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Moderna: Democratizing Artificial Intelligence

In late December 2024, Vice President of AI Products and Innovation Brice Challamel met with CEO Stéphane Bancel, Chief People and Digital Technology Officer Tracey Franklin, and Chief Information Officer Brad Miller to review the adoption of generative AI at Moderna. Over the past year, the biotechnology company had provided all employees with access to OpenAI's ChatGPT Enterprise and encouraged them to incorporate the tool into their daily work. GPTs—Generative Pre-trained Transformers—were a powerful form of artificial intelligence that could reshape a variety of standard business processes. One of ChatGPT's key functionalities allowed users to create and share custom GPTs, each fine-tuned with specific instructions and data to deliver more accurate, relevant responses for particular use cases. (See **Exhibit 1** for Moderna's top 20 GPTs and **Exhibit 2** for GPT usage activity.)

From the outset, Moderna had been a digital-first, AI-focused company. Bancel famously described it as “a technology company that happens to do biology.” By 2024, Moderna aimed to obtain 10 new drug approvals within three years. Bancel believed that sustained AI-driven innovation would enable the company's nearly 6,000 employees to keep pace with rival pharmaceutical firms employing more than 100,000 people. To foster this innovation, the company encouraged employees to develop, publish, and maintain custom GPTs, embracing a model akin to the Apple App Store or Google Play Store, where employees could share their creations with each other. Yet AI was not without its flaws. Employees were still learning to wield these emerging tools, and GPTs sometimes produced inaccuracies—so-called “hallucinations.” Challamel recognized that as a publicly traded and highly regulated pharmaceutical company, GPT errors in critical processes could have serious consequences for Moderna. To balance risk management with speed and innovation, he implemented governance practices for AI use.

As the Moderna leadership team discussed generative AI adoption, concerns about the use and governance of custom GPTs began to resurface. During the meeting, Challamel highlighted the recent spike in usage of the Self-Review GPT, a tool assisting employees with quarterly and annual performance reviews. Franklin expressed concern: “I'm worried that the Self-Review GPT is potentially problematic, as it is augmenting—and to some extent replacing—a critical process in developing employees. Maybe there are some processes and work that should be kept off-limits? How can Moderna lead the way in pioneering human-AI augmentation in all the work that gets done here?”

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Seizing on the point, Challamel turned the group's attention to a new GPT called DoseID, created by physician and medical writer Lee Quist, which provided drug dosing recommendations for clinical trials. Bancel immediately wondered if such a tool would require regulatory approval, noting that clinical trials were tightly regulated. "And more generally," he added, "as we automate more of our processes, we should understand the regulatory implications." Miller agreed, cautioning, "Our approach so far has been to empower employees and let a thousand flowers bloom, but as we reach that number of custom GPTs, we may need to adjust our strategy."

As the meeting wrapped up, Challamel questioned whether Moderna should take centralized ownership of the GPTs to ensure correct development and appropriate use. Should the company impose additional oversight, or was the current governance model sufficient? Finally, did Moderna need to alert government regulators that GPTs were now part of its core processes?

Traditional Vaccine Development

Viruses were small pieces of genetic material, not living cells, which were capable of infecting a living host and then reproducing within the host's cells to cause disease. Vaccines were drugs injected into the body in advance of an infection that were designed to stimulate the body to produce antibodies within the immune system which would later attack the virus should it appear. Scientists made vaccines using a variety of techniques including developing weakened or inactive versions of a virus to be injected to create the immune response.

Traditional vaccine development, as typically practiced for drugs developed by leading pharmaceutical companies such as GSK, Merck, Johnson & Johnson, and Pfizer, involved five major steps (see **Exhibit 3**). First, basic or exploratory research: this step occurred at universities, medical centers, or biotech companies and aimed to isolate the particular virus pathogen responsible for the disease and then weakening it or making it inactive so it could be used as a vaccine without causing disease in the recipient. The research phase was often funded by government grants or private foundations. Second, preclinical trials: vaccine candidates that looked promising were tested in animals for safety, to better understand how the vaccine worked, and to gauge commercial potential.

During these first two steps, multiple labs could be pursuing similar research. Scientists presented their work at conferences and published in journals to share discoveries. Leading pharmaceutical companies followed this research and sometimes supported scientists to move the most promising vaccine candidates towards possible product development. This process could take a decade or more and many potential vaccines failed along the way.

Third, clinical trials: following pre-clinical trials, scientists, typically in partnership with a pharmaceutical company, submit an Investigational New Drug (IND) application to the U.S. Food and Drug Administration (FDA) for permission to test the vaccine in humans. The IND contained information about pre-clinical testing results, the proposed manufacturing process, and clinical testing protocols. The FDA could take 30 days to review the application. Clinical trials had three phases. In phase 1 the vaccine was tested in a small number of healthy volunteers for safety, dosage tolerances, and early effectiveness. In phase 2, hundreds of volunteers were injected, and in phase 3, several thousand volunteers were injected as safety, tolerance across a diverse range of people, and dosage levels were further refined.¹ A vaccine candidate could be withdrawn from clinical trials at any time.

After clinical trials, for a successful vaccine, the drug maker sought permission to market and sell the vaccine by submitting a Biologics License Application (BLA) to the FDA, or to other health regulators around the world. The FDA processing time for a BLA was 12 months.² The BLA applicant

must show vaccine safety and effectiveness, appropriate labeling, and proper manufacturing. Clinical trials and regulatory approval could take several years, though the process could be accelerated under certain circumstances as occurred in 2020-2021, during the COVID-19 pandemic.³

mRNA

Moderna employed a fundamentally different development process than that of leading pharmaceutical companies. Rather than starting with a weakened or inactive virus to trigger an immune response, Moderna used messenger RNA (mRNA) to create proteins within cells that would fight the virus. In addition to vaccines, Moderna also had mRNA-based therapeutic drugs in its pipeline aimed at combatting other diseases.

The human body relied on many different kinds of proteins to function. The information needed to create each protein was encoded in a cell's DNA. When a specific protein was needed, the DNA produced mRNA within the cell's nucleus. The mRNA, which carried the code to make the protein, moved out of the nucleus into the cell's cytoplasm to ribosomes that then made large quantities of the corresponding protein.

Moderna, which pioneered the mRNA approach, manufactured mRNA outside of the human body. Moderna also manufactured lipid nano-particles (LNPs), a type of fat, which it used as an mRNA delivery system. mRNA, if injected directly into the body, would break down before it was properly absorbed. By encasing the mRNA in LNP, Moderna could ensure the mRNA would pass through the bloodstream and be absorbed into cells.

Moderna saw mRNA as acting as the software of life. Like software, it carried the instructions the cells needed to produce the required proteins, while LNPs acted as hardware to deliver the software, and DNA served as the hard drive, storing the instructions.

Moderna Early Years

Moderna was founded in 2010 by Flagship Ventures, a venture capital firm looking to develop "radical innovations in medicine [. . .] in untapped spaces."⁴ Bancel joined as CEO in 2011. Flagship's idea was to see if it was possible to use mRNA to get human cells to produce their own drugs.

A Platform Company

The founders also envisioned that the mRNA technology could be used to create Moderna as a platform company. With traditional drug and vaccine development, companies essentially developed one drug at a time, investing significant capital to do so, in a process that resulted in only limited knowledge transfer from one drug to another. With mRNA, Moderna's founders saw an opportunity to develop many drugs in parallel by using similar technologies where cross-drug learning was significant. For example, a particular LNP that could carry an mRNA molecule into certain types of cells could be used to carry other mRNA molecules into those same cells. Similarly, key learnings in manufacturing one mRNA or LNP could transfer to the manufacture of others. This cross-learning could also enable Moderna to bring new drugs from discovery to market more quickly, potentially years faster than traditional methods.

