doi:10.2533/chimia.2025.292 Chimia 79 (2025) 292–298 © M. Altorfer, J. M. Lucht, H.-P. Meyer

# Biomanufacturing in Switzerland – Past, Present, and Future

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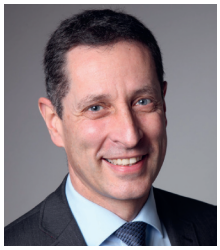
*Abstract*: Chemistry and biotechnology played a central role in transforming a poverty-stricken region in the middle of Europe into a flourishing industrial country. Rural areas remained destitute well into the 18th century. However, during the second half of the 18th century the foundation of the chemical powerhouses was laid. The biotechnological sector was built on these strong fundaments. This paper describes the development of the Swiss biotechnology sector from the early beginnings in the 1930s with a biocatalytic step in Vitamin C production to today's multifaceted application of biotechnology in Switzerland. As a matter of fact, biotechnology has become a key asset of the contemporary Swiss economy, and this paper outlines what is needed to stay on a successful path.

**Keywords**: Biologics · Biomanufacturing · Biotechnology · Fermentation



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## 1. Introduction

Once a rural poorhouse and landlocked without meaningful resources in the heart of Europe, Switzerland was one of the first countries to become industrialized. Two hundred years later the country is one of the richest countries in the world, in terms of GDP; surprising given its situation and the fact that two thirds of the country is mountainous.

*Why Nations Fail - The Origin of Power and Powerfulness* by Acemoglu and Robinson[1] provides insights into why some countries became rich while others remained poor. The Swiss success story may be summarized as follows.

- Feudal privileges were removed. Guilds, feudal landlords and churches were defeated, which opened the way for inclusive institutions and a pluralistic society.
- Open borders allowed the influx of know-how and the establishment of industrial sectors. Several Swiss international companies were founded or co-founded by immigrants.
- A mixture of ingenuity, opportunistic shrewdness and occasionally luck, navigated the small country through difficult times during the last two centuries.

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- Today's combination of political and financial stability, property protection, attractive tax system for businesses and individuals, encourages both domestic and foreign investment.

In 2024, Switzerland exported goods worth CHF 283 billion. More than half of this (CHF 149 billion) is contributed by the chemical and pharmaceutical sector, now Switzerland's largest export industry (Fig. 1). Exports from this sector more than quadrupled in the 25 years from 2000 to 2024 (+315 %), making it today's strongest driver of Swiss export growth. Products of biomanufacturing, for example immunological products, therapeutic monoclonal antibodies and vaccines, contribute significantly to this.[2]

In this article we outline how modern biotechnology and contemporary biomanufacturing were established and we aim to provide some answers to the following questions.

- What were the early steps and key factors leading to the successful industrialization in Switzerland?
- How did life sciences and biotechnology become the major economic factor in the Swiss economy?
- Who are today's biotechnology players in the Swiss economic space?
- What are today's key success factors?
- What can we expect in the future?

### 1.1 *Early Phase of Biotechnology in Switzerland*

The development of the textile industry in the early 18th century led to the development of the technology that underpins today's chemical industry. Originally, textile dyeing relied on natural dyes derived from plants, insects, and minerals, which were limited in color range and stability. As a consequence, synthetic dyes using organic chemistry were developed in the second half of the 19th century, and Alexander Clavel started the first synthetic dye factory in 1864 in Klybeck, Basel. Dyes remained the core business of Ciba Geigy and Sandoz until the first decades of the 20th century.

Today, the organic chemical industry is vast and multifaceted, having evolved significantly from its roots in textile dyeing. It plays a crucial role in various sectors, including pharmaceuticals, agriculture, and materials science, driven by ongoing research and development. This evolution, which started with the textile industry, finally culminated in a strong, globally active biotechnology community.

A common denominator of early biotech activities in Switzerland was the fact that Swiss companies initiated R&D for the fermentative production of natural substances such as antibiotics and other small molecules, but the production know-how was almost exclusively obtained by acquisition. Roche, Sandoz, Ciba-Geigy (or later Lonza) had their first products and processes developed in-house, but manufactured in Germany, Austria, Italy, or the Czech Republic. The large-scale industrial fermentation know-how was originally implemented in the USA by the UNRRA (United Nations Relief and Rehabilitation Administration) and the Marshall Plan.[3] In the early phase, biotechnology was seen as a competitor to the chemical industry, which was an obstacle to development.

