvements* in enzyme performance and manufacturing cost*

- Increased enzyme activity (left): Better hydrolysis process performance at commercial loads
- Decreased enzyme cost (right): Better strains and improved manufacturing process

**Improvement in Enzyme Performance**

- Fold-improvement in glucose converted

<table>
<thead>
<tr>
<th>Oct-09</th>
<th>Aug-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Strain</td>
<td>CodeXyme 1</td>
</tr>
<tr>
<td>CodeXyme 1</td>
<td>CodeXyme 2</td>
</tr>
<tr>
<td>CodeXyme 2</td>
<td>CodeXyme 3</td>
</tr>
<tr>
<td>CodeXyme 3</td>
<td>CodeXyme 4</td>
</tr>
</tbody>
</table>

**Reduction in Enzyme Manufacturing Cost**

- Fold-reduction in relative units

<table>
<thead>
<tr>
<th>Oct-09</th>
<th>Aug-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Strain</td>
<td>CodeXyme 1</td>
</tr>
<tr>
<td>CodeXyme 1</td>
<td>CodeXyme 2</td>
</tr>
<tr>
<td>CodeXyme 2</td>
<td>CodeXyme 3</td>
</tr>
<tr>
<td>CodeXyme 3</td>
<td>CodeXyme 4</td>
</tr>
</tbody>
</table>

Licensing the C1 technology enabled Codexis to rapidly reduce costs and improve efficiencies of its enzymes.
INDUSTRIAL ENZYMES
$7 billion global industrial enzyme market by 2013

<table>
<thead>
<tr>
<th>Sector</th>
<th>Market size</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal health and nutrition</td>
<td>$600mm</td>
<td>7%</td>
</tr>
<tr>
<td>Food, starch, alcohol &amp; brewing</td>
<td>$1 billion</td>
<td>7-9%</td>
</tr>
<tr>
<td>Pulp &amp; paper</td>
<td>$50mm (N. America only)</td>
<td>4%</td>
</tr>
<tr>
<td>Textiles &amp; leather</td>
<td>$350mm</td>
<td>(4%)</td>
</tr>
<tr>
<td>Personal care &amp; cosmetics</td>
<td>$550mm¹</td>
<td>5%</td>
</tr>
<tr>
<td>Wastewater</td>
<td>$50mm (US only)</td>
<td>8%</td>
</tr>
<tr>
<td>Detergents</td>
<td>$750mm</td>
<td>5%</td>
</tr>
<tr>
<td>Nutraceuticals</td>
<td>$20bn (end market)²</td>
<td>high growth</td>
</tr>
</tbody>
</table>

Source: Freedonia, Frost & Sullivan, equity research, company estimates

Note: Market size numbers represent latest available current global estimates, unless otherwise indicated

¹ Global market for active ingredients in cosmetics and personal care
Attractive business dynamics — Enzymes

**Enzymes business overview**

- Industrial enzymes is a highly favorable, structural growth industry characterized by: (1) high profitability level, (2) high industry concentration and (3) scope for further production yield improvement
- Enzymes benefit from mega-trends, including substitution of renewable products for petrochemicals and societal bias towards more sustainable processes and products
- Demand for products is high and the customer base (mostly multi-nationals) is growing each year
- High barriers to entry—specialty strains are few and new entrants depend on technology
- Approval time for products depends on market segment; in high value markets like food and feed, approval takes 6-12 months but sales could take another 2 years to develop with regulatory approvals and commercial introduction periods

**Enzyme industry margins**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Industry benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth rate</td>
<td>Organic growth typically 6-10% over an economic cycle</td>
</tr>
<tr>
<td>Gross margins</td>
<td>Typically 35-60%</td>
</tr>
<tr>
<td>EBITDA margins</td>
<td>Typically 22-28%</td>
</tr>
</tbody>
</table>

C1 is ready to be leveraged for rapid growth in industrial enzyme production
Animal health and nutrition enzymes