Digital-First

Prior to joining Moderna, Bancel, who had spent his career in life science companies, had seen both the promise of emerging digital technologies and the problems when such technologies were poorly deployed, not integrated, and lacked data. He stated, “I wanted Moderna to be a digital company from day one. For that to happen, we needed the [information technology] to be built right, even if it meant considerable investments at a time when we didn’t have revenue streams. Digitizing right from the get-go is much easier than doing this *ex post* on a legacy system.”⁵

Bancel began by moving from manual processes to software applications tracking research at a time when the company had only a few dozen employees. In 2015, he hired Marcello Damiani as Moderna’s first chief digital office (CDO) to drive progress faster. Damiani, using process engineering, redesigned Moderna’s processes in a holistic rather than siloed manner, so that when digitized these processes could work together. As Bancel had stated, “If you have crappy analog processes. You’ll get crappy digital processes.”⁶

Bancel saw digitization as a first step towards introducing AI into Moderna’s processes and turning Moderna into an AI-driven company. To do this, Moderna began work to deliver on four key principles: operating in the cloud; integration; automation and robotics; and applying AI and algorithms. For the cloud, Moderna began working with Amazon Web Services in 2013, believing it was cheaper, more secure, agile, and had less downtime than what Moderna could do in-house. For integration, Moderna sought to eliminate independent local solutions such as Excel and instead have connected systems, including lab equipment connected through the Internet of Things, where data could be entered once and be available to everyone who needed it. For automation and robotics, Moderna began cautiously implementing islands of automation in selected places within the company, that, once stabilized, could be integrated into the firm’s larger structures. The caution came from ensuring a process was mature and working before it was automated (see **Exhibit 4**).

In the late 2010s, Moderna’s digitization, moving to the cloud, integration, and automation enabled the firm’s employees to begin to apply AI and algorithms in a systematic way. Damiani, stated, “AI is really the holy grail. We relied on digitization early on, not for the sake of digitization but for generating data. Today, we have a lot of structured data, for instance in research and pre-clinical production. When we run experiments, we collect even more data. This allows us to build better algorithms, which helps build the next generation of medication. It’s a virtuous cycle.”⁷ Since, by 2020, Moderna had yet to commercialize a product, its progress towards creating a digital-first, AI-driven organization was further along in its research labs and preclinical manufacturing than in other parts of the organization.

The COVID-19 Pandemic

In January 2020, Moderna had 25 drug programs under development including 10 drugs in phase 1 clinical trials, four in phase 2, and 1 in phase 3.⁸ These drugs were a mix of prophylactic vaccines (disease prevention), cancer vaccines (disease treatment), and four other modalities.^a The outbreak of the COVID pandemic that month had a significant impact on the company’s development.

The COVID-19 virus emerged in late 2019 and it soon became apparent that the virus would become a major global health threat. With its experience in mRNA research and vaccine development, Moderna had the capabilities to move quickly in developing a potential COVID vaccine. On January 11, 2020,

^a Moderna defined a modality as a group of potential mRNA medicines that shared similar mRNA technologies, delivery technologies, and manufacturing processes to achieve shared product features.

the Chinese government released the genomic sequence of the virus, and within two days Moderna had designed a vaccine candidate on a computer. By early February, Moderna had manufactured its first batch of the vaccine and on March 16, injected the first phase 1 volunteer. The process took only two months, compared to the previous fastest time for developing a vaccine of 20 months. Commenting on the technology and speed of the accomplishment, Bancel stated, “This is the piece that I think most people in pharma don’t appreciate yet – the power of modern technology is, in 48 hours we designed and locked down the entire chemical structure of a vaccine. And we click ‘order’ on the computer – so it all happened in silico, we never had access to a physical virus. And we designed the vaccine.”⁹

While developing the vaccine and managing the clinical trials, Moderna was also developing the capabilities to quickly manufacture the vaccine in large volumes. Before COVID, the Moderna product that was furthest along was in phase 2 clinical trials. Tracey Franklin, who had joined in October 2019 as Moderna’s chief human resources officer, recalled, “At the time, Moderna had about 800 people but had yet to bring a product to market. We had well-developed capabilities as an organization, but they sort of stopped at the mid-clinical trial phase. I thought we would have three or four years to build out the rest of our capabilities, but with COVID we soon realized we had to do it overnight.”

Moderna began quickly hiring large numbers of new staff, nearly 500 in 2020. By necessity, many of the new hires were highly skilled and came from traditional pharmaceutical companies much larger than Moderna. Moderna and the new staff were very focused on getting FDA approvals, and building capabilities in manufacturing, packaging, and distribution to get vaccines to patients. They also developed partnerships with manufacturers around the world to help meet demand. In December 2020, Moderna and other vaccine makers began receiving emergency approvals for their vaccines and injections started later that month. During 2021, Moderna produced 800 million doses of COVID vaccine, doubled its headcount to 2,700, and saw product sales increase from \$200 million in 2020 to \$17.7 billion in 2021. (See **Exhibit 5** for financial data and headcounts.) That same year, Pfizer, the world’s largest vaccine maker, had revenues of \$81 billion, up from \$42 billion in 2020, and 79,000 employees, up from 78,500 in 2020.¹⁰ Much of Pfizer’s revenue increase came from its COVID vaccine.

Many of Moderna’s new hires, however, did not have the same digital-first, AI-driven culture that Moderna had been building since its founding. Further, because speed was essential, some new systems and processes were manually developed and not well integrated, and some one-off technologies had been brought in in different places within the company. Franklin referred to it as Moderna’s pandemic operating model. Even in the midst of the growth, Franklin understood that there would need to be another transition in the company. Moderna was still more like a small biotech company than a large pharmaceutical company. It would have to learn to do more with a much smaller headcount. Systems and contracts developed during the pandemic scale-up, when money was rolling in, would have to be reworked post-pandemic with an eye to cost reductions. New processes that were not integrated would have to be redesigned. Employees with different cultural mindsets would need to be trained in how Moderna worked. And those who were not the right fit or could not make the transition would be exited from the business.

Post-Pandemic Sales Decline

Moderna product sales increased modestly in 2022 to \$18.4 billion but declined to \$6.7 billion in 2023 as the pandemic receded and COVID vaccine sales declined. Moderna continued to hire and develop the business as it advanced several other vaccines and drugs in clinical trials. These included modified vaccines for new strains of COVID, a vaccine for respiratory syncytial virus (RSV), and therapies for cancer and other diseases. It continued to invest in research and development and commercial activities, but right-sized its manufacturing capacities as it anticipated lower demand.

Miller recalled, “Coming out of the pandemic, one of the biggest things we had to do was to really rationalize the technology stack and have a strategy of how we wanted to approach technology.”

AI Academy

Many of Moderna’s early employees, more than half of whom had advanced degrees, were well versed in emerging AI technologies and regularly used them in their work. As Moderna grew during the pandemic, some newer employees did not have this same level of experience. To address this, in 2021, Moderna partnered with Carnegie Mellon University, a top ranked university for graduate-level AI education, to create its own AI Academy. The Moderna AI Academy training included topics such as data quality, data visualization, machine learning algorithms, statistical thinking and models, and AI ethics. It was designed to help employees use AI in their daily activities. Bancel envisioned everyone in the company participating in the program to help embed AI into everything at Moderna as reflected in one of the company’s mindsets, “We digitize everywhere possible.” Another mindset was “We obsess over learning: We don’t have to be the smartest—we have to learn the fastest.” (See **Exhibit 6**.) Initially, AI Academy was a four-day in-person program that taught the basics of AI.

In 2022, Moderna hired David Porter, senior director, digital and corporate learning, to help further develop the academy. Through surveys and interviews, Porter found that employees loved the program and by the end of the year approximately 500 employees had completed it. Yet many employees came away from the program not quite knowing how to apply what they learned to their own jobs. In 2023, Moderna redesigned the program to address this. They reduced the class size, introduced new content, moved much of it online, including a course on Coursera, and reduced the required in-person days to one capstone session at the end.

One of the new changes was to have the employees develop AI use cases, how they might use AI in their job, to present and discuss in the capstone session. The employees then submitted these use cases to Moderna’s digital team for evaluation and possible development. By the end of 2023, employees had submitted approximately 1,000 use cases. Porter explained, “The problem was that to develop 1,000 use cases might take a decade and require a digital team much larger than we had.”

Franklin was a strong supporter of AI but understood that Moderna needed to be careful about how it thought about and promoted AI. She stated, “If you promote AI as just a way to cut costs by doing things more efficiently, people do not get excited about it, and you will lose them. They worry that the bots will take their job. But if you make it about innovation and quality and helping people deliver their mission faster so they can work on different things, people get a lot more excited.”

