Applications and Impacts of Bioinformatics Across the Agrifood and Health Ecosystem

Lead Analysts:
- Joshua Haslun, Ph.D.
  Senior Analyst
- Cole McCollum
  Analyst

Contributors:
- Sara Olson, Ph.D.
  Director, Research
- Shriram Ramanathan, Ph.D.
  Director, Research
Executive Summary

This thematic part two of three builds from “Bioinformatics, the digital toolbox for the biological data revolution” to explore applications across the ecosystem.

Discovery remains the largest opportunity for and application of bioinformatics but new and impactful opportunities like risk assessment, safety, and personalization emerge across the ecosystem.

Health and pharma is the development center, but new opportunities to apply the technology are evident in food and agriculture.

Expert analysis remains requisite in nearly all aspects of bioinformatics applications except in the most simplified circumstances such as pathogen strain detection.

While identifying or developing bioinformatic pipelines that produce standardized and comparable data remain important to success, securing the data necessary to develop solutions or working with those that have data access must be given priority.
Defining the current applications of bioinformatics

Capturing value through bioinformatics is no longer optional but a must. Its expanding applications stem from the interconnectivity of industry sectors and the need to understand this connection at a deep level to remain competitive (see below). However, understanding the prevailing applications of bioinformatics remains concealed behind R&D programs, a growing list of bioinformatic tools, and academic research. To address this challenge, Lux identifies six key applications of bioinformatics.

**KEY APPLICATION DEFINITIONS**

**Diagnostics** – Applications to detect pathogens or beneficial organisms and diagnose health or disease phenotypic characteristics

**Discovery** - Includes pipelines to support target identification, drug candidate screening, and genome and metagenome search, among numerous other potential options

**Personalization** – Bioinformatics applications targeting personalized approaches based upon an ever-improving resolution

**Quality and optimization** – Applications of bioinformatics leading to improved quality attributes of food, feed, crops, or health, or industrial processes, often microbial in nature

**Risk assessment and safety** – Applications related to the evaluation of risk and safety in food, feed, health, and industrial processes

**Traceability** – Applications to detect or trace provenance
Ecosystem drivers blend with sector-specific needs

Most companies view agriculture, food, and health as distinct value chains; however, the reality is that they are pieces of a single, interconnected system of technologies, markets, and demands. Consumer preferences are a core driving force in this ecosystem. In addition to seeking unique experiences, consumers are taking more active roles in maintaining wellness, leaving innovators at the mercy of fleeting trends and struggling to foresee major shifts.

**Bioinformatics is playing a key role enabling companies to be more agile and more certain about innovation efforts across verticals for each sector.**

<table>
<thead>
<tr>
<th><strong>Agriculture</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The agriculture ecosystem is rapidly changing as digital technologies gain recognition. Bioinformatics is no different as it enables innovation in crop protection, crop nutrition, and crop development targeting regional agricultural challenges. Crops generically include livestock.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Food</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer demands push trends like clean label, personalized nutrition, convenience, and safety. Food, ingredient, and CPG companies need to develop strategies to meet those demands while being constrained by cost, regulatory pressures, and complex supply chains.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Health and pharma</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The divide between health and wellness becomes less clear, and data continues to become a unifying foundation. Bioinformatics resides at the developmental crossroads for precise, personalized, preventative, and participatory advances in diagnostics, treatment, and care.</td>
</tr>
</tbody>
</table>
RESEARCH TRENDS

Health and pharma drive bioinformatics research

Discovery remains the leading application across the three sectors of the agrifood and health ecosystem, followed by risk assessment and safety. **Expect risk assessment and safety to gain further momentum in agriculture and food moving forward.**

Bioinformatics research in health and pharma outweigh that of the other sectors multifold. This is an expected result given the high degree of regulation and certainty required for drug development and health care as well as the need to connect symptoms to biological processes. **Innovations developed for health and pharma will trickle into agriculture and food.** Lux breaks down these opportunities by sector.