Enzymes in the animal health and nutrition industry

- Used in animal health and nutrition to improve the digestibility of dietary components
- Enable better-feed efficiency by making larger amounts of feed available for absorption
- Enable feed producers to extend the range of feed ingredients in order to reduce costs and maximize efficiency of diet formulations
- Enzymes in animal health and nutrition contribute to:
  - Uniform production
  - Better animal waste control
  - Reduced environmental pollution

Rising population and protein demand per capita, global

Key animal health and nutrition enzymes

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Benefits / Function</th>
</tr>
</thead>
</table>
| Phytase      | More popular in the United States  
|              | Works more efficiently with corn or soybeans                                      |
|              | Improves phosphorus availability and reduces the risk of mineral discharge into the environment |
| Non-phytase  | More popular in Europe  
|              | Works better with wheat, sorghum, barley, oats and rye  
|              | Recently developed applications in corn and soybeans |

Total market size is $600mm — One of the fastest growing segments in the industrial enzyme industry

Source: Frost & Sullivan, J.P. Morgan research, Verenium press release
C1 enables the production of advanced enzymes for animal health and nutrition

Dyadic can address the following key enzymes

- Alpha-Amylase
- Alpha-Galactosidase
- Beta glucanase
- Catalase
- Cellulase (23)
- Ferulic acid esterase
- Glucoamylase (1)
- Glucanase (1)
- Glucose oxidase
- Laccase
- Lipase

(Parenthesis indicate number of enzymes in Dyadic library—these enzymes have been expressed and generally characterized)

C1’s history of development and future potential

- More than 20 years of research and development by Dyadic and its scientific partners has resulted in Dyadic’s C1 platform technology which can be programmed to efficiently produce most enzymes and other proteins at commercial scale (e.g., enzymes which degrade or modify the fibers in the cell walls of plants) from genes contained in the C1 genome as well as from other genomes
- Expressed enzyme library of more than 80 cell wall degrading enzymes
- Biofuel research and development work and C1 biofuel strains are leveragable for use in the development of next generation animal health and nutrition enzymes

Key benefits

- Greater efficiency in the production of animal products such as meat and eggs
- Minimize the environmental impact of increased animal production
- Improve digestibility of nutrients
Case study: Animal health and nutrition enzymes

Gene overexpression using C1’s enzyme library

Overview

- A C1 strain was developed that can increase the activity level of the most important enzyme in a commercial product by more than 4-fold, as compared to the enzyme produced by another microorganism.
- Dyadic's enzyme library was used to identify enzymes that have complementary or synergistic effects.
- A C1 enzyme was identified that, at only a 5% level, boosted the activity of the commercial enzyme by a factor of 4.25.
- Next step: Overexpress the gene encoding the C1 enzyme in strain A.
- The resulting strain will produce a mix of enzymes which will show a substantially higher activity at a lower production costs.

Combining the C1 enzyme library with the C1 expression system enables the production of better performing, lower cost enzymes.
## Food & beverage enzymes market