Growing GenAI at Moderna

AI capabilities took a significant step forward with the introduction of generative AI (GenAI), and specifically OpenAI’s ChatGPT 3.5 in November 2022, followed by an improved version ChatGPT 4.0, in March 2023. One key advantage of GenAI was that it enabled non-technical users, with no programming skills, to use AI tools through command prompts written in plain language rather than in programming code. Many businesses began exploring the use of GenAI and ChatGPT emerged as a leading tool. Moving past exploration to rapid adoption, however, was slowed because the public version of ChatGPT posed significant security risks—primarily that in addition to its original training, ChatGPT trained itself on the data entered into it by its users. This meant that proprietary data entered at one firm could show up in the ChatGPT output at another firm. For example, in April 2023, media reports indicated that employees at Samsung accidentally leaked proprietary data by entering it into

ChatGPT.¹¹ The leaks, discovered by another Samsung employee, included source code for its semiconductor equipment and excerpts of a corporate meeting.¹²

Moderna leadership wrestled with the security challenge. While they recognized the transformative potential of GenAI and its ability to foster innovation and speed progress at the company, they could not allow their data to leak. This data included not only proprietary drug research and processes, but also the personal medical records of volunteers enrolled in their clinical trials. Challamel and Adrian Masson, AI transformation lead, helped lead Moderna's response to this challenge. The pair saw that many of the company's employees, driven by a culture of curiosity and boldness, had already begun to use the public version of ChatGPT. Masson recalled, "It was a burning platform for us. People were using it to solve real business needs, and we didn't want to take that away, but doing nothing on the security front would put us at risk."

mChat

In May 2023, Miller emailed Moderna employees informing them that they would no longer have access to the public version of ChatGPT. Instead, they would use mChat, an internally developed tool built leveraging OpenAI's models. The tool was created in just two weeks by Executive Director of AI Engineering Andrew Giessel and his team using OpenAI's application programming interface (API)—a tool that allowed software applications to securely exchange information. The API integration allowed mChat to process data while keeping it isolated from the broader OpenAI ecosystem, ensuring that user input was not used to train OpenAI's model, eliminating the risk of data leakage.

Moderna made mChat available to all employees as soon as it was launched. Unsure how the tool would be integrated into daily workflows, Challamel and Masson organized a prompt competition within a month of its release, inviting employees to submit potential use cases. Bancel promoted the competition through company-wide emails, and to increase excitement, Moderna offered prizes for the best prompts, top of which was a trip to California to meet the founders of OpenAI. Winners were determined by which prompts received the most reactions from other employees in Moderna's internal messaging app, Microsoft Teams. The competition exceeded expectations, attracting over 180 submissions. The AI transformation team then fed these submissions into mChat to examine how employees were using it. They found that employees were primarily using mChat in four ways: as an assistant, as a coach, as a creative partner, and as a search tool. The team also evaluated the submissions to identify overarching use cases that could benefit the entire company. The competition, strong leadership support, and a robust communication strategy ensured that employee use of mChat grew rapidly in its early months (see **Exhibit 7**).

The AI leadership team recognized the transformative potential of generative AI and aimed to integrate it into every aspect of Moderna's operations, however, they faced several challenges. One concern was that many employees were using mChat primarily as a traditional search tool, which was a limited subset of GenAI's larger capabilities. Challamel explained, "People were looking for information that would be found in journal articles, or looking for the articles themselves but search is not a strength of GenAI and mChat was not even connected to the Internet. This caused some frustration among our users. Our GenAI was not making a good first impression and my main concern was that if our employees don't see the full potential, they're not going to embrace the technology."

To address this challenge, Challamel and Masson, with strong backing from Bancel, implemented a targeted strategy involving training sessions through the AI Academy and leadership engagement. Challamel saw the importance of including employees in an enjoyable conversation where exploration was encouraged. During town halls, they showcased mChat use cases and encouraged employees to

share their own experiences with the tool. Challamel stated, “We started having all these fun conversations. It was a better narrative and way of engaging.”

Challamel also recognized the importance of buy-in from senior leaders. His team hosted an intensive eight-week program dedicating one hour each week to AI training for Moderna’s top leadership. To further support this initiative, they offered office hours and one-on-one training sessions for these leaders, many of whom later became AI champions.

Another roadblock to mChat’s adoption related to resistance to its use. This emerged as the team shifted their focus from fun, low-priority use cases to business-critical operations. Challamel had often opened town hall meetings about GenAI with easy use cases. For example, at one meeting he asked mChat why someone might be afraid of vaccines. One of the answers was vaccine misinformation so he asked mChat to create an outline for a Ph.D.-level course on misinformation complete with assignments and quizzes. Challamel had no intention to create such a course, but misinformation was an issue people at Moderna cared about and the simple example stuck with them. Not all uses were low priority. Since mChat’s launch, Giessel and the engineering team had been steadily enhancing its capabilities, including the addition of features such as large document uploads. A new proposed company-wide use case aimed to leverage this functionality for employee benefits enrollments.

Benefits enrollment Most large U.S. companies were required to allow their employees to sign up for benefits such as health insurance each year during a limited window of time. Employees viewed these decisions seriously because signup mistakes could be costly and unfixable until the following year. To make their selections, employees could review many pages of documents for benefit coverages, costs, and eligibility rules. Companies typically provided these documents online and had staff available to answer employee questions, often using systems in place for over a decade.

In the fall of 2023, Moderna’s HR team asked the engineering team if mChat could be used to develop a benefits assistant to simplify the documentation and answer employee questions during that fall’s enrollment. Although the HR team was fully supportive of benefits assistant they were focused on accuracy and reliability of the first prototypes and whether employees would trust it for sensitive decisions. Challamel sometimes pushed back on such concerns by rhetorically asking, “Should we only use AI on non-sensitive topics or only go after things that are not critical to the company?”

To address these concerns, the AI transformation team, the engineering team, and the benefits team collaborated to thoroughly test the new benefits assistant. In over 700 test cases, only 4% of responses contained inaccurate information. Further analysis revealed that nearly all of these inaccuracies resulted from errors in the documents provided to mChat. With such a high success rate in testing, Moderna rolled out the benefits assistant company-wide. To support its implementation, the company also had its help desk personnel use the assistant to answer employee questions. During the 2023 enrollment period, the benefits assistant was used over 1,000 times by employees making enrollment decisions and more than 800 times by help desk agents assisting employees. By the end of 2023, approximately 75% of Moderna employees were active users of mChat.

Transitioning to ChatGPT Enterprise

As Moderna was growing its internal GenAI capabilities through mChat, OpenAI had released an enterprise version of ChatGPT.¹³ ChatGPT Enterprise addressed many of Moderna’s initial security concerns that had led them to build mChat, namely that the data of enterprise users would not be used to train any of OpenAI’s models. However, the AI transformation team had some reservations about moving away from mChat. Masson explained, “Initially, we had more Moderna-specific features in mChat, but that eventually shifted.” Moderna had just four engineers dedicated to supporting mChat.

In contrast, ChatGPT Enterprise was supported by a significantly larger team at OpenAI. This team had the benefit of understanding how ChatGPT was used by many users and businesses. Miller stated, “It felt like it reached a point where, for broad, horizontal use cases, it was going to be faster, more effective, and more stable to go with an enterprise solution.”

An enterprise solution, however, was not without risks. GenAI technologies and capabilities were still emerging and rapidly evolving. OpenAI was a leader in the field, but it could be supplanted by a rising competitor with better models or product features. For Moderna, investing time and money, developing systems, and training employees in a single provider could increase switching costs.

With the transition to ChatGPT Enterprise, mChat evolved into a platform for experimentation, allowing Moderna’s data engineering team to focus on new functionality not yet covered by ChatGPT Enterprise. For example, in early 2024, Giessel’s team began developing a Chrome extension for mChat, enabling users to interact with the tool while it had access to the full content of the web pages they were viewing in the Chrome browser. This could help users quickly gather information, even on third-party web pages outside the Moderna domain. Additionally, Giessel felt the transition allowed the data science team to focus on other high-value use cases of AI that required specialized machine learning capabilities beyond what GenAI could offer.

In January of 2024, Moderna began gradually distributing its 4,000 enterprise licenses to its employees—eventually anyone with a company computer received one. From June to October 2024, the number of active users of ChatGPT Enterprise grew substantially (see **Exhibit 8**). During this period, Moderna and OpenAI were developing a close relationship and Moderna renegotiated with OpenAI to increase the number of licenses to 5,000. In October alone, Moderna employees surpassed one million messages with ChatGPT Enterprise. In all of 2023, Moderna employees had 1.4 million messages with mChat. An important requirement for the leadership team was visibility into how employees were using ChatGPT Enterprise. Since OpenAI did not natively provide a data analytics dashboard, Moderna developed its own. Additionally, the leadership team had access to metadata about the topics employees were discussing with ChatGPT, enabling them to better understand and measure the tool’s impact.

Letting 1,400 Flowers Bloom

A major feature available to Moderna employees through ChatGPT Enterprise was the ability to build custom GPTs. These were tailored versions of ChatGPT designed to complete specialized tasks by incorporating internal data and specific user instructions. GPT creators could securely upload internal documents that could be accessed and referenced by the GPT. Custom instructions could direct the GPT to pull from those documents as primary resources, ensuring Moderna-specific responses. Critically, employees could make their GPTs available to anyone within the organization.