**LUX TAKE**

Health and pharma dominates research efforts of agriculture and food multifold, with discovery and risk assessment and safety leading the way for applications.
### HEALTH AND PHARMA

**Discovery drives bioinformatic research but new opportunities emerge**

<table>
<thead>
<tr>
<th>Discovery</th>
<th>Risk assessment and safety</th>
<th>Personalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioinformatics has become a critical component in the early-stages of drug discovery, particularly in target discovery. As the pharmaceutical and biotech industry increasingly shifts towards biological treatments, bioinformatics will play a larger role throughout the development process.</td>
<td>Bioinformatics plays a critical role in predicting and tracking off-target effects, adverse events, and the spread of disease. With falling sequencing costs, such approaches to risk assessment and safety will surge in adoption and improve the efficiency of other core applications like discovery.</td>
<td>The major opportunities for personalization include pharmacogenomics and personalizing treatment plans in oncology, where actionable results are generated. Reducing the time to actionable insight, reducing cost, and developing new treatments will be critical.</td>
</tr>
</tbody>
</table>

### Innovative Players

<table>
<thead>
<tr>
<th>Discovery</th>
<th>Risk assessment and safety</th>
<th>Personalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genedata</td>
<td>Galaxy Trakr</td>
<td>Nebula Genomics</td>
</tr>
<tr>
<td>CYClica</td>
<td>CDC</td>
<td>AB-BIOTICS</td>
</tr>
<tr>
<td>CARIBOU BIOSCIENCES</td>
<td>U.S. FOOD &amp; DRUG ADMINISTRATION</td>
<td>WuXiNextCODE</td>
</tr>
<tr>
<td>creoptix</td>
<td>Jet Propulsion Laboratory</td>
<td>Foundation Medicine</td>
</tr>
<tr>
<td>BROAD INSTITUTE</td>
<td></td>
<td>NovogeneAIT</td>
</tr>
</tbody>
</table>
| Genentech | | |}

Client confidential. Not for redistribution.
DRIVING VALUE WITH BIOINFORMATICS

Partnering with research institutes to expand bioinformatics resources and expertise

WHAT IS THE OPPORTUNITY

Many organizations, particularly those earlier in their stages of adoption of bioinformatics, can benefit greatly from working with an independent research institute. Such institutes can address the need for the significant amounts of computational and data resources that bioinformatics demands in addition to providing the necessary analysis expertise.

Going forward, these institutes will also provide a hub for data sharing efforts which can accelerate multiple areas of R&D as Lux has recommended in the related materials informatics space.

WHO SHOULD YOU ENGAGE WITH

Research organizations with vast computational resources and bioinformatics expertise. Look specifically to those with other strong academic and industry partnerships, which will open up the potential for collaboration, such as through data sharing.

FIND YOUR PARTNER
### AGRICULTURE

Bioinformatics research initiatives are driven by discovery, risk, and safety but many target quality and optimization

<table>
<thead>
<tr>
<th>Discovery</th>
<th>Risk assessment and safety</th>
<th>Quality and optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given the broad range of environmental, food/health, and regulatory challenges facing agriculture, discovery remains the priority, as crop development and protection along with livestock health and nutrition are pressing concerns.</td>
<td>Bioinformatics continues to play an important role in all aspects of safety, from the detection and prevention of active ingredient off-target affects to the improvement of food and feed security. These technologies are slowly making it to the point-of-use for producers.</td>
<td>Quality is a significant area of advancement for bioinformatics in agrifood, especially as synthetic biology and the microbiome provide novel, specific, and bio-based solutions. These solutions require industrial optimization and quality control. In addition, improved quality crops drives innovation.</td>
</tr>
</tbody>
</table>

Innovative Players

![Innovative Players](image)

---

8

Client confidential. Not for redistribution.
WHAT IS THE OPPORTUNITY

Arvinas' success with PROTAC human trials opens opportunities for developers, but few consider the potential role of targeted protein degradation in agrifood. The slow process and high cost of active ingredient development along with the emergence of pest and disease resistance decreases the market longevity of conventional active ingredients. A changing regulatory structure may limit opportunities further, and therefore, the need for novel chemistries and the greater than $100 billion dollar opportunity across crop and livestock health are real.

It will be necessary to target large agrifood markets in order to attract companies targeting human health directly.