### Role of enzymes in current Dyadic end markets (parentheses indicate number of enzymes in Dyadic library)

<table>
<thead>
<tr>
<th>Brewing</th>
<th>Baking</th>
<th>Fruit juice</th>
<th>Alcohol</th>
<th>Starch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key enzymes:&lt;br&gt;α-acetolactate decarboxylase&lt;br&gt;Amylases (1)&lt;br&gt;Glucanases (1)&lt;br&gt;Proteases (1)&lt;br&gt;Xylanases (13)&lt;br&gt;Accessory enz. (20)</td>
<td>Amylases (1)&lt;br&gt;Lipases&lt;br&gt;Glucanases (1)&lt;br&gt;Oxidases&lt;br&gt;Xylanases (13)&lt;br&gt;Proteases (1)</td>
<td>Amylases (1)&lt;br&gt;Glucose oxidases&lt;br&gt;Pectinases (15)&lt;br&gt;Proteases (1)&lt;br&gt;Cellulases (23)&lt;br&gt;Xylanases (13)&lt;br&gt;Accessory enz. (20)</td>
<td>Glucanases (1)&lt;br&gt;Xylanases (13)&lt;br&gt;Accessory enz. (20)</td>
<td>Alpha-Amylases&lt;br&gt;Glucoamylase (1)&lt;br&gt;Glucanotransferases&lt;br&gt;Glucose isomerases&lt;br&gt;Pullulanase&lt;br&gt;Transglucosidase</td>
</tr>
<tr>
<td>Benefits / applications:&lt;br&gt;Improve wort filterability and lautering&lt;br&gt;Improve filtration&lt;br&gt;Encourage conversion of poor quality barley to acceptable malts&lt;br&gt;Lower attenuation and haze&lt;br&gt;Increase in available nitrogen</td>
<td>Maintain flour consistency&lt;br&gt;Reduce impact of variations of raw material quality on dough&lt;br&gt;Improve bread volume&lt;br&gt;Extend shelf life in baked goods</td>
<td>Breakdown of cell wall&lt;br&gt;Liquefaction&lt;br&gt;Clarification of juice&lt;br&gt;Prevent oxidative off taste development</td>
<td>Maceration&lt;br&gt;Clarification and filtration&lt;br&gt;Colour and aroma improvement&lt;br&gt;Increase yield</td>
<td>Liquefaction&lt;br&gt;Depolymerisation of starch&lt;br&gt;Debranching of starch&lt;br&gt;Increase yield of glucose&lt;br&gt;Fructose production</td>
</tr>
</tbody>
</table>

>80 total enzymes in Dyadic’s C1 library for multiple product opportunities

Source: Frost & Sullivan, J.P. Morgan research

Note: Current Dyadic end markets only
Case study: Brewing enzymes

Development of a new brewing enzyme

Results demonstrate successful use of combining the C1 library and C1 expression system

- Better performing enzyme, at a significantly lower cost

- Generation #1: Starting C1 library strain

- Generation #2: After multi copies inserted and fermentation optimization

- Generation #3: Addition of multi copies of second gene encoding for beta-glucanase with higher specific activity
Pulp & paper enzymes market

**Market size**
- In 2007, the North American market for enzymes was $47mm, with a CAGR of 4% from 2007 to 2014

**Market overview**
- Paper pulp consists of cellulose, hemicellulose and lignin
- The key activity of enzymes in the pulp & paper industry is to modify the cellulose fibers and thus optimize bleaching, refining, deinking, and wastewater processes
- Usage is encouraged because it is potentially more environmentally-friendly than the chemical process
- Other key benefits include:
  - Energy savings
  - Improved brightness
  - Improved strength characteristics
  - Less linting and dusting
  - Reduction in stickies
  - Wastewater stream cleaning
  - Reduction in total biological oxygen demand and chemical oxygen demand
- Enzymes can be applied in the processing of both virgin and recycled fibers

**Key pulp & paper enzymes**

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Benefits / Function</th>
<th># in C1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amylase</td>
<td>Remove the starch contents in the pulp</td>
<td>1</td>
</tr>
<tr>
<td>Cellulases and hemicellulases</td>
<td>Enhance the fiber bonding properties without reducing pulp viscosity / Improve drainage / biobleaching / biorefining / deinking</td>
<td>23 Cellulases 13 Xylanases</td>
</tr>
<tr>
<td>Esterases</td>
<td>Remove the stickies that are present in the recycled fibers</td>
<td></td>
</tr>
<tr>
<td>Lipases</td>
<td>Remove or control the pitch</td>
<td></td>
</tr>
<tr>
<td>Proteases</td>
<td>Microbial control</td>
<td></td>
</tr>
</tbody>
</table>

**Dyadic products**

- **Bleach boosting**: FibreZyme™ LBL CONC
- **Bio-refining**: FibreZyme™ G200, G5000
- **Waste treatment**: AlternaFuel™ CMAX
- **De-inking**: FibreZyme™ LDI

Source: Frost & Sullivan, broker reports, J.P. Morgan research
Dyadic's pulp & paper bio-refining enzyme benefits