### 1.2 *Early Adopters of Biotechnology*

**Clariant** was created in 1995 as a spin-off from the chemical business of Sandoz during the formation of Novartis. In 2011 Clariant acquired Süd-Chemie AG and their Sunliquid process and plants for the production of cellulosic ethanol. Clariant's product range includes biobased surfactants and natural-based products for the cosmetic industry.

**dsm-firmenich** was created in 2023 through the merger of Firmenich with the Dutch multinational company DSM. Firmenich was founded in 1895 in Geneva and has been a private, family-owned company for 125 years. Even before the merger, Firmenich was a leader in its industry when it came to biotechnological manufacturing.

Clearwood®, launched in 2014, was the first biotechnologically produced perfumery ingredient. Ambrox® and Z1, fragrance products with musk and wood tonalities, are manufactured using biotechnological methods. DSM has been present in Switzerland since 2002, with a large production facility for vitamins and food additives; the former Roche vitamin business which DSM acquired from Hoffmann-La Roche.

**F. Hoffmann-La Roche** is the only Swiss pharmaceutical company with its origins in pharmaceuticals. It was also the first company in Switzerland to apply biotechnology, implementing a biocatalytic process for the production of vitamin C in 1934. By 1938, vitamins were the company's mainstay[4] with products like Benerva (vitamin B1), Nestrovit (multi vitamin), Beflavin (vitamin B2) and Ephynal (vitamin E).

Roche was also active in antibiotic research and Rocephin (cephalosporin) was launched in Switzerland in 1982 only four years after its discovery. But like Ciba-Geigy, Roche outsourced its antibiotic fermentation mainly to Hoechst in Frankfurt. The first large molecule was interferon, for which Roche identified the corresponding interferon gene and used the *E. coli* expression system from Genentech for the production of Roferon-A, a recombinant alpha-2a interferon protein.

Early in the 2000s Roche expanded its mammalian cell manufacturing for biotechnology products in Basel and Penzberg. Genentech became a wholly-owned member of the

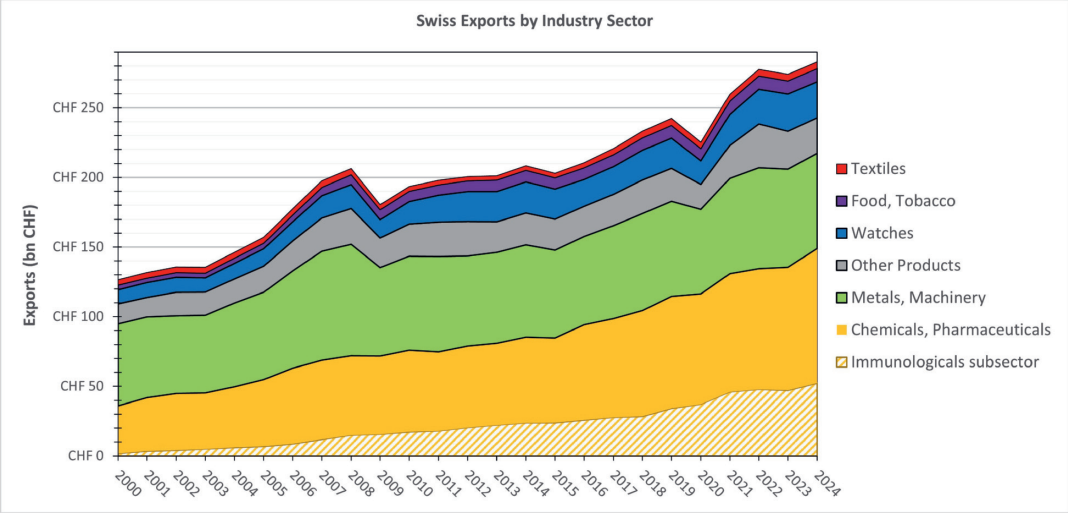


Fig. 1. Annual Swiss exports by industry sector demonstrate the growing importance of chemical and pharmaceutical products, including those produced by biomanufacturing. Data: Federal Office for Customs and Border Security, scienceindustries.

Roche group in 2009, after years of close cooperation which started in 1990.