WHO SHOULD YOU ENGAGE WITH

Companies with strong computational capabilities and early initiatives into targeted protein degradation technology. For now, partners reside in the pharmaceutical industry, and leading PROTAC partners are found below.

FIND YOUR PARTNER
## FOOD

### Risk, safety, and discovery drive bioinformatic research

#### Discovery

Many academic groups look to leverage bioinformatics to characterize the effects of bioactive ingredients. Bio-based ingredients as well as pro- and prebiotics impact consumer choice. Bioinformatics are the tool that aids in linking ingredient to impact with less effort and investment.

#### Risk assessment and safety

Bioinformatics will play a more important role in all aspects of food safety from the detection and prevention off-target affects (allergies) to the improvement of food and feed security (pathogens). Expect food and health to become more entwined through bioinformatics.

#### Quality and optimization

Optimization of flavor or production is possible, especially in the case of foods and ingredients produced through fermentation or cell culture. More ingredients have transitioned to this bio-based approach due to the potential for improved scalability.

### Innovative Players

- NURITAS
- shiru
- GINKGO BIOWORKS
- ONE CODEX
- USDA
- CP
- Creative Proteomics
- Resphera Biosciences
- igenbio
- IBM
- AgriProtein
- CALORIE
- Novozymes
- Purissima
- EUROFINS
- ISO
- NEODEN
- IDT
- Galaxy Trakr
- Clear Labs
WHAT IS THE OPPORTUNITY

Public genomic and biological databases continue to emerge and grow. For instance, the data from GTN is shared across NCBI, the European Molecular Biology Laboratory (EMBL), and the Data Bank of Japan (DDBJ). While global efforts to identify and trace pathogens back to the source will continue to improve in the future, the opportunity lies in the development or improved speed of development for cheaper, more cost-effective diagnostics. Connect these public data repositories to your own and in doing so join the food safety and food traceability initiatives currently underway.

Advances in food safety and security provide a significant opportunity to rapidly identify and reduce food losses and medical costs stemming from pathogens, as evidenced by the U.S. lettuce industry’s annual struggles with health risk.

WHO SHOULD YOU ENGAGE WITH

Companies with the potential to produce cheap, accurate, and low detection level products are a good starting point. Next, determine whether the technology is flexible enough for rapid expansion to the desired diversity of targets.

FIND YOUR PARTNER
Major trends consistent across applications

Bioinformatics enables the merger of previously distinct applications, such as discovery, risk assessment and safety, and diagnostics.

**Partnerships are requisite for success, and in every case, data must be the key factor to partner selection.** Partners and data sources may come from a wide array of freely available and private sources.

**Bioinformatics will become a key factor in the development of regulations, especially as biology becomes an asset across industries.** Prepare your innovation efforts with this future in mind.

**Bioinformatics is not a silver bullet** – expert interpretation remains a key component of its application, and even then innovations must be borne out from later bench work. Do not expect this to change in the near-term, even as algorithms aim to simulate systems biology.
FUTURE OUTLOOK
Bioinformatic efforts double as opportunities grow

Comparing research effort between 2014 and 2019 indicates that opportunity for different applications will be sector-specific as research publications mentioning bioinformatics have doubled over that last five years. The figure provides an overview of research effort by sector.

**Health and Pharma** – Expect opportunities to remain consistent across applications, but discovery will become more targeted, with increasing interest in areas like personalization.

**Agriculture** – Bioinformatics applications in diagnostics, risk assessment and safety, and traceability will gain industry momentum as the line between agriculture production, food, and health becomes more blurred.

**Food** – Food security and safety are a global priority evident in this analysis. Food personalization remains at lower resolutions than for health and pharma and is indicated by the smallest growth rate. Expect all other applications to remain key areas of opportunity.

Growth in research effort among sectors indicates future opportunities
5-year bioinformatics research CAGR
Innovate Smarter & Grow Faster With Lux

Contact us:  
www.luxresearchinc.com  press@luxresearchinc.com

@LuxResearch  
Blog:  
Lux Blog

@LuxResearch  
Free Webinars:  
Lux Webinars

Lux Research, Inc.

YouTube:  
Lux Research