Product/Process benefits

- ✓ Improved machine speed
- ✓ Better bulk/softness
- ✓ Increased drainage
- ✓ Less steam used
- ✓ Reduced refiner energy

**Option #1**

**FibreZyme™ G200**

Decrease Refiner Energy

*Decrease the amount of energy (mostly electricity) used to run the wood pulp refiner*

**Option #2**

Maintain Refiner Energy

*Maintain the amount of energy (mostly electricity) used to run the wood pulp refiner*

Product/Process benefits

- ✓ Increases paper strength
- ✓ Improved machine speed
- ✓ Greater refiner capacity
- ✓ Fewer strength additives required
- ✓ Reduced picking

Dyadic currently has multiple enzymes for the pulp & paper industry
Case study: Pulp & paper enzymes

- Results achieved in 12 months
- Improved productivity by approximately five-fold
- Further demonstrates R&D capabilities to aid:
  - New product development
  - Improve productivity
  - Dramatically lower enzyme cost

Next-generation FibreZyme® G5000 was launched at Tissue World 2012
Other industrial enzyme opportunities

<table>
<thead>
<tr>
<th>Category</th>
<th>Market size</th>
<th>Growth rate</th>
<th>Dyadic position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastewater treatment</td>
<td>$46mm (US only)</td>
<td>8%</td>
<td>New large market with potential C1 applicability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Currently selling an enzyme for septic tank processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Product from pulp &amp; paper can be used in this market</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dyadic pH characteristics favorable</td>
</tr>
<tr>
<td>Cosmetics and Personal care</td>
<td>$550mm</td>
<td>5%</td>
<td>New large market with potential C1 applicability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ability to create cell line to let people produce skin bleaching and de-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>hairing enzymes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small amounts used by select competitors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regulated by law; clinical testing required</td>
</tr>
<tr>
<td>Detergents</td>
<td>$750mm</td>
<td>4%</td>
<td>Alkaline cellulase that could be competitive with current market leader</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alkaline protease in development</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Initial customer evaluations were favorable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Large volumes, small margins</td>
</tr>
<tr>
<td>Nutraceuticals</td>
<td>$20bn</td>
<td>3%</td>
<td>Existing beta-glucanase, cellulase, and xylanase with potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>applications in nutraceuticals</td>
</tr>
<tr>
<td>Textiles</td>
<td>$270mm</td>
<td>(4%)</td>
<td>Dyadic’s original and historically largest market</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Current sales to stone-wash jeans and denim</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Traditionally a lower margin business</td>
</tr>
</tbody>
</table>

1 Represents total US nutraceuticals market—enzyme breakdown not available
2 Global market for active ingredients in cosmetics and personal care
Dyadic has partnered with Mark Alfenito, a leading pharmaceutical scientist and entrepreneur, to develop C1 into a biopharmaceutical platform.

A 66.7%/33.3% ownership structure term sheet is under negotiation, whereby Dyadic would provide an exclusive license for C1 technology to EnGen Bio, Inc. (“EnGen”) for biopharmaceutical applications (agreement not yet finalized).

Platform will be used for internal and partner pipeline of protein therapeutics, vaccines and therapeutic antibodies.

Already well-established commercially.

No engineering needed for some human therapeutics, and minor changes needed for others.

Three validating collaborations signed with major pharmaceutical companies (antibodies and vaccines), several others outstanding.
## EnGen highlights

| Mature biologics production system | - C1 has undergone two decades of development by Dyadic International  
- Despite limited R&D and financial resources, has successfully produced a fully biologically active human monoclonal antibody at more than 1 gram per liter |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Low scientific risk | - Quantifiable engineering tasks to complete  
- Low cost of media, defined media with no animal components  
- Wide range of growth conditions |
| Rapid timelines to completion | - Fermenter time is less than one week  
- Direct, linear scaling from lab to commercial scale, saving a year of pre-clinical development time |
| High value system | - C1 system is valuable as a platform alone  
- Can be used to create high value Rx proteins for today’s market |
| Strategic and funded collaborations | - C1 technology has been validated by numerous existing strategic collaborations  
- EnGen has a track record of successfully working with major players in the pharmaceuticals industry |
| High value pipeline in development | - Two human mAbs and two animal mAbs  
- Two therapeutic proteins (second generation)  
- Two vaccines |
Advantages in biopharmaceutical applications