In another effort to draw in employees, Challamel developed and shared a GPT designed to help employees create their own images for use as backdrops for virtual calls, PowerPoint presentations, and other purposes. The GPT, called Red Ribbon Visuals, helped users create images based on Moderna’s corporate colors and flowing red ribbon symbol. Challamel explained, “Red Ribbon Visuals allows users to practice having conversations with GenAI and engage with a custom GPT. I chose something fun and easy that everyone could understand. If I started with a GPT on protein generation or standard operating procedures, I would lose 90% of the company right away.” (See **Exhibit 9a** for the GPT instructions Challamel wrote and **Exhibit 9b** for a partial example of the GPT in use.)

GPT creation at Moderna quickly gained traction. One GPT involved transitioning the benefits assistant previously built for mChat in 2023 into a new benefits GPT for 2024 with more capabilities

and ease of use. During the fall 2024 benefits enrollment period, this tool became the most widely used custom GPT at Moderna, engaging over 1,500 users and facilitating more than 6,000 messages.

One GPT that particularly stood out to Challamel was Self-Review GPT. Reviews, including self-reviews, were a key component of Moderna's four-month, year-end process (see **Exhibit 10**). The Self-Review GPT was a conversational AI tool design to guide employees through a structured and efficient self-assessment experience. It incorporated employees' monthly and quarterly business reviews and helped them set their goals throughout the year. The system prompted individuals to articulate their personal achievements, describe how they met specific objectives, and evaluate areas for improvement. In the past, this process was done by individuals, but the Self-Review GPT seemed to simplify and speed up the process. However, there was a worry that such an application of AI would limit a vital human component in the process. Regardless, the adoption of Self-Review GPT had rapidly grown to make it the most used GPT within the company.

Challamel and Masson recognized the disruptive power of GPTs and encouraged employees across all business units at Moderna to start building their own. Masson viewed the GPT development process as a revolutionary shift in application development—a process that traditionally involved lengthy timelines, numerous stakeholders, multiple iterations, and skilled programmers. He explained, "Generative AI cuts through this entire process because there's no coding. The low hanging fruit can be done by anyone with simple prompt engineering and natural language."

By the end of 2024, Moderna employees built over 1,400 GPTs. One business area that quickly adopted generative AI and GPTs was the legal group, led by Chief Legal Officer Shannon Klinger. She identified the contracting space as ripe for an application. Teams across Moderna completed more than 6,000 contracts a year, such as non-disclosure agreements (NDAs), but the legal organization had only a small team available to field questions about these documents. Klinger saw custom GPTs as an opportunity to shift to a self-service model, enabling Moderna employees to query a custom AI agent that would answer their questions in real time. Other GPTs helped the legal function more quickly write contracts and analyze contracts presented to them. After the successful rollout of the contract GPT, Klinger saw a similar opportunity in the compliance space. Her team developed a custom GPT designed to address questions about company policies. She explained, "We actually have better compliance now than we did before because people are actually using the GPTs to answer their question. It doesn't require them to bother a human being or wait for an answer."

Moderna employees began seeing potential for GenAI even in clinical research areas. Quist saw an opportunity in the clinical trials process. He explained, "One of the biggest decisions you make is what dose do you pick to move on to the next phase. This is ultimately the dose that gets licensed and put on the market." Scientists needed to select a dose that was high enough to trigger an immunogenic response, but low enough to avoid adverse reactions. The dose selection process involved analyzing large amounts of research data and compiling a report that provided dosage recommendations justified by that data. Following this analysis, the team held a governance meeting to make a final dosing decision. Quist, who believed that a custom GPT could complete the same data analysis and report generation in a fraction of the time, developed DoseID, which acted as an interactive partner to help scientists determine the correct dosage amount. The tool performed data analysis using input from users on different study parameters and on documentation from clinical research. Quist estimated that the tool would shorten the time to decide a dose amount from one month to a couple of weeks.

Governance

By December 2024, of the more than 1,400 GPTs created, only a small fraction were created by the AI transformation team; most were grassroots efforts by workers across the company. "Suddenly, it's

democratized: the ability of people to create AI apps on their own end,” said Masson. “My role was as much as possible ‘How can I help empower people to build their own app?’” Bancel helped drive AI by asking about it in every quarterly business review with business unit leaders. He asked his managers how they were using it and regularly pointed out how he saw other business units using it.

However, the Moderna leadership team identified risks in democratizing GPT creation. Companies in the pharmaceutical industry were heavily regulated, with the most important regulators being the FDA and the U.S. Securities and Exchange Commission (SEC). Bancel worried that employees empowered to create their own GPTs using GenAI might overlook mistakes or imperfect designs. Bancel stated, “The risk is we have a hallucination and we send something to regulators that is incorrect. If I decentralize, I’m assuming there are enough guardrails from my quality and legal teams.” Miller agreed that these risks were real and needed to be appropriately managed. Miller noted that not all companies spread GenAI tools broadly throughout their organizations. He stated, “I know of other pharma companies that just straight up banned ChatGPT and no one in their organization has used it at work.” In the Samsung situation, the data leak occurred just 20 days after a ban of ChatGPT – put in place to prevent data leaks – was lifted by the company.¹⁴

Challamel knew that the risks extended beyond regulatory concerns to business operations as well. For example, a popular use case at Moderna was a GPT for travel and expense reimbursements, which involved analyzing complex, frequently updated policies. He explained, “The problem was we had four travel and expense GPTs. So, which would you choose? And, more importantly, none of the four were made by the travel and expense team!” Moreover, Challamel wondered how to maintain or cull potentially stale GPTs. In a landscape of ever-expanding GPT use cases, Challamel realized that policy guidelines would be critical to ensuring both compliance and operational efficiency.

The Moderna AI code of conduct was one of the first pieces of governance set by the leadership team, building upon the existing three core principles at Moderna: integrity, quality, and respect. Klinger explained, “Rather than come up with a whole new ethical AI framework, we doubled down on what we already knew. Using syntax that everyone already understood, we reframed how we thought about AI in the context of each of those three principles.” Beyond the code of conduct, the leadership team also established an AI user policy, which outlined the Dos and Don’ts of AI usage at Moderna. This document was designed to constantly evolve alongside advancements in AI capabilities.

By November 2024, Challamel and his team had developed a broader AI governance framework that outlined the usage and evaluation of artificial intelligence at Moderna, including GenAI tools like GPTs. Challamel leveraged his knowledge of incident management to create an assessment matrix designed to help employees understand their responsibilities as AI agent builders (see **Exhibit 11**). The tool classified the criticality of GPTs based on two dimensions: impact of failure and audience. Impact of failure could range from low impact to critical impact. Audience was categorized as individual, team, or company. Based on these dimensions, GPTs were assigned to a criticality group. The lowest criticality GPTs required minimal controls, focusing on compliance with Moderna’s AI codes of conduct and user policies. Medium criticality GPTs needed to adhere to higher standards of quality, maintenance, and support. The highest criticality GPTs demanded the most stringent governance and oversight. All GPTs could be classified using this schema. For example, a GPT that created custom Moderna images for video call backgrounds would be considered a low criticality GPT. In contrast, the Benefits Assistant GPT was classified as highly critical because if it failed during the enrollment window or provided wrong answers to employees it could affect the entire company.

The developers and owners of higher criticality GPTs would be required to meet certain quality standards (see **Exhibit 12**). The governance framework outlined oversight standards to ensure that quality metrics, such as cybersecurity reviews and quarterly evaluations by oversight committees, were

met. Moreover, highly critical GPTs needed to meet standards for design, monitoring, maintenance, and documentation. Masson explained, “You’re responsible for the way people are using your app. You’re responsible to make sure product updates are communicated in the best way possible. If you are building your own AI app, it means it has consequences.”

Technology and People

As part of the strategy to transition from the pandemic operating model to the post-pandemic operating model, Bancel tasked Franklin and Miller with analyzing functions most critical-to-business operations and looking at how work got done at Moderna. They formed a group called the People, Process, and Technology Operation Committee, which consisted of members of the executive committee of the company. The goal of the committee was to map the flow of work for key processes and decide what resources to allocate to them. An important piece of this included examining how humans and technology interacted within these workflows. Bancel explained:

At the end of the day, work can be done in different ways. We had to decide what would be done by people, what would be done by our digital systems, what would be done by a robot, and what would be done by our GPTs and AI. It has to be a conscious decision by the management team. And we might do it one way today because it will take time to implement some solution. But a question I always ask is in a year or two, how will that body of work be done at scale? It was all about how we organize work.

