**I. EXECUTIVE SUMMARY**

**A. Pharmacogenomics Overview**

**Figure I-1**

OVERVIEW OF THE PHARMACOGENOMICS MARKET

### WW MARKET SIZE AND GROWTH

<table>
<thead>
<tr>
<th>Segment</th>
<th>2003E</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>ROW*</td>
<td>5%</td>
<td></td>
</tr>
</tbody>
</table>

**2003E: $670 Million**  
**2008E: $1,655 Million**  
**CAGR 2002-2007: 20%**

### KEY COMPANY MARKET SHARES

<table>
<thead>
<tr>
<th>Company</th>
<th>2003E</th>
<th>2008E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company A</td>
<td>24-28%</td>
<td>17-21%</td>
</tr>
<tr>
<td>Company B</td>
<td>12-16%</td>
<td>10-14%</td>
</tr>
<tr>
<td>Company C</td>
<td>7-11%</td>
<td>6-10%</td>
</tr>
<tr>
<td>Company D</td>
<td>4-8%</td>
<td>7-11%</td>
</tr>
<tr>
<td>Company E</td>
<td>4-8%</td>
<td>2-6%</td>
</tr>
<tr>
<td>Company F</td>
<td>3-7%</td>
<td>3-7%</td>
</tr>
<tr>
<td>Company G</td>
<td>3-7%</td>
<td>3-7%</td>
</tr>
<tr>
<td>Company H</td>
<td>3-7%</td>
<td>2-6%</td>
</tr>
<tr>
<td>Company I</td>
<td>1-5%</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Company J</td>
<td>1-3%</td>
<td>2-6%</td>
</tr>
<tr>
<td>Company K</td>
<td>18-22%</td>
<td>26-30%</td>
</tr>
</tbody>
</table>

### SEGMENT SHARE

<table>
<thead>
<tr>
<th>Segment</th>
<th>2003E</th>
<th>2008E</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNP Discovery</td>
<td>xx%</td>
<td>xx%</td>
<td>xx%</td>
</tr>
<tr>
<td>SNP Genotyping</td>
<td>xx%</td>
<td>xx%</td>
<td>xx%</td>
</tr>
<tr>
<td>Diagnostics</td>
<td>xx%</td>
<td>xx%</td>
<td>xx%</td>
</tr>
</tbody>
</table>

### CURRENT APPLICATIONS

- Drug Discovery
- Drug Development
- DNA Based Diagnostics

### FUTURE APPLICATIONS

- Agriculture
- Animal Health
- Disease Prevention
- Personalized Medicine

* Rest of World
Source: Front Line Strategic Consulting, Inc.
E. Worldwide Market


The compound annual growth rate (CAGR) of the pharmacogenomics market will be 22% over the next three years. The growth pattern reflects a shift of revenue streams from SNP discovery and validation to applications in clinical trials and diagnostics.

"We're living in an era when DNA diagnostics for clinicians are already north of $500 million. I would imagine that with other companies developing genetic tests for medical practice, and if we can be successful, that this market is very large."

- Senior Management, DNA Sciences, Inc.

**Figure I-6**

**WORLDWIDE PHARMACOGENOMICS MARKET**

<table>
<thead>
<tr>
<th>Year</th>
<th>SNR Discovery</th>
<th>SNP Genotyping</th>
<th>Diagnostics</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003E</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>2004E</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>2005E</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>2006E</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>2007E</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
<tr>
<td>2008E</td>
<td>xx</td>
<td>xx</td>
<td>xx</td>
</tr>
</tbody>
</table>

CAGR = xx%

**SALES BY REGION IN 2003E**

- U.S. 60%
- Europe 25%
- Japan 10%
- ROW 5%

Source: Front Line Strategic Consulting, Inc.; analyst reports; company annual reports; interviews
5. Segment Market Projections

a. SNP Discovery Revenues (2003E to 2008E)

Front Line expects this segment to grow at a 14% CAGR to reach nearly $xx million in 2008, due to limited future investment in a well occupied and maturing marketplace. Revenues will continue to stream from these private SNP databases which still have more content than the SNP Consortium’s database.

“Our point of view is that more information is better. Biology is pretty complicated, and people will want to look at a lot of SNPs to make sure they’re making the right decisions.”
- Management, Affymetrix

Growth is sustained by the ongoing need to identify and validate new SNPs, but limited by competition from in-house SNP identification and publicly available SNP data.