<table>
<thead>
<tr>
<th>Discovery</th>
<th>Expression</th>
<th>Downstream Processing</th>
<th>Product Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>❖ Mature system of industrial enzymes</td>
<td>❖ High expression level, allowing for smaller reactors</td>
<td>❖ Target protein secreted into media</td>
<td>❖ Glycoprofile needs little modification to become ‘human neutral’</td>
</tr>
<tr>
<td>❖ Short time to develop MCB</td>
<td>❖ Adaptable to current reactors and/or to new, single use reactors</td>
<td>❖ Secretion at high titer (no microbial inclusion bodies)</td>
<td>❖ Naturally afucosylated</td>
</tr>
<tr>
<td>❖ Direct and single step transformation with minimum strain selection (fast clone-to-clinic)</td>
<td>❖ Low cost of media</td>
<td>❖ Low host cell protein in supernatant</td>
<td>❖ GRAS designation</td>
</tr>
<tr>
<td>❖ Can be used for various high-value Rx proteins today</td>
<td>❖ Defined media</td>
<td>❖ No viral inactivation/removal/validation</td>
<td>❖ “Simpler” glycoprofile</td>
</tr>
<tr>
<td>❖ Already proven for human antibodies</td>
<td>❖ Short fermenter times</td>
<td>❖ Low viscosity</td>
<td>❖ Homogeneity of glycoforms can enhance drug profile</td>
</tr>
<tr>
<td>❖ Process validation upfront for biosimilars and streamlining first-in-class molecules</td>
<td>❖ Wide range of growth conditions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Low scientific risk
C1 advantages over CHO and Pichia

Overview of benefits and competitive advantages

<table>
<thead>
<tr>
<th>Competitor weaknesses</th>
<th>Corresponding C1 strengths</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHO (Chinese hamster ovary) and other mammalian cells (including Per.C6)</strong></td>
<td></td>
</tr>
<tr>
<td>- Takes a year or more for fermentation optimization</td>
<td>- Linearly scalable</td>
</tr>
<tr>
<td>- Not amenable to high-speed screening in a robotic set up for finding new and/or</td>
<td>- Fermenter time is less than a week</td>
</tr>
<tr>
<td>improved versions of antibodies and human proteins</td>
<td>- C1 High-Throughput Screening (HTS) technology could speed up the discovery and development process</td>
</tr>
<tr>
<td>- Concerns about mammalian viral or mycoplasma contamination</td>
<td>- C1 is non-mammalian, and therefore requires no viral inactivation or validation</td>
</tr>
<tr>
<td><strong>Pichia</strong></td>
<td></td>
</tr>
<tr>
<td>- Limited intron processing ability</td>
<td>- Capable of intron processing</td>
</tr>
<tr>
<td>- Limited expression of eukaryotic proteins</td>
<td>- Able to express a wide range of eukaryotic proteins</td>
</tr>
<tr>
<td>- Yeast cells have much lower levels of secretion than fungal cells</td>
<td>- C1 HTS technology enables faster discovery and screening of unknown genes</td>
</tr>
<tr>
<td>- High viscosity</td>
<td>- High expression levels</td>
</tr>
</tbody>
</table>

1 Owned by Merck, acquired in its 2006 purchase of GlycoFi for approximately $400mm in cash
# Market overview — Therapeutic proteins

## Product overview
- The therapeutic protein industry comprises all proteins engineered in a laboratory for pharmaceutical use, most commonly for treating cancers, heart disease, cystic fibrosis, diabetes, anemia, and hemophilia.
- Human health problems can arise when the body is not maintaining certain proteins at an appropriate level — protein therapy is the delivery of additional protein to compensate for deficiencies.