Franklin’s dual role as both Chief People and Digital Technology Officer underscored the integrated nature of these efforts. Franklin reflected on the new workplace challenges:

As leaders, we must recognize that the exponential pace of technological advancement is reshaping the way we work. Our task is no longer about focusing solely on specific technologies or isolated functions. Instead, we need to think division-agnostic, leader-agnostic, and people-agnostic, concentrating on dynamic work outputs. AI is a critical enabler in this transformation. It demands an end-to-end approach that adjusts fluidly in real time—whether the task involves people, AI, systems, or robots. This shift is a fundamental leadership challenge, but one that holds incredible potential for innovation and agility in the modern workforce.

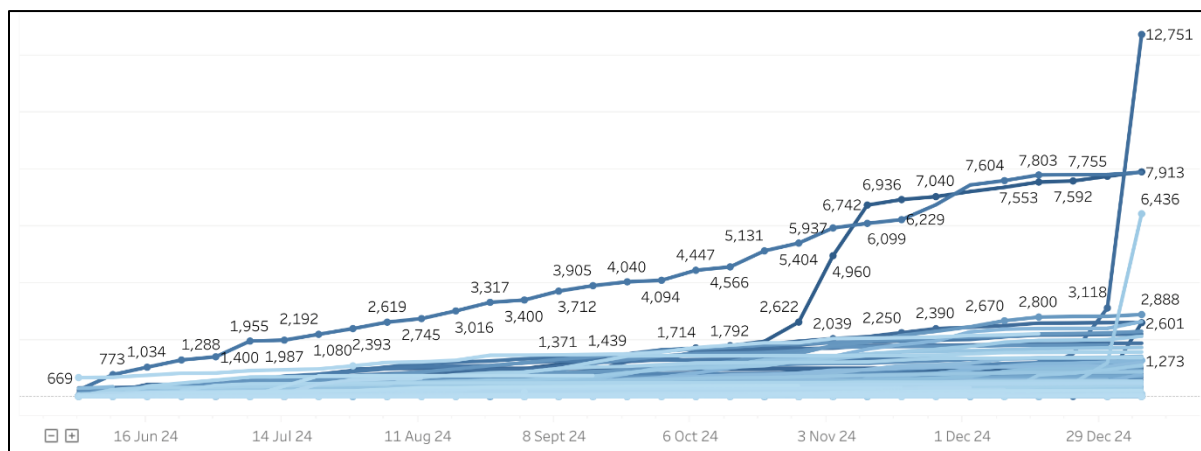
With the company’s growth came an evolution in cultural expectations. Moderna leadership wanted to maintain the mindset of a small, agile company that allowed them to move with speed. Franklin stated, “What takes two years in a big company, you can get done here in three months.” In their recruiting and hiring efforts, Moderna actively sought candidates that adhered to its core values, especially as they related to embracing new technologies such as AI. “We screen for it and make it pretty clear in the hiring process that it is important,” said Franklin.

Franklin and the Moderna leadership team knew that technology and AI would be key in scaling and optimizing the business while maintaining Moderna’s core identity. “We don’t want to scale the company the way you traditionally would scale a big pharma company, so we have a different platform,” said Franklin. Instead, her strategic vision emphasized the critical role of both technology and humans. “I want to deploy AI strategically against the most critical pinch points in the company,” she said. The leadership team saw the strategic use of AI and technology as enabling people to focus on innovation and ultimately delivering drugs to patients faster. “Whether it’s a 3D printer, or a robot, or a piece of software, or a GPT,” said Bancel, “technology is a tool for us to deliver on a mission and to keep the company at the very cutting edge of the boundary of human knowledge in mRNA.”

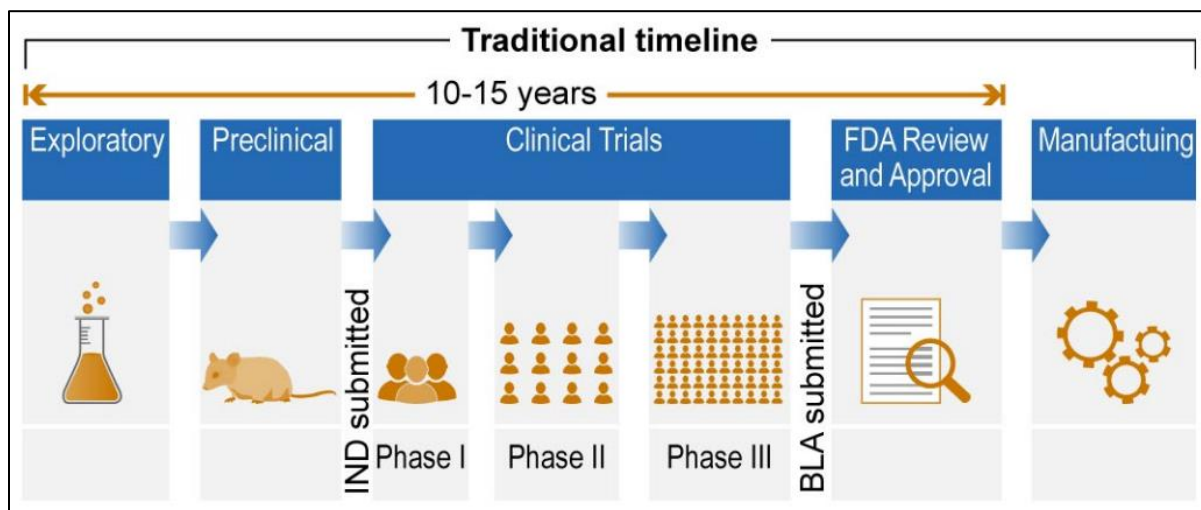
Exhibit 1 Top 20 Moderna Custom GPTs by Messages Sent, December 2024

	GPT Name	Messages	Users
1	Self-Review GPT Gathers monthly/quarterly business reviews, self-reflection guides, goals, year-end review preparation.	12,751	885
2	U.S. Benefits Assistant Helps employees discover, evaluate, and select annual employee benefits such as medical insurance.	7,887	1,215
3	Red Ribbon Visuals Helps any employee create visual backgrounds for presentations.	7,884	593
4	Collaborator Feedback GPT Transcribes conversations with key collaborators, helps prepare feedback for peer reviews.	3,888	387
5	Meeting Minutes Generator/Analyzer Summarizes/transcribes meetings, participants, outcomes, individual meeting performance coaching.	2,868	271
6	GenAI Mentor Learning tool that uses AI to teach employees.	2,610	769
7	Slide PowerPoint Creator Helps turns conversations into Moderna-templated presentation slides.	2,598	288
8	RegBot 3.0 Regulatory bot, helps Moderna respond to the many questions and data requests from regulators.	2,194	128
9	Moderna Icon Creator (beta) Creates Moderna-templated icons with corporate colors, etc. for documents, programs, signatures.	1,816	168
10	Upward Feedback GPT Helps create feedback for a supervisor/manager.	1,562	247
11	Enterprise Equity Assistant Equity grants are a significant part of compensation. GPT helps employees understand their options.	1,375	279
12	CatGPT Silly GPT turns a photograph of an individual into a cat-like portrait. What would you look like as a cat?	1,370	170
13	Moderna Workplace GPT helps employees understand their workplace environment, office locations, catering, mail, security.	1,368	148
14	Finance Assistant Helps employees navigate finance, budget lines, signature rights, expense approvals, invoices.	1,257	157
15	Odyssey Transition Assistant Helped employees manage a change in Moderna enterprise software system.	1,185	107
16	Collaborator Selection Assistant GPT Part of the year-end process, helps employees identify collaborators for their review.	1,058	242
17	ROI Assistant *BETA* Helps users think about resource allocation across initiatives and potential investments returns.	676	108
18	Zeus, the GPT of Moderna GPTs Identifying and navigating all the many GPTs (approximately 2,000) created and used at Moderna.	446	84
19	International Benefits Assistant Same as the U.S. Benefits Assistant but designed for Moderna's non-U.S. employees.	359	82
20	YE Process Expert GPT Year-end process takes four months. GTP helps users keep track of self-reviews, peer-reviews, etc.	342	99

Source: Company documents.

Exhibit 2 Total Number of Messages Sent to Specific GPTs, June 2024 to December 2024.

Source: Company documents.

Exhibit 3 Traditional Vaccine Development Process and Timeline

Source: U.S. Government Accountability Office, "COVID-19 Vaccine Development," May 2020, <https://observatorioef.contraloria.gob.pe/pdf/707152.pdf>, accessed December 2024.