**Givaudan** was founded in 1895 and was a longstanding customer for intermediates from Hoffmann La-Roche's vitamin A production. As a consequence, Roche acquired Givaudan in 1963, only to spin it off in 2000. The beginnings of biotechnology at Givaudan took place in the mid-1970s, with a 'multiflavor' product using the hydrolysis of a yoghurt base.

Up until 2000, Givaudan was able to use Roche's old fermentation plants in Grenzach. Givaudan, like many other Swiss companies, was also in negotiations with BASF as well as Hoechst in Frankfurt for contract fermentation. In the mid-1990s. Givaudan took over parts of the plants in Kemptal from Nestlé. As of today, Givaudan uses biotechnology principles, and it has strengthened its biotechnology arsenal with a number of acquisitions.

**Lonza** opened a biotechnology research and development group in Visp in 1983, focused on biocatalysis to support chemistry. With the fall of the Iron Curtain, Lonza acquired a manufacturing plant in Kouřim, about 30 km east of Prague. Today Lonza is the largest custom manufacturer, offering its service for microbial, mammalian manufacturing, mRNA vaccines, cell technology, and it pioneered the large scale production of antibody drug conjugates (ADCs). The former Lonza specialty ingredients business spin-off, rebranded as Arxada in 2021, also took over the large microbial production facility in the Czech Republic, including Lonza's biochemicals business.

**Novartis** was the result of two major mergers. The first one, also known as 'Elefantenhochzeit' (elephant wedding), merged Ciba with Geigy in 1970,[5] creating a global company with 70,000 employees. This was one of the first of many mergers in the pharmaceutical industry. An interesting fact is that Geigy was founded in 1758 as a business dealing in extracts. This makes it the first pharmaceutical company in Switzerland; one which later diversified into the silk business and dyestuffs.

The foundation of Ciba (Chemical Industry Basel) took place in 1804, and Ciba was the largest chemical company in Switzerland at the beginning of the 20th century. Ciba's diversification into pharmaceutical products began with the antiseptic Vioform. In 1938, a pharmaceutical department was founded at Geigy. Even earlier, the three largest Swiss chemical companies - Ciba Ltd, Geigy SA and Sandoz Ltd – had already formed a cartel, Basel AG; a trust that existed from 1918 to 1951.

**Sandoz** acquired Biochemie GmbH in Kundl in 1963, with large fermentation capacities (up to 250 $m^3$ fermenters at the time) which were also used for contract production. In the 1960s and 1970s, Sandoz was one of the leading companies in the large-scale production (fermentation) of Bt toxins, produced in 100 $m^3$ fermenters (in California). In the 1980s, Sandoz became increasingly involved in the fermentation of cell culture products and invested in a facility for the production of pro-urokinase based on mammalian cells.

**Syngenta** was created in 2000 by the merger of the agricultural divisions of Novartis and Astra Zeneca (crop protection). Since 2020 Syngenta has been part of Sinochem's agricultural business. Both original companies (Ciba-Geigy and Sandoz) used genetic engineering in the plant seed division and were involved in the development of Bt-corn, that is genetically engineered to produce insecticidal proteins from the bacterium *Bacillus Thuringiensis* (Bt).

### 1.3 *A History of Profound Changes*

The history of Swiss companies is marked by continuous change and refocusing on novel manufacturing methods and products. The early steps in biotechnological manufacturing used what we categorize today as industrial biotechnology methods, while red biotechnology (recombinant microbial and mammalian cell technology in the health sector) principles dominate in present times.[6]

A good example of this transition is Lonza, which started in 1897 as a smokestack industry producing inorganic chemicals for nearby customers. In the early 1980s Lonza was a purely organic fine chemical manufacturer,[7] that mainly followed a 'what we sell we make' principle.

In the late 1970s Lonza pioneered customer manufacturing services for fine chemicals serving the pharmaceutical and agrochemical sectors. In 1983, the company started to investigate microbial tools for the synthesis of ever more complex and chiral molecules. Almost exactly ten years after implementing industrial biotechnology principles, Lonza acquired Celltech, a pioneer in mammalian cell culture. This added a red biotechnology activity to the existing industrial biotechnology basis for small molecule pharmaceuticals and intermediates.