## Market activity
- The FDA has approved 75 therapeutic proteins, and there are approximately 500 additional proteins under development.
- Nearly all current therapeutic protein sales are within the U.S., but there is expected to be substantial demand growth in Asia as the base of eligible patients increase and disposable income rises.
- Many therapeutic proteins in advanced clinical trials will be coming to market in the next few years.
- From 2005 to 2012, the global therapeutic protein market grew from $60bn to $130bn.
- The protein therapy market holds major potential for future growth, and is expected to reach $143bn by 2015, and $169 by 2017, as many therapeutic proteins in advanced clinical trials come to market.

## Approx. global therapeutic protein sales ($bn)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales ($bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012E</td>
<td></td>
</tr>
<tr>
<td>2015E</td>
<td></td>
</tr>
<tr>
<td>2017E</td>
<td></td>
</tr>
</tbody>
</table>

\[ '12-'17E CAGR: 5.4\% \]

Market overview — Monoclonal antibodies

Product overview

- Monoclonal antibodies (mAbs) are proteins of the immune system that all bind to the same locus (epitope). They can now be generated in the lab by many different techniques.
- mAbs can repress or even stimulate a patient’s immune system to attack a specific set of cells, and can be customized to destroy nearly any cell target.
- Historically, the application of mAb therapy has focused on the use of monoclonal antibodies in destroying tumor cells and preventing tumor growth.

Market activity

- The usage of monoclonal antibodies is expected to grow quickly in the coming years, due to technology’s substantial advantages over traditional vaccine technology (faster to develop and more effective for patients who are immunocompromised).
- Partnerships between small, technology-focused businesses and major pharmaceutical companies have been successful.

Approx. global mAbs sales ($bn)¹

Source: U.S. National Library of Medicine, Insight Pharma Reports

A “magic bullet” for targeting specific diseases and destroying cancer cells
Market overview — Vaccines

Product overview

- A vaccine is a biological treatment that improves immunity to a certain disease, typically consisting of a weakened or dead version, or subunit of the actual microbe.
- Immunity is achieved by stimulating the patient’s immune system to attack the disease, eliminate it, and prepare itself to confront it later if encountered again.
- Vaccines have typically been prophylactic (preventive of future infection), although research into therapeutic vaccines for certain cancers is ongoing.

Market activity

- The vaccine market is one of the fastest-growing subcomponents of the pharmaceutical sector, with continued double-digit growth expected year-over-year.
- Global sales of adult and pediatric vaccines in 2010 reached $12.5 billion and $12.7 billion respectively.
- Adult and pediatric vaccine sales are expected to grow at a CAGR of 10.3% and 8.4% respectively, to 2015.

Approx. global vaccine sales ($bn)"
C1’s existing pipeline of vaccines, Rx proteins and mAbs

**Pipeline summary**
- Two human mAbs
- Two animal mAbs
- Two therapeutic proteins (second generation)
- Two vaccines
- Pipeline chosen on the basis of commercial opportunity and time-to-approval

**Select opportunities**

**Seasonal flu vaccine (already partnered with Sanofi)**
- Subunit vaccine
- Chicken egg production, approximately 50-year-old technology
- Six months to engineer and manufacture
- Glycoprofile is that of C1, which may be perfect for many vaccines
- Many alternate production systems have been attempted

**Human serum albumin**
- Most abundant protein in human blood (30-50g/L)
- Most-used IV protein in the world (500 tons per year) as plasma expander and excipient in vaccines, therapeutic proteins, and mAbs
- Several billion dollar per year opportunity
- Constant concerns about blood-borne pathogens
- 1 recombinant HSA on market (yeast)
- The industry’s grail: $1/gram (GMP) wholesale — C1 can produce at: $5/Kilogram (nonGMP)
GLOSSARY
Glossary