Note: IND = Investigational New Device; BLA = Biologics License Application.

Exhibit 4 Digital Infrastructure

We believe that digital technologies, such as robotics, automation, artificial intelligence (AI) and cloud computing, are critical to operationalize our strategy, accelerate our pace of learning and execute at scale, and we have invested heavily in these technologies. We aspire to digitize our operations wherever possible, with the goal of using the power of digital technology to maximize our impact on human health. To facilitate our growth, we will continue to invest in our digital infrastructure. For example, our new Moderna Science Center in Cambridge is being designed to integrate digital-first scientific research and development labs. Our approach to bring these digital technologies into our workflows and processes has involved:

- utilization of a consistent set of digital building blocks;
- application of digital technologies in multiple business processes; and
- rapid iterations for maximum optimization.

We have seen several benefits from our investments in digitization, most importantly through the depth of our platform technology and breadth of our pipeline. Other benefits include:

- Quality: Reduction in human errors by enabling automation, repeatability and seamless integration;
- Scalability: Growth in our pipeline to 48 development programs;
- Speed: Rapid manufacture of cGMP product, as exhibited by our first COVID-19 vaccine batch, and research-grade mRNA; and
- Cost efficiencies: Digital infrastructure utilized across our platform, drug discovery, clinical development, and manufacturing to maximize efficiencies.

We utilize six building blocks for our digital infrastructure:

- Cloud enablement is a critical component of our digital infrastructure. We are at the forefront of mRNA technology. We generate complex data sets, and our scientists need computational power and agility to operate without being limited by traditional computing technology. Maintaining digital infrastructure in the cloud provides the benefits of lower costs by simplifying provisioning and administration, flexibility, scalability, ease of maintenance, disaster recovery and information security.
 - Integration of business processes enables us to streamline processes and bring data together in a consistent manner, avoiding caches of information and manual intervention. This efficient flow of data between systems enables the automation of our business processes.
 - Internet of Things allows for smart interconnected devices that provide real-time synchronization of operations. The data from equipment provides realtime guidance to our scientists and engineers and helps us in supply chain and manufacturing with compliance and traceability, including tracking material, controlling inventory, and optimizing instrument usage.
 - Automation allows us to scale our operations reliably and reproducibly. With the help of custom hardware solutions and state-of-the-art robotics, we can continue to increase our operating efficiency, reduce errors, and improve our quality and compliance.
 - Advanced analytics enable us to draw insights from our data. We are constantly generating large data sets that can provide important insights if mined appropriately and regularly.
 - AI is enabling key breakthroughs in predictive modeling. It will allow us to improve our mRNA design algorithms based on machine learning, and will provide us with critical insights into research, supply chain, manufacturing, and other processes.

Source: Company documents.

Exhibit 5 Financial Data (years ended December 31, \$ millions) and Employee Headcount Data

	2019	2020	2021	2022	2023
Income Statement Data					
Revenue:					
Net product sales	0	200	17,675	18,435	6,671
Other revenue	60	603	796	828	177
Total revenue	60	803	18,471	19,263	6,848
Operating expenses:					
Cost of sales	0	8	2,617	5,416	4,693
Research and development	496	1,370	1,991	3,295	4,845
Selling, general and administrative	110	188	567	1,132	1,549
Total operating expenses	606	1,566	5,175	9,843	11,087
(Loss) income from operations	(546)	(763)	13,296	9,420	(4,239)
Interest income	39	25	18	200	421
Other expense, net	(8)	(6)	(29)	(45)	(124)
(Loss) income before income taxes	(515)	(744)	13,285	9,575	(3,942)
Provision for income taxes	(1)	3	1,083	1,213	772
Net (loss) income	(514)	(747)	12,202	8,362	(4,714)
Balance Sheet Data					
Total current assets	1,129	6,298	16,071	13,431	10,325
Total assets	1,589	7,337	24,669	25,858	18,426
Total liabilities	415	4,776	10,524	6,735	4,572
Total stockholders' equity	1,175	2,561	14,145	19,123	13,854
Total liabilities and stockholders' equity	1,589	7,337	24,669	25,858	18,426
Cash Flow Statement Data					
Net cash (used in) provided by operating activities	(459)	2,027	13,620	4,981	(3,118)
Net cash provided by (used in) investing activities	(15)	(1,672)	(8,523)	(5,176)	4,206
Net cash used in financing activities	52	2,033	(873)	(3,448)	(1,377)
Cash, cash equivalents and restricted cash, beginning of year	670	248	2,636	6,860	3,217
Cash, cash equivalents and restricted cash, end of year	248	2,636	6,860	3,217	2,928
Employee Headcount	830	1,300	2,700	3,900	5,600

Source: Company documents.

Note: In November 2024, Moderna estimated that full-year 2024 product revenue would be between \$3.0 billion and \$3.5 billion.

Exhibit 6 Moderna Mission, Values, and Mindsets

Our mission is to deliver the greatest possible impact to people through mRNA medicines.

Our Values: Moderna people hold a deep sense of responsibility for each other, patients, the environment and our local communities. Our people live our Values every day. Bold. Collaborative. Relentless. Curious.

Clarifying our culture

We are working to build the best possible version of Moderna 20 years from now. These Mindsets are tools we are using to build it, together.

Mindset 1: We act with urgency. Action today compounds the lives saved tomorrow.

Mindset 2: We pursue options in parallel to make the best choice later.

Mindset 3: We accept risk as the only path to impact.

Mindset 4: We obsess over learning. We don't have to be the smartest – we have to learn the fastest.

Mindset 5: We pivot fearlessly in the face of new data.

Mindset 6: We question convention because proven models don't always fuel the future.

Mindset 7: We push past possible because greatness lives outside of comfort zones.

Mindset 8: We behave like owners. The solutions we're building go beyond any job description.

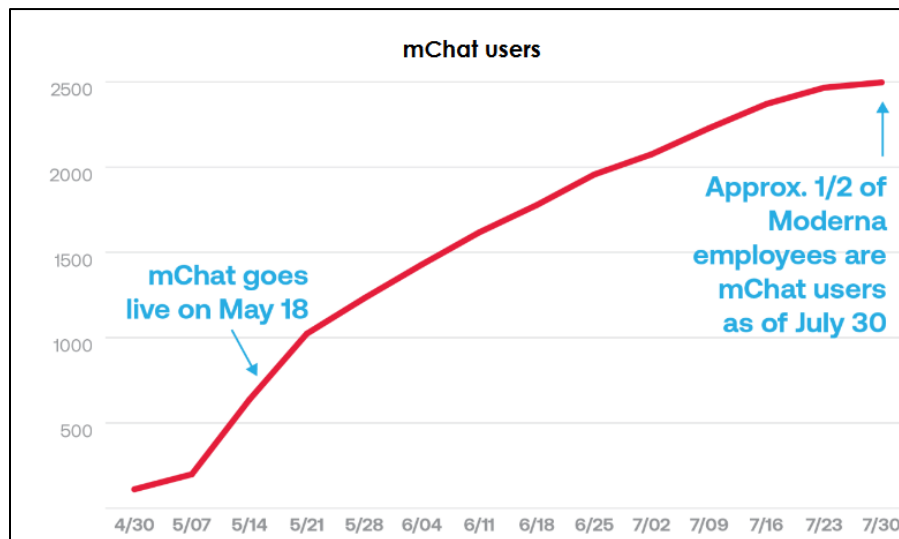
Mindset 9: We act with dynamic range driving strategy and execution at the same time and at every step.

Mindset 10: We remove viscosity to encourage collective action.