Source: Front Line Strategic Consulting, Inc.; analyst reports; company annual reports; interviews
c. Diagnostics Revenues (2003E to 2008E)

Diagnostic tools based on pharmacogenomics are currently very rare. As the use of pharmacogenomics gains validation alongside clinical trials, medical care will grow to include SNP testing as a diagnostic tool.

"Some diagnostic companies are bringing tests to the market without regard for the pharmaceutical companies, but are doing it for the benefit of the patient. It will be quite a big impact when those tests go into the marketplace, and people see how valuable they can be."

- Senior Management, DxS Genotyping

Current diagnostic tools focus on patients’ adverse reactions to drugs, especially to chemotherapy. In some cases lethal side effects can be averted.

Source: Front Line Strategic Consulting, Inc.; analyst reports; company annual reports; interviews
B. Pharmacogenomics

1. Definition

Pharmacogenomics is the study of how genetic variations among the population affect drug response. It involves the analysis of genomic data to develop new drug targets, a screening process of more efficient clinical trials and molecular diagnostic tests used to determine a drug response for individuals. The current pharmacogenomics field focuses on SNP analysis which is known to be one of the major forms of genetic variations.

Pharmacogenomics  noun  1. The study of genomics to determine the differences between individuals’ responses to a drug. 2. An application of genetic variation analysis such as SNP discovery and SNP genotyping to create personalized drugs and diagnostics to minimize adverse effects and maximize efficacy.
2. Segments of Pharmacogenomics

Innovations in genomics based technologies and analytical approaches have created three specific fields within pharmacogenomics including SNP discovery, SNP genotyping and diagnostics.

Figure III-6
PHARMACOGENONMICS LEADING SEGMENTS

Segment: SNP Discovery
Application:
- Gene to Disease Association
- Gene to Drug Response Association
- SNP Identification and Validation
- Population Genetics

Segment: SNP Genotyping
Application:
- Various Phases of Clinical Trials
- Drug Recovery
- Specific Market Segmentation and Penetration

Segment: Diagnostics
Application:
- Gene to Drug Response Association
- DNA Based Diagnostics Tools
- Genoprophiling
- Population Genetics

Source: Front Line Strategic Consulting, Inc.
II. OBJECTIVES AND METHODOLOGY

A. Report Objectives and Scope

1. Objectives

The objective of this report is to present a comprehensive discussion on pharmacogenomics used in the drug discovery and medical environments. The assessment includes an analysis of factors driving the growth of the market, revenue forecasts through 2008 and strategic recommendations.
2. Scope

Innovations in genomic based technologies and analytical approaches propelled the adoption of pharmacogenomics techniques in the overall SNP discovery, SNP genotyping and diagnostics fields. This report focuses on the pharmacogenomics market according to its applications in the industry.

Figure II-2

PHARMACOGENOMICS APPLICATIONS AND SCOPE OF THIS REPORT

Pharmacogenomics
An application of genetic variation analysis to SNP discovery and development for the goal of creating personalized drugs and diagnostics to minimize adverse effects and maximize efficacy.

- SNP Discovery
- SNP Genotyping
- Diagnostics

Source: Front Line Strategic Consulting, Inc.
B. Methodology

1. Pharmacogenomics Market Model

Financial analysis of the pharmacogenomics market is presented in Section IV. The model used in the analysis is based on company and division revenues, product revenues and market shares, and the forecasted market dynamics.

Source: Front Line Strategic Consulting, Inc.
2. Model Assumptions

The assumptions and rationale of the pharmacogenomics market model are described below.

**Figure II-4**

**GENERAL ASSUMPTIONS MADE IN MARKET MODEL CONSTRUCTION**

- **The Dominant Players in the Worldwide Pharmacogenomics Market in 2003:**
  
  The dominant worldwide players in the 2003 pharmacogenomics market were identified based upon historical sales data, SEC filings, information from interviews, annual reports, internal database and analyst reports.

- **Dominant Players in the Market will Remain Strong from 2003 - 2008:**
  
  The dominant players' products and services are supported by ongoing collaborations with pharmaceutical companies, an established user base and name recognition. Sales forecasts are based on information gathered through analyst and industry reports, primary interviews, assessments of historical patterns and rigorous market analysis.