**Amylases** — a class of enzymes which catalyse the breakdown of starch into sugars

**Annotated genome** — a genome with its genes and regions identified and functionally described

**Aspergillus** — the genus of a fungus widely used as a host organism in commercial enzyme production.

**Bacteria** — single-celled microorganisms lacking organelles and an organized nucleus

**Bagasse** — the fibrous matter that remains after extraction of sugar from sugarcane or sorghum stalks

**Beta-glucanases** — a class of enzymes which catalyze the degradation of beta-glucans (such as cellulose).

**Bio-based chemicals** — chemicals that are composed, in whole or in significant part, of biological products or renewable materials

**Bioenergy** — renewable energy made available from materials derived from biological sources

**Biofuel** — bio-energy offered as solid, liquid, or gas fuel

**Biomass** — organic materials, such as wood, agricultural crops, and municipal wastes, used as renewable energy sources; organic material which has stored sunlight in the form of chemical energy; can be burned directly or processed into biofuels such as ethanol and methane

**Biopharmaceuticals** — a pharmaceutical product manufactured by biotechnology methods (involving live organisms and/or bioprocessing)

**Biorefining** — the separation and valorization of components that are part of a complex structure or mix. An example is the separation of wood components and the marketing of the individual components as such or after certain modifications. Enzymes are being applied in the separation and modification of the components that make up the mix
Glossary (cont’d)

**Bleach boosting** — the use of xylanase and other hemicellulose degrading enzymes to enhance the bleaching of pulp fiber prior to converting the fiber to white paper products

**Butanol** — a primary alcohol with a 4 carbon structure; belongs to the higher alcohols and branched-chain alcohols; primarily used as a solvent, as an intermediate in chemical synthesis, and as a fuel

**Cellulases** — a class of enzymes which catalyze the degradation of cellulose

**Cellulose** — the most common organic compound on Earth; a polysaccharide (complex carbohydrate) consisting of beta 1-4 linked glucose units; cellulose is one the structural components (fibers) of plant cell walls and about 33% of all plant matter is cellulose

**Cellulosic ethanol** — (interchangeable with “lignocellulosic ethanol”) a type of biofuel produced from lignocellulose, a structural material found in plants and composed mainly of cellulose, hemicellulose and lignin. Cellulosic ethanol is chemically identical to ethanol from other sources, such as corn, sugar or starch

**Chitinases** — a class of enzymes which catalyze the breakdown of chitin; chitin can be found in the hard outer covering of shrimp, insects and the cell wall of fungi

**Deinking** — a process used in the recycling of waste paper where most of the printing ink and other impurities are removed from the waste paper to allow it to be re-used in the production of new paper

**Delignification** — a chemical process for removing lignin from wood and other plant sources

**Dominant marker (Genetic marker)** — a gene or DNA sequence with a known location on a chromosome that can be used to identify individuals or species. Dominant markers allow for analyzing many loci at one time

**Downstream processing (DSP)** — the recovery and purification of the compound of interest from natural sources such as animal or plant tissue or fermentation broth; an essential step in the manufacture of pharmaceuticals such as antibiotics, hormones, antibodies and vaccines
Glossary (cont’d)

**Eukaryotes** — a class of organisms whose cell(s) contain complex structures enclosed within membranes; the defining membrane-bound structure that sets eukaryotic cells apart from prokaryotic cells is the nucleus, within which the genetic material is carried.

**Expression vector** — a DNA molecule that is used to introduce and express a specific gene in a target cell.

**Fermentation** — with respect to ethanol, a biological process in which sugars such as glucose, fructose, and sucrose are converted into cellular energy and thereby produce ethanol and carbon dioxide as waste products; a form of anaerobic respiration since yeast performs this conversion in the absence of oxygen.

**Filamentous** — composed out of filaments which are long threads; thin in diameter and many times longer than wide.

**Gene** — the molecular unit of heredity of a living organism; holds the information to build and maintain an organism’s cells and passes genetic traits to offspring.

**Gene discovery** — the mining of genomes to identify novel genes whose encoded proteins are of commercial, clinical or scientific interest.