Since 2000, Lonza has continued expanding its offering, adding for example mRNA drug substance manufacturing, and cell and gene therapy manufacturing to its portfolio. The divestment of Lonza's former Specialty Ingredients business marked another break with the past, as Lonza now focuses on its core CDMO (contract development and manufacturing organization) business structured into three business platforms: Integrated Biologics, Advanced Synthesis, Specialized Modalities.[8]

### 1.4 *Industrial Biotechnology Next*

How can we replicate the remarkable success of red biotechnology in the realm of industrial biotechnology, as this is a field where Swiss companies have thrived. The answer: by focusing on innovative, sustainable solutions, we can transform the production of materials, bioplastics, custom perfume scents, and small molecule pharmaceutical ingredients into an equally compelling success story.[9]

The industrial biotechnology sector has a variety of promising subsectors that can leverage the country's strength in innovation and sustainability. The biotechnological applications range from pharmaceutical to concrete and cement (see Table 1 for twelve examples of markets and applications).

## 2. Biomanufacturing in Switzerland Today

The conducive framework conditions in Switzerland attract significant investments in biotech production facilities, mostly in the pharmacological sector. Therapeutic monoclonal antibodies, biologicals, but also vaccines, cell and innovative gene therapies from Switzerland contribute to the global healthcare supply. The importance of biomanufacturing in Switzerland can be judged by the share of its products among total exports. In 2024, CHF 52.3 billion of Swiss exports (18.5%) came from immunological products that include therapeutic monoclonal antibodies and vaccines. Over the last 25 years, this sector has grown continuously and much faster than the other sectors (Fig. 1).

As illustrated in Fig. 2, a survey of biomanufacturing facilities in Switzerland reveals that there is a dispersed distribution of such facilities across the country, with notable concentrations observed in the Basel, Zurich, and western regions. A comprehensive overview of the companies involved, in addition to the geographical distribution of their manufacturing facilities and the diverse range of product classes, is provided in Table 2. Two notable biomanufacturing sites connected to Swiss companies are located just outside the Swiss territory, but in the immediate vicinity of the border: a fermentation plant for the production of vitamin B2 (riboflavin) in Grenzach, Germany, and a bioproduction facility for monoclonal antibodies for different therapeutic applications in Huningue, France.

In addition to the presence of globally leading Swiss companies such as Roche, Novartis and Lonza, there has been an increasing establishment of international companies in Switzer-

Table 1. Beyond traditional applications such as chemicals, materials, food or energy, industrial biotechnology holds exciting potential for unusual and ground-breaking applications going forward. Examples of markets, applications and solutions offered using industrial biotechnology principles are featured below.

| | |
|---|---|
| Fine chemicals and small molecule APIs (active pharmaceutical ingredients) | Overcome the limitations of the chemical toolbox for complex chiral pharmaceutical or agrochemical molecules. |
| 2D and 3D printing | Biocompatible polymers for regenerative medicine and other applications. |
| Flavor & Fragrance | Natural sources are at risk from climate change and overharvesting. The label "natural" requires biotech approaches. |
| Food & Feed | Cell-based meat and dairy products. |
| Cosmetics & Personal Care | The cosmetic industry must be attentive to sustainable sourcing and greenchemistry. |
| Polymer & Fashion Industry | Renewable fibers, cell-based and mycelial based leather, microbial dyes. |
| Surfactants & Lubricants | Wind turbines require about 1,000 liters of sustainable lubricating oils and around 200 kg of grease per year. |
| Commodity Chemicals | Acetone, butanol, ethanol (ABE) fermentation was developed in the UK during World War I. A great number of different chemicals can nowadays be produced by a fermentation process. |
| Fuels & Energy | 1st (starch), 2nd (lignocellulose) and 3rd generation (algae) biofuels. |
| Carbon Capture Utilization | Using over 3 billion year-old $CO_2$ fixation pathways of organisms like *Clostridium carboxidivorans* for the production of basic chemicals. |
| Mining | Highly selective microbial lanthanides (rare earth elements) binding proteins for mining and recycling. |
| Construction | Microbial conversion of $CO_2$ into calcium carbonate for construction materials without using the heat for classic brick production. |