- **The Revenues Resulted from Pharmacogenomics:**
  
  The fraction of revenues resulting from pharmacogenomics was estimated based upon data from SEC filings and the range of product and service offerings along with licensing deals, collaborations and partnerships. Discussions with company representatives further validated revenue assumptions.

- **Market Growth from 2003 - 2008:**
  
  With the need to reduce cost and continue to keep the solid product pipeline, pharmaceutical companies are searching for alternative and more efficient drug discovery techniques. However, the poor economic climate coupled with depressed budgets and competition from other drug discovery techniques will hinder growth in pharmacogenomics in coming years. Specific company growth rates were analyzed using information gathered from interviews, analyst reports, annual reports, product evaluations and additional secondary resources.

*Detailed market model assumptions and rationales can be found at the end of section IV.

Source: Front Line Strategic Consulting, Inc.
## a. Comparison in 2002E

<table>
<thead>
<tr>
<th></th>
<th>TECHNOLOGY/PIPELINE</th>
<th>MARKET POSITION</th>
<th>Overall Competitive Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current Technology</td>
<td>Product Offerings</td>
<td>Future Applications</td>
</tr>
<tr>
<td>Company 1</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Company 2</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Company 3</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Source: Front Line Strategic Consulting, Inc.
D. Data Collection

The following primary and secondary resources were used to develop this report:

- Pharmacogenomics Suppliers
- Industry Experts
- Industry Websites
- Company Websites
- Scientific and Industry Periodicals
- Internal Databases
- Industry Conferences
- Company SEC Filings
- Company Annual Reports
- Company Press Releases
- Financial Analyst Reports

Source: Front Line Strategic Consulting, Inc.
1. Primary Sources

Front Line compiled a panel of industry experts and conducted interviews to address specific questions related to pharmacogenomics, unmet needs and potential market opportunities.
a. Pharmacogenomics Thought Leaders

Front Line interviewed industry players and technology experts to obtain primary data. All leading pharmacogenomics companies were contacted and asked to participate in our study. Experts were selected based on their experience in the field and their position in the company.

**Figure II-9**
FRONT LINE’S PANEL OF EXPERTS

- **Affymetrix**, Business Development
- **Caliper**, Senior Management
- **Epidauros**, Senior Management
- **Illumina**, Marketing
- **deCODE genetics**, Senior Management
- **DNA Sciences**, Senior Management
- **DxS Genotyping**, Senior Management
- **Third Wave Technology**, Business Development
- **Third Wave Technology**, Research & Development

Source: Front Line Strategic Consulting, Inc.
A. Overview

1. Background

Current prescription drugs in the market promise confident levels of safety and efficacy for most of the population. However, there are significant cases where people do not respond to or suffer serious adverse effects from drugs they are prescribed. These outcomes are the results of the nature of drug development in which only a sampling of the population is included in the clinical trials. In the past, many drugs were not approved or were withdrawn due to severe adverse effects on certain groups of people despite benefits for the rest of the population. Pharmacogenomics addresses these unmet needs in drug discovery and development by accounting for genetic variations of individuals and populations.
2. Historical Perspective

Successful mapping of the human genome has given rise to a series of “omics” fields that aid in drug discovery and development. Pharmacogenomics surfaced over the past decade through discovery of single nucleotide polymorphism (SNP) and its usefulness in understanding genetic variations.

Figure III-2

PHARMACOGENOMICS OVER THE PAST TWO DECADES

- **1950’s**: Scientists identified deficiency in enzymes that explained adverse effects of drugs.
- **1988**: The National Research Council calls for a scale-up phased approach to the Human Genome Project and endorses $200 million a year.
- **1988**: Stephen Altschul at NCBI publishes BLAST, a DNA sequence search engine that becomes the standard for online gene searching.
- **1990**: The Human Genome Project presents its preliminary results that each individual could have fewer than 30,000 genes.
- **1990-1992**: The Human Genome Project is initiated and sequence information begins to increase exponentially.
- **1990**: The Human Genome Project presents its preliminary results that each individual could have fewer than 30,000 genes.
- **1997**: Abbott and Genset agree on co-development of a SNP map and its application in developing and marketing diagnostic systems. The deal is considered to be the beginning of the pharmacogenomics era.
- **1997**: The SNP Consortium begins to create a public SNP database. It is initiated by the NIH and a number of private pharmaceutical companies.
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- **1999**: The SNP Consortium begins to create a public SNP database. It is initiated by the NIH and a number of private pharmaceutical companies.
- **2000**: The Human Genome Project presents its preliminary results that each individual could have fewer than 30,000 genes.
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Source: Front Line Strategic Consulting, Inc.
3. Scientific Background

a. Single Nucleotide Polymorphism (SNP)