**Gene expression** — the process by which the information in genes is translated or converted into proteins. These proteins are often referred to as gene products.

**Gene transcription terminator** — a section of genetic sequence that marks the end for transcription of a gene or operon.

**Glucoamylases** — a class of enzymes which catalyze the degradation of starch into glucose by removing glucose units from the non-reduced end of the polysaccharide chain.

**Glucose** — a simple sugar (monosaccharide) that is the chief source of energy for living organisms; the end product of carbohydrate metabolism and known as “blood sugar” since it is the principal sugar in blood.
Glossary (cont’d)

**Glycosylation** — the process of attaching sugar molecules to proteins, carbohydrates, lipids or other organic molecules

**Hemicellulose** — any of a group of polysaccharides (complex carbohydrates) that constitute the chief part of the skeletal substances of the cell walls of plants; resemble cellulose but are soluble and more easily extracted and decomposed

**High Throughput Screening** — a robotic and miniaturized technique used to screen a vast number of organisms for the production of a desired component, such as enzymes

**Host organism** — an organism in which foreign genes are introduced. Often these genes are overexpressed in order to produce a gene product such as an enzyme or a biopharmaceutical product

**Lignin** — a complex chemical compound most commonly derived from wood, and is together with cellulose and hemicellulose the most important constituent of the secondary cell walls of plants and some algae

**Lignocellulosic ethanol** — see “cellulosic ethanol”

**Monoclonal antibodies** — antibodies that are identical because they are produced by one type of immune cell that are all clones of a single parent cell. Given almost any substance, it is possible to produce monoclonal antibodies that specifically bind to that substance; they can then serve to detect or purify that substance. This has become an important tool in biochemistry, molecular biology and medicine

**Morphology** — the form or shape of an organism or part thereof

**Mutagenesis** — a process by which the genetic information of an organism is changed, either in nature or experimentally by the use of chemicals or radiation
Glossary (cont’d)

**Overexpression** — a situation in which the protein product of a gene is produced in larger quantities or more rapidly than the protein product normally is produced in its natural state; overexpressing allows those products to be produced more economically

**Pectinases** — a class of enzymes which catalyze the degradation of pectin, a polysaccharide substrate that is found in the cell walls of plants

**pH** — a measure of the acidity or alkalinity of a solution; solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline

**Phytases** — a class of enzymes that catalyze the degradation of indigestible phytic acid (phytate) found in grains and oil seeds and thus release digestible phosphorus, calcium and other nutrients

**Polymer** — a large molecule (macromolecule) composed of repeating structural units; well known examples of polymers include plastics, DNA and proteins

**Prokaryote** — simple, single-celled organisms without a well-defined nucleus or organelles; the largest class of prokaryotes is bacteria

**Promoter** — a region of DNA that directs the transcription of a particular gene

**Proteases** — a class of enzymes which catalyze the degradation of proteins into peptides or amino acids

**Protein** — molecules made up of long chains of amino acids (polypeptides) which build tissues and carry out many critical functions in a living organism
Glossary (cont’d)

Saccharification — the process of breaking a complex carbohydrate (such as starch or cellulose) into its monosaccharide components (simple sugars)

Signal peptide — a short peptide chain that directs the transport of a protein

Substrate — a molecule upon which an enzyme acts; enzymes catalyze chemical reactions involving the substrate(s), transforming the substrate into one or more products

Therapeutic protein — proteins with curing properties; pharmaceutical proteins developed directly from DNA sequences for medical applications in human beings; e.g. insulin to cure diabetes

Thermophile — an organism that thrives at relatively high temperatures

Transcription — the process of creating a complementary RNA copy of a sequence of DNA

Trichoderma — a genus of fungi that is present in all soils; used to produce a wide array of enzymes

Viscosity — the extent to which a fluid resists a tendency to flow; may be thought of as a measure of fluid friction

Xylanases — a class of enzymes which catalyze the degradation of xylan, the back bone of hemicellulose
THANK YOU