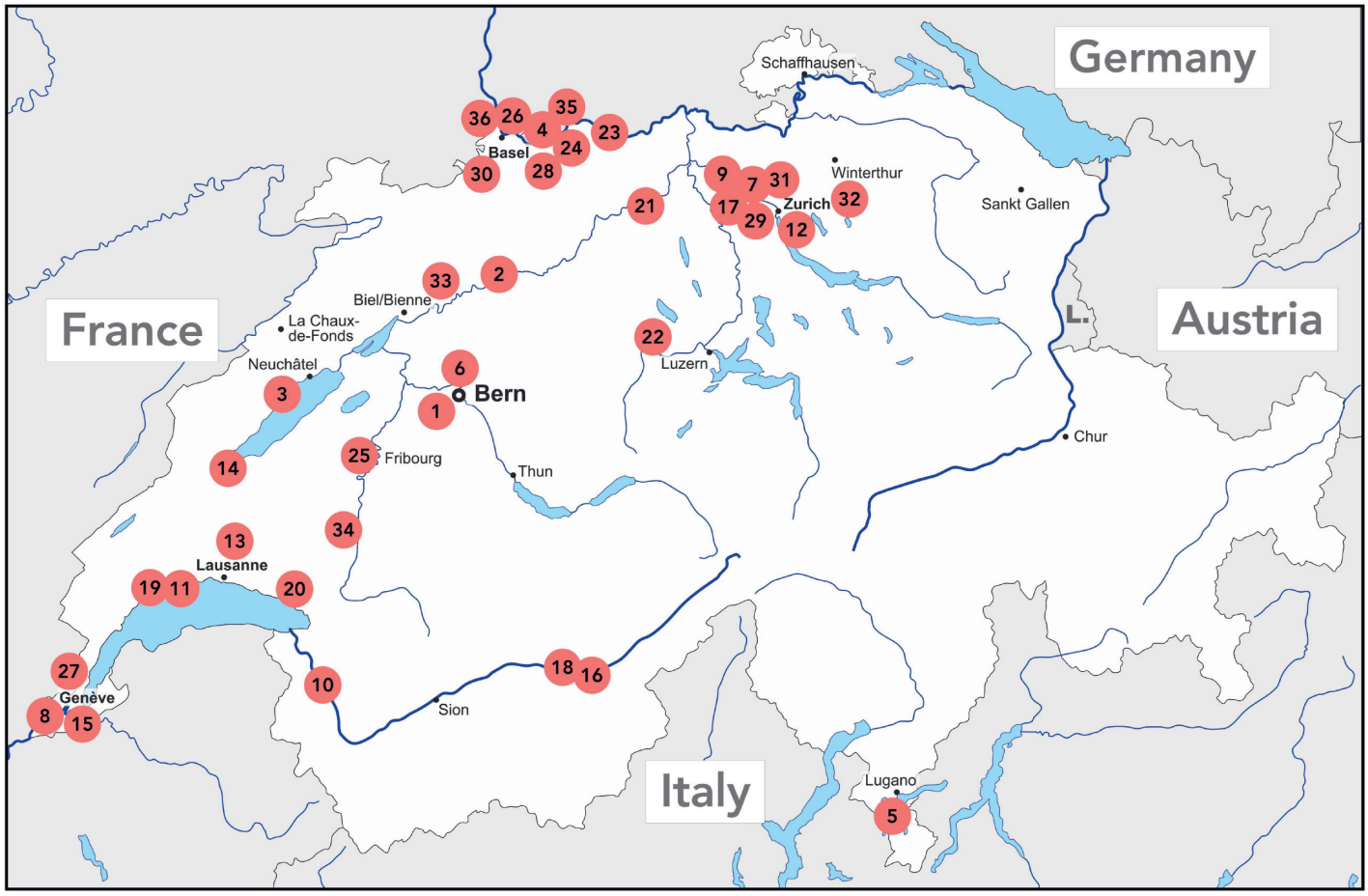


Fig. 2. Location of Swiss biomanufacturing sites. For details, see Table 2. Sites Nr. 35 (dsm-firmenich, Grenzach, Germany) and Nr. 36 (Novartis BioProduction Operations Huningue, F) are just outside the Swiss territory. Background map source: d-maps.com.