DNA is made with four different nucleotides: adenine, guanine, thymine and cytosine. Single nucleotide polymorphism (SNP) refers to a single base substitution of one nucleotide with another, such as adenine for guanine, and both types occurring in at least 1% of the general population. The DNA sequence from one individual to another is 99.9% identical; only 0.1% difference in sequence accounts for all genetic variations. The high frequency of SNPs allows them to be effective biomarkers of the genomic map. Although 80% of SNPs are known to reside in non-coding regions, the remaining 20% are likely to be in coding regions and be involved in genetic variations.

Among different types of genetic variations, SNP is one of the most prevalent and informative biomarkers. The shaded region in this figure shows the base change from guanine to cytosine as an example of SNP. This type of genotypic change could change the phenotype of an individual.
b. Genetic Variation and Drug Response

Genetic variations can cause unexpected drug responses in certain individuals. For example, the multidrug-resistance gene (MDR1) encodes a drug transporter protein that is known to be used by more than 30% of all drugs. Certain genetic variations in MDR1 cause abnormal protein expression levels, prohibiting proper drug transportation in the body. There are several known genes affecting administration, distribution, metabolism, elimination and toxicology (ADMET) of the drug response. Genetic variations in any of those genes involving ADMET will result in various responses in individuals.

Figure III-4
MDR1 GENE EXPRESSION

Source: Front Line Strategic Consulting, Inc.; Epidauros
b. SNP Genotyping

By pre-screening clinical trial participants for non-respondents and people with high risk of severe adverse effects, drug manufacturers can increase the success rate of drugs in their development pipeline and reduce the size of the clinical trial participant pools. A variety of high-throughput SNP genotyping tools serve this purpose and key players compete against each other on the basis of accuracy, cost and high-throughput capacity. Pharmacogenomics can also be used for drugs that have not been approved or were withdrawn from the market by the FDA due to an unexpectedly high occurrence of adverse side effects. By limiting drug usage to a specific population, drug companies can salvage their products and gain incremental revenue.

Figure III-13
PHARMACOGENOMICS IN DRUG DEVELOPMENT

- Development of therapeutics with a stratified target population.
- Increased clinical trial success rate.
- Reduced clinical trial time and cost.
A. Overview

Pharmacogenomics is a growing field of study. Multiple factors are acting upon the industry and will influence growth over the next five years. Bottlenecks are preventing pharmacogenomics from being fully adopted while industry drivers are pushing the technology’s development and commercialization. These drivers and bottlenecks will help mold the industry in coming years as pharmacogenomics gains popularity in the life sciences.

Figure V-1

PHARMACOGENOMICS TRENDS, DRIVERS AND BOTTLENECKS

Drivers:
- Driver 1
- Driver 2
- Driver 3
- Driver 4
- Driver 5
- Driver 6

Trends:
- Trend A
- Trend B
- Trend C
- Trend D
- Trend E

Bottlenecks:
- Bottleneck A
- Bottleneck B
- Bottleneck C
- Bottleneck D

Source: Front Line Strategic Consulting, Inc.
A. Overview

There are specific strategies that companies with pharmacogenomics interests should consider when planning for future growth and profitability. These strategies are based on current business scenarios as well as technical and market opportunities in pharmacogenomics.

Figure VI-1

ANALYTICAL COMPONENTS OF STRATEGIC EVALUATION

- Business Scenarios
- Opportunities
- Recommended Strategies

- A
- B
- C
- D
- E
- F

- Technical Opportunities
  - 1
  - *2
  - *3

- Market Opportunities
  - *1
  - *2

Source: Front Line Strategic Consulting, Inc.
3. Opportunities

Given the current landscape of the pharmacogenomics industry and its expected growth over the next five years, Front Line has identified specific opportunities for corporate growth. Exploitation of these opportunities provides the means to position companies for future growth and ensure a stake in this dynamic market.

Figure I-19
STRATEGIC OPPORTUNITIES FOR PHARMACOGENOMICS

- Opportunity A
  - Technical
  - Market
  - One
  - Two
  - Three

Source: Front Line Strategic Consulting, Inc.