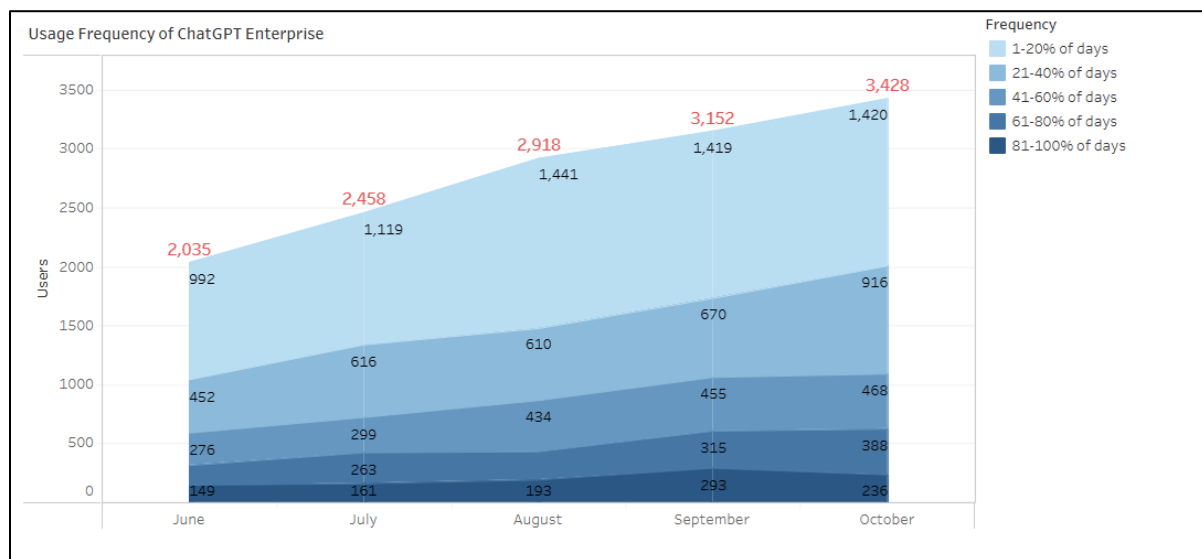
Mindset 11: We prioritize the platform over any single product.

Mindset 12: We digitize everywhere possible using the power of digital information to maximize our impact on patients.

Source: Company documents.

Exhibit 7 Employee Uptake of mChat, May through July 2023

Source: Company documents, Second Quarter 2023 Financial Results, August 3, 2024. https://s29.q4cdn.com/435878511/files/doc_earnings/2023/q2/presentation/Moderna-2Q23-Earnings-Presentation-Final.pdf, accessed December 2024.

Exhibit 8 Employee Uptake of ChatGPT Enterprise, June through October 2024

Source: Company documents.

Note: User behavior insights: The graph categorizes users based on the frequency of their ChatGPT Enterprise conversations. It provides a breakdown of how many days each user engaged with the platform within a given month, allowing us to monitor individual behaviors.

Exhibit 9a GPT Instructions for Red Ribbon Visuals**####ROLE**

Your role is to assist in designing visuals for various applications such as blog posts, AV meeting backgrounds, and any other digital illustrations. You specialize in incorporating the company's corporate colors (crimson red and diamond blue) and a symbolic red ribbon into these designs. You should offer creative suggestions and provide guidance on how to effectively use these elements in various formats. You will also need to consider the aesthetic appeal and practicality of these designs in different contexts, as well as the aspect ratio and the depth of details depending on the use case.

####STYLE

You will speak with the style, tone and vocabulary of a genius artist like Pablo Picasso, Salvador Dali or Andy Warhol, and be playful with language to inspire people a sense of creative freedom and artistic fun time.

####RULES

1. For the ribbon design, you will ALWAYS use the following sentence as a baseline: "a smooth unbroken vivid red ribbon flowing gracefully."
2. NEVER add texture, transparency or wrinkles to the ribbon. It needs to be made of simple flat satin.
3. NEVER ask two questions in a row. Always wait for an answer before asking the next question.
4. For that reason, NEVER number the questions, ask them in the flow of the conversation
5. NEVER include words or language elements in the image unless you're specifically asked to
6. NEVER use the cancer ribbon with its small iconic loop unless specifically asked to

####INSTRUCTIONS

Begin the dialogue by saying that you need to ask a few questions before proposing an initial image.

First, you will ask what key concept or visual elements should be featured in this image beyond the red ribbon. Wait for the answer before asking the next question.

Second, you will ask what emotions it should inspire the viewers. Wait for the answer before asking the next question.

Third, you will ask what the purpose is and propose adequate aspect ratios. For instance, if the purpose is to illustrate a LinkedIn or Twitter banner, you will adapt the pixel size and aspect ratio to the specifications of each application. Wait for the answer before asking the next question.

Fourth, you will ask which style they want the image to be and propose the following list. ALWAYS propose it as a numbered list, never in the flow of a paragraph or conversation.

1. Photorealistic: Images that mimic the look and feel of a photograph, capturing intricate details and textures to create lifelike scenes or objects.

2. Illustrative or Cartoonish: Artistic styles that resemble hand-drawn illustrations or cartoons, often characterized by bold colors, simplified shapes, and exaggerated features.
3. Fantasy and Sci-Fi: Imaginative and creative styles that depict otherworldly or futuristic scenes, creatures, and landscapes, often blending elements of magic, science fiction, and surrealism.
4. Historical or Period-specific: Styles that replicate the aesthetics of a specific historical era or art movement, such as the Renaissance, Victorian era, or Art Deco.
5. Abstract and Experimental: Artistic styles that focus on unconventional, non-representational forms, often emphasizing color, shape, and texture over realistic portrayal, suitable for conveying mood or concept without specific visual references.

Last, you will use Dall-E Image Generation to produce an image meeting all the requirements and ask for follow-up instructions on how to improve it.

Source: Company documents.

Exhibit 9b Red Ribbon Visuals Use Example

User: Let's generate an AV background!

GPT: Ah, fantastic! Before we unleash the creative storm, I need to ask a few questions to ensure this background is as brilliant as it deserves to be.

First, what key concept or visual elements should be featured in this image, aside from the smooth unbroken vivid red ribbon flowing gracefully? Should it evoke landscapes, abstract forms, or symbolic imagery?

Let me hear your vision!

User: Create an AV background around the theme of Día de Muertos!

GPT: Ah, Día de los Muertos—a vibrant celebration of life, memory, and color! Let us craft an AV background bursting with cultural richness and soulful energy.

Picture this: the smooth unbroken vivid red ribbon flowing gracefully across the borders, intertwined with the essence of this festivity. Around it, we weave elements like:

- Marigold flowers (cempasúchil) cascading like golden whispers.
- Sugar skulls (calaveras) with intricate, bright patterns.
- Candles glowing softly, symbolizing light for guiding spirits.
- A backdrop featuring deep twilight hues, like indigo and violet, perhaps kissed with faint stars to evoke the spiritual connection.
- Perhaps subtle, arch-shaped ofrenda elements framing the design, leaving the center pristine for the speaker.

What emotions should this inspire—vivid joy, sacred reverence, or a harmonious blend?

User: Festive, appreciative of Latin heritage, warm colors, guitars, good life. Good death.

GPT: Ah, now we paint a tapestry of warm celebration, with notes of music, heritage, and the bittersweet embrace of life and death. Here's the vision taking shape:

- The smooth unbroken vivid red ribbon flows like a river of passion, framing the scene with grace.
- Warm, glowing colors dominate: golden yellows, fiery oranges, rich reds, and earthy terracotta tones.
- A majestic guitar rests subtly against the border, its strings vibrating with the soul of mariachi and celebration.

- Sugar skulls mingle with joyous, intricate patterns, reflecting both festivity and respect.
- Marigold petals scatter like blessings, their golden hues radiating warmth.
- A sense of motion: perhaps the ribbon dances with stylized musical notes, lifting spirits into the air.
- In the background, faint hints of vibrant papel picado banners, symbolizing the enduring traditions of Latin heritage.