Table 2. Selected Swiss biomanufacturing sites. For locations refer to Fig. 2. Information from company websites and publicly available data.

| # | Company | Global Headquarters | Swiss Biomanu-facturing Location | Product/s |
|---|---|---|---|---|
| 1 | Bavarian Nordic Berna GmbH | Hellerup (DK) | Thörishaus | Vaccines |
| 2 | Biogen International GmbH | Cambridge (USA) | Luterbach | Biologics, antibodies |
| 3 | Bristol-Myers Squibb | Princeton (USA) | Boudry | Biologics |
| 4 | Celonic AG | Basel (CH) | Basel | Biologics (pilot scale) |
| 5 | Cerbios | Lugano (CH) | Barbengo-Lugano | Biologics, probiotics, living microorganisms |
| 6 | CSL Behring | King of Prussia (USA) | Bern | Biologics, immunoglobulins |
| 7 | Siegfried DINAMIQS AG | Zofingen (CH) | Schlieren | Viral vectors for cell and gene therapies |
| 8 | dsm-firmenich | Kaiseraugst (CH) / Maastricht (NL) | Geneva | Flavor/fragrance compounds (pilot plant) |
| 9 | Evitria | Zurich (CH) | Zurich | Antibodies |
| 10 | ExcellGene | Monthey (CH) | Monthey | Biologics |
| 11 | Ferring | St-Prex (CH) | Saint-Prex | Biologics |
| 12 | Givaudan | Vernier (CH) | Dübendorf | Flavor/fragrance compounds |
| 13 | Ichnos Glenmark Innovation | New York City (USA) | Epalinges | Biologics (research center) |
| 14 | Incyte | Wilmington, DE / Morges | Yverdon-les-Bains | Biologics |
| 15 | KBI Biopharma | Durham, NC (USA) | Geneva | Cell lines |
| 16 | Kodiak Sciences | Palo Alto (USA) | Visp | Ophthalmological bioconjugates |
| 17 | LimmaTech | Schlieren (CH) | Schlieren | Vaccines |
| 18 | LONZA | Basel (CH) | Visp | Biologics, vaccines, antibodies |
| 19 | Merck | Darmstadt (D) | Aubonne | Biologics |
| 20 | " | " | Corsier-sur-Vevey | Biologics |
| 21 | Mibelle Biochemistry | Buchs (CH) | Buchs | Personal care ingredients |
| 22 | MSD | Rahway (USA) | Schachen | Biologics |
| 23 | Novartis | Basel (CH) | Basel | Biologics |
| 24 | " | " | Schweizerhalle | Therapeutic RNA Oligos |
| 25 | " | " | Stein | Cell- and gene therapeuticals |
| 26 | " | " | Freiburg | Gene therapies |
| 27 | Om Pharma | Meyrin (CH) | Meyrin | Bacterial lysates |
| 28 | Roche | Basel (CH) | Basel | Monoclonal antibodies, antibody- drug conjugates |
| 29 | " | Basel (CH) | Schlieren | GlycoMAb / engineered antibodies |
| 30 | T3 Pharmaceuticals | Allschwil (CH) | Allschwil | Modified bacteria targeting cancer |
| 31 | Takeda | Tokyo (JP) | Neuchâtel | Biologics |
| 32 | The Cultured Hub | Kempthal (CH) | Kempthal | Sustainable food proteins |
| 33 | Thermo Fisher Scientific | Waltham MA (USA) | Lengnau | Biologics |
| 34 | UCB Farchim S.A. | Brussels (BE) | Bulle | Biologics |
| Production sites in the immediate vicinity of Switzerland | | | | |
| 35 | dsm-firmenich | Kaiseraugst (CH) / Maastricht (NL) | Grenzach (DE) | Vitamin |
| 36 | Novartis BioProduction | Basel (CH) | Huningue (FR) | Biologics |

land with facilities dedicated to biotechnological production, thus positioning the country as a prominent global biomanufacturing hub. Conversely, numerous Swiss-headquartered companies have opted to establish biomanufacturing plants in foreign countries, with the aim of contributing to the establishment of a global supply network.

For instance, Arxada (headquartered in Basel) operates a versatile CDMO biomanufacturing site for specialty chemicals in Kouřim, Czech Republic, while Sandoz (also headquartered in Basel) runs a large-scale antibiotic production plant in Kundl, Austria.

Some Swiss companies co-locate biomanufacturing facilities with existing biorefineries abroad for complex, highly integrated production processes. For instance, dsm-firmenich produces low-calorie sweetening compounds at a fermentation plant in Blair, Nebraska (USA) in its joint venture Avansya with Cargill, and at the same location, in the joint venture Veramaris with Evonik, valuable omega-3 fatty acids are produced by fermentation with microalgae. Givaudan produces active cosmetics ingredients as a key player in the large, multi-company Bazancourt-Pomacle biorefinery in France. Besides forming an important global biomanufacturing hub, Swiss companies also drive biomanufacturing developments globally and contribute to the continuous expansion of biotechnology applications for industrial production.

## 3. Outlook

### 3.1 *Switzerland is a Strong, Globally Connected Biomanufacturing Hub*

Switzerland has been selected as a preferred biomanufacturing location by multi-national pharma companies (such as Novartis, Roche, J&J, Biogen, CSL, MSD, Merck Group, UCB, Takeda), as well as global CDMOs. Both businesses benefit from the stable political framework, public safety and high work ethics, a reliable infrastructure and availability of essential utilities. On top of this there is the diverse and knowledgeable talent pool in one of the leading, global R&D innovation hubs. The close proximity of all stakeholders facilitates collaborations and know how transfer.

Manufacturing sites can recruit talent from academic institutions as well as a wide range of industrial life sciences companies. These talent pools have established strong international networks and are already engaging in international collaboration. Thus, they are not only valuable in providing specialist's know-how but also supporting international exchange of best practices and the ability to support global supply chains, storage, and distribution of the manufactured products.[10]

Most of the output from the manufacturing units of global CDMOs and multinational corporations is destined for export. 'Swiss made' is a quality label that is important across many industries. Partners all over the world count on Swiss R&D partners and manufacturers to provide reliable, high-quality results in a timely fashion and within the agreed budget. Typically, biomanufacturing in Switzerland focuses on complex active ingredients, such as peptides, oligonucleotides, darpins, a wide variety of antibodies or antibody drug conjugates and increasingly cell and gene therapy products (ATMPs[11]).

Over the past 30 years, the life sciences sector has steadily grown. And since 2013, its contribution to Swiss exports is the largest of all industry sectors, exceeding an annual value of 100 billion CHF. During this period, the life sciences sector has not only become more important but the percentage contribution of biomanufacturing products has also increased disproportionately, given a global trend whereby an increasing share of all newly approved drugs rely on biomanufacturing synthesis processes.[12,13]

Biotechnology process steps can be combined with chemical synthesis to shorten the synthesis process, to make it more energy efficient or to use fewer or replace non-renewable natural resources. In the vast majority of cases, biomanufacturing is still dedicated to application in medicinal products, but increasingly, biotechnology applications also play an important role in the industrial processes of food manufacturing, crop optimization, environmental protection, and the efficient use of natural resources. The research collaboration between Novartis and Syngenta for late-stage enzymatic halogenation is an example,[14] and demonstrates how shared know-how and manufacturing processes can generate benefits across industries. Similarly active ingredients can be beneficial for different applications across a range of industries or therapeutic applications.

### 3.2 *Building International Alliances with Global, Robust and Reliable Manufacturing Networks and Supply Chain Redundancy*

The Swiss manufacturing sites have all developed broad international networks to support their supply chains, R&D collaborations, or their distribution networks. Together with the leading universities, hospitals, research centers and a vast network of biotech and pharma companies, Switzerland has built one of the densest life sciences hubs in the world.

Global distributors, financial institutions as well as quality assurance companies, such as SGS, complement the life sciences hub and enable Switzerland to be a strong partner for other countries to further develop their healthcare systems and to jointly establish reliable and redundant supply chains.

Many organizations have built subsidiaries and manufacturing plants around the globe and thereby have also established diverse and resilient networks of suppliers and business partners. These networks can be valuable tools in times when the world is seeking to learn from the experience made during the COVID pandemic. The dependence on single supply chains proved to be tricky because such supply chains have either not been robust enough or subject to political power play.[15]

Many countries have thus decided to 're-shore' manufacturing capabilities and to invest significant amounts of taxpayer funds to build manufacturing capacities and independent supply chains. While this might be an option for large countries/unions such as the US or the EU, smaller countries like Switzerland do depend on international collaboration and alliances to establish reliable and robust supply chains and to ensure also geopolitical independence. Naturally, it is in the interest of Switzerland to offer its strong R&D, manufacturing and distribution capacity and know-how to partners that are interested in such collaboration and alliance formation.

Switzerland is known as a 'bridge-builder' and has a strong track record in facilitating international collaboration. At the same time, Switzerland has always relied heavily on free markets rather than engaging in industrial policy. Consequently, Switzerland is not engaging in taxpayer-funded capacity building or trying to establish its own supply chains. For a small country this is, in any case, not a reasonable option.