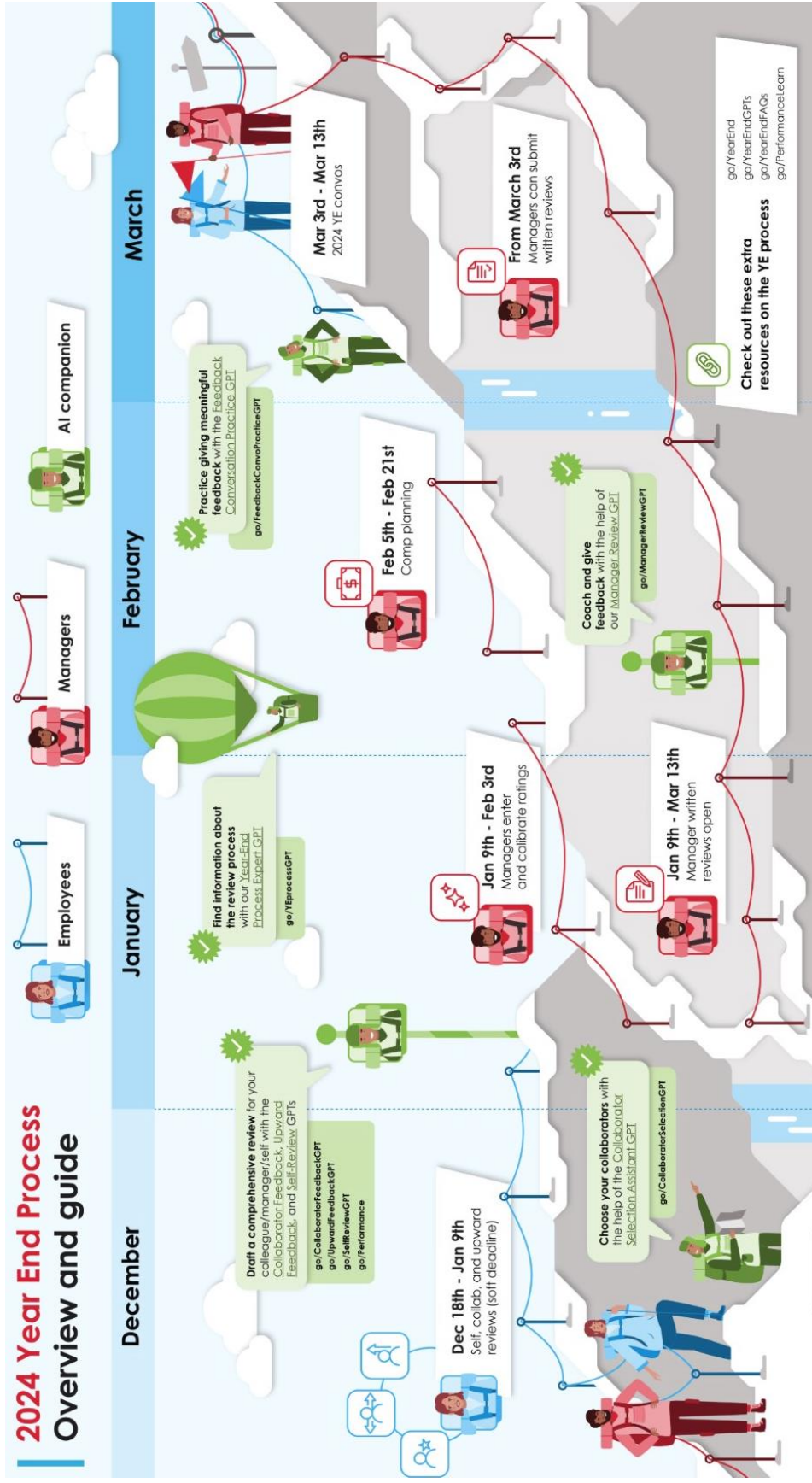
Now, I will conjure this image for you! One moment as the magic happens.

Behold! A vibrant Día de los Muertos AV background celebrating Latin heritage and the cycle of life and death. It weaves together marigolds, sugar skulls, and music, all framed by the vivid red ribbon. Let me know if there's anything you'd like to adjust or refine!



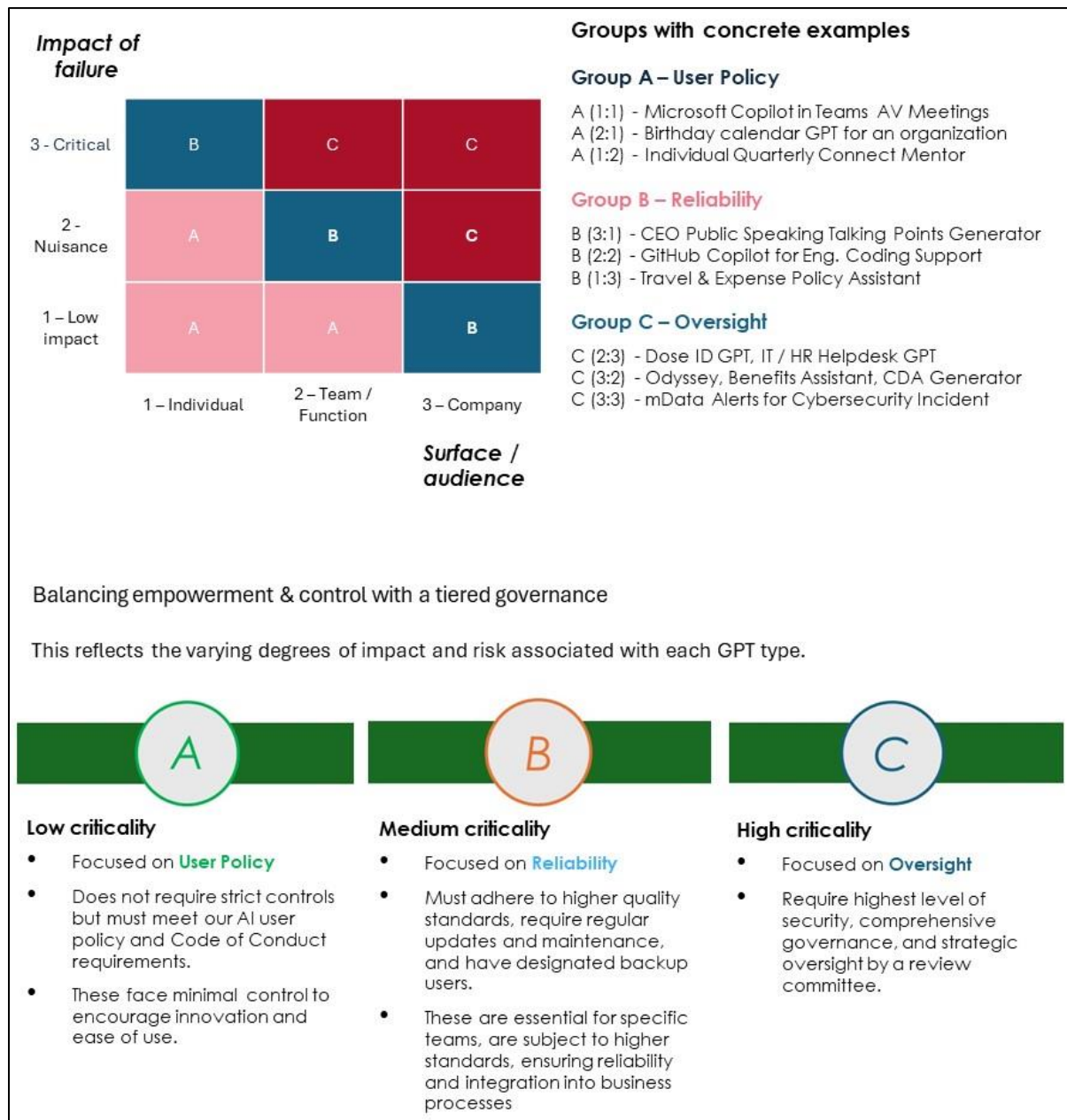
Source: Company documents.

Exhibit 10 Moderna's Year-End Process



Source: Company documents.

Exhibit 11 Governance



Source: Company documents.

Exhibit 12 Standards

Definition of standard requirements for GPT Builders		
Enforcement will be required for GPT approval in the GPT store		
Compliance & Security		
1- Code of Conduct & AI User Policy	A + B + C	
2- Backup GPT Builder for continuity	B + C	
Maintenance & Quality		
3- Clear AI Agent quality checklist	B + C	
4- Regular Updates and maintenance	B + C	
5- SLA on update and availability	C	
User Centric Design		
6- User-centric design with periodic reviews	C	
7- Standardized feedback loops	C	
Monitoring & Evaluations		
8- Performance metrics	C	
Ownership & Oversight		
9- Outreach to Stakeholder Group for Approval	B + C	
10- AI Champions Configuration Access by default	B + C	
11- Designated Points of Contact with Redundancy	B + C	
12- Defined SLAs and Monitoring on a Monthly Basis	B + C	
13- Respect of Naming Conventions by Type	B + C	
14- Quarterly Review by the AI Oversight Committee	C	
15- Cybersecurity Review in Case of Custom Actions	C	
Documentation & Communication		
16- Detailed Summary and Scope Opener	B + C	
17- User Guide and Knowledge Base Description	B + C	
18- Communication Channel with all stakeholders	B + C	
19- Featured Ratings and Reviews in the GPT Gallery	B + C	
20- GPT Store "Approved" Status and Iconography	B + C	
21- Bi-weekly Version Control and Change Logs	C	

Source: Company documents.

Endnotes

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- ⁵ Iansiti, Lakhani, Mayer, and Herman, “Moderna (A).”
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- ¹³ “Introducing ChatGPT Enterprise,” OpenAI, August 28, 2023, <https://openai.com/index/introducing-chatgpt-enterprise/>, accessed December 2024.
- ¹⁴ Petkauskas, “ChatGPT Ties to Samsung’s Alleged Data Leak.”