The recently established Access Consortium in the collaboration of the regulatory agencies of the UK, Canada, Australia, Singapore, and Switzerland demonstrates how a close collaboration of like-minded countries can lead to a harmonized and accelerated process that benefits both the countries engaged in this alliance as well as other countries that can benefit from such a joint approval process. Similarly, alliances can be formed to establish reliable and robust supply chains that can benefit those countries that engage in such alliances and beyond.[16]

### 3.3 *Experience and Networks in the Red Biotech Sector (Medicinal Biotechnology Applications) can be Expanded into Industrial Biotech Applications*

'Red biotech' - also known as medical biotechnology - encompasses the areas of biotechnology that deals with the development

of therapeutic and diagnostic procedures. The benefit of biotechnology in the development of novel therapeutic options has been demonstrated across many disease indications and patient groups, and in recent years an increasing proportion of new drugs have been developed with the support of biotechnology, or the drugs are the direct product of a biotechnology manufacturing process.

Beyond this, other biotechnology applications are playing an increasingly important and valuable role. Such applications can be summarized as 'industrial biotechnology' applications. These applications range across various industries and enable us to optimize resource consumption, energy efficiency, and chemical manufacturing processes, and they also play an increasing role in environmental protection/regeneration. Such industrial biotech applications often help solve the fundamental challenges mankind faces as energy and resource consumption grows in line with the expansion of the world's population and its changing life styles.[17]

Switzerland is well equipped to make a major contribution to innovation in industrial biotech applications and recently joined the European Biosolution Coalition.[18] With its leading role in red biotech, Swiss innovators are focusing on developing solutions for global challenges and not for their home market alone. Many of the strengths of the Swiss biotech hub (such as leading universities, strong research centers, manufacturing specialists, as well as innovative start-ups and SMEs) can again be beneficial when developing industrial biotech applications.

As with red biotech, it is highly likely that the various players that form the innovation hub in Switzerland - academic institutions, startups, SMEs, and multinational corporations - will play an important role in the development of industrial biotech applications. Some challenges or product developments might be just too risky or costly to be driven by a small organization. However, as in the life sciences sector, large corporations often rely on smaller organizations to take the first steps.

From an innovation in an academic institution or a startup, the first steps of the product development and de-risking of a new application can be financed by venture capitalists. Some of these ventures will fail and others prevail. But the innovation hub in Switzerland has developed the ability to support the foundation of startups and to ensure that such startups operate professionally from the start and benefit from the experience of global investors and seasoned industry leaders.

Whether such innovation, developed by startups and SMEs, will be licensed, or sold to larger multi-national corporate partners is open and will often depend on the nature and size of the challenge that is being addressed. In some cases, the SMEs will be able to finance the expansion and global sales force step by step by themselves. In other cases, it will be smart or even mandatory to take advantage of the distribution power and sales force larger multinational companies have already established.

### 3.4 *Continued Role as the Innovation Hub is Expanded to Other High Value, High Quality Sectors*

The continued investment of Switzerland in the STEM (science, technology, engineering, and mathematics) sector - in the vocational training and leading universities and hospitals - is a key prerequisite for Switzerland to retain its position as a global innovation hub. Equally, Switzerland needs to preserve its optimized framework conditions to continue to be an attractive workplace and provide the quality of life that also attracts talent from all over the world.

Forward-looking indicators support the assumption that Switzerland remains well positioned to be a strong partner for all those countries that are interested in global collaboration and alliance formation. These indicators include a robust flow of new biotech companies; funding provided by international investors; a high number of world-class patents filed (most of which are established in international collaboration[19]) and the solid investment in manufacturing infrastructure.

The World Intellectual Property Organization (WIPO) has put Switzerland atop of the Global Innovation Index for the 14th consecutive year.[20] But this is no reason to become complacent. Rather, this is an encouragement to work harder and to engage in collaborations all around the world. The innovation power and the success of innovative industries has not been built on products that were produced for Switzerland but rather on the ability of Swiss institutions to be innovative and to contribute to the development of solutions that address global challenges. The fact is that the broader the application and the bigger the challenge that an innovative solution helps to address, the more valuable and impactful the contribution will be.

Received: February 21, 2025

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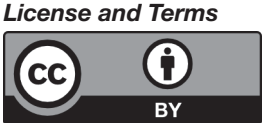

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