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AI in Pharma IT: Architecture, R&D, and Manufacturing

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Executive Summary

Artificial intelligence (AI) is fundamentally transforming pharmaceutical information technology (IT) – shifting from isolated “bolt-on” tools to embedded, enterprise-wide capabilities. Historically, pharma companies applied AI in narrow projects (e.g. specialized analytics or expert systems), but today AI is being re-architected into core data platforms, R&D pipelines, **manufacturing systems**, and supply-chain networks. Leading life sciences firms are rebuilding their IT architectures around AI, integrating machine learning (ML) pipelines, cloud data lakes, and digital twins to drive drug discovery, clinical trials, manufacturing, and commercialization. This report examines the profound ways AI is reshaping pharma IT—drawing on industry data, case studies, and expert analyses. Key findings include:

- **Drug Discovery & R&D:** Generative and predictive AI models (e.g. DeepMind’s AlphaFold) are accelerating target identification and molecule design ([moneyweek.com](#)) ([fortune.com](#)). Although clinical results have been limited so far, dozens of AI-driven drug candidates have entered trials after ~\$18–30 billion invested by 2024 ([fortune.com](#)). Companies like Insitro and Recursion are partnering with Big Pharma to analyze massive datasets and speed R&D ([apnews.com](#)) ([cloud.google.com](#)).
- **Clinical Trials & Development:** Formation Bio describes Muse as a tool intended to accelerate preparation of patient recruitment strategies and materials ([Formation Bio: Introducing Muse](#)). Recruitment-workflow goals are distinct from measured trial outcomes; administrative automation alone does not establish shorter patient treatment periods.
- **Manufacturing & Supply Chain:** AI-driven automation and analytics are integrated into production and logistics. “Smart factory” initiatives use predictive maintenance and computer vision for quality control, while digital twins of plants can support process optimization ([ondrugdelivery.com](#)) ([www.sciencedirect.com](#)). In the supply chain, ML-enhanced demand forecasting and real-time data

(from IoT sensors, sales channels, etc.) greatly improve [inventory management](#) ([www.sciencedirect.com](#)) ([www.sciencedirect.com](#)). For instance, AI analytics now ingest social media, IoT and weather data to adjust production plans on the fly ([www.sciencedirect.com](#)).

- **Data Infrastructure & MLOps:** Pharma companies are overhauling data architecture. Shared data lakes, cloud platforms and AI governance frameworks are replacing siloed applications. ModelOps/MLOps practices (integrated with DevOps and DataOps) are being established to manage AI lifecycles ([healthcarereimagined.net](#)). With robust data integration and quality controls, firms can train and deploy AI models at scale ([www.pharmalex.com](#)) ([www.pharmalex.com](#)). Notably, early adopters like Pfizer, AstraZeneca, and others have launched cloud-based AI labs and innovation hubs.
- **Business Strategy & Investment:** On 17 September 2025, GSK announced plans to invest \$30 billion in US R&D and supply-chain infrastructure over five years, including \$1.2 billion for advanced manufacturing facilities, AI and advanced digital technologies ([GSK investment announcement](#)). Nvidia CEO Jensen Huang predicts drug R&D will shift from “wet” laboratories to AI supercomputing platforms, citing Eli Lilly’s new AI-driven R&D supercomputer ([www.axios.com](#)). Furthermore, C-suite executives increasingly stress AI-led digital transformation: Takeda’s CEO calls for “harnessing big data and AI across the entire value chain” ([www.axios.com](#)).
- **Regulatory & Governance:** Regulators are moving to accommodate AI in pharma. In January 2025, the FDA released [draft guidance on AI](#) in drug submissions, acknowledging AI’s “transformative potential” while emphasizing safeguards ([www.fda.gov](#)) ([www.fda.gov](#)). As one FDA official noted, robust scientific and regulatory standards must accompany AI innovation ([www.fda.gov](#)). Kiteworks’ June 2025 cross-industry survey of 461 cybersecurity, IT, risk-management and compliance professionals reported that 17% of organizations had technical controls capable of preventing sensitive data from entering public AI tools ([Kiteworks survey](#)).

In sum, AI is no longer an experimental add-on but a driving force in pharma IT strategy. By integrating AI into core architectures – from R&D platforms to enterprise systems – pharmaceutical companies aim to shorten development cycles, reduce costs, and improve patient outcomes. This report provides a detailed analysis of this transformation, with extensive data, case examples, and expert perspectives on current progress and future directions in AI-driven pharma IT.

Introduction and Background

Pharmaceutical research and manufacturing have always been data-intensive and highly regulated. Historically, *pharma IT* focused on large enterprise systems (ERP, [LIMS](#), [ELN](#), CRM, etc.) with relatively siloed data. Early AI and analytics in pharma were likewise isolated experiments or point solutions (often added later as “bolt-on” modules to legacy systems). For example, by the mid-2010s, much of pharma’s AI use was in specialized tasks—predicting basic chemical properties or scanning medical images—rather than deeply ingrained in core processes.

Today, however, the landscape is changing dramatically. The emergence of powerful machine learning (ML) techniques, coupled with vast biological datasets (genomic, proteomic, clinical, imaging, etc.) and scalable cloud computing, means AI can touch virtually every part of the pharma value chain. Industry leaders now

speak of transforming their entire organizations into “digital biotech” companies powered by AI (www.axios.com). As one expert observed, the pharmaceutical sector “contains many numerical and categorical scientific or clinical measurement results” ripe for AI-driven discovery (www.pharmalex.com). But to leverage AI fully, companies must move beyond experimental tools to a **core architecture** where data and AI models flow seamlessly across functions (healthcarereimagined.net) (www.fda.gov).

This report examines how AI is reshaping pharma IT on multiple fronts. We begin with historical context and early AI initiatives in pharma, then explore current applications (in R&D, trials, manufacturing, supply chain, and commercial functions). We detail how data infrastructure and engineering practices (data lakes, MLOps/DevOps integration, cloud HPC) are being overhauled to support integrated AI. We incorporate data points and case studies illustrating AI's impact – both promises and pitfalls – including investment levels, trial efficiencies, and regulatory responses. Finally, we discuss strategic implications and future directions: how AI-driven “core” architecture will affect pharma's innovation process, competition, and patient care. Throughout, we anchor claims with recent research and industry sources (www.sciencedirect.com) (www.fda.gov) (www.pharmaceuticalonline.com).

Evolution of AI in Pharma: From Bolt-On to Core

The transformation from “bolt-on” AI features to core architecture can be understood as a shift from peripheral projects to enterprise-level integration. In the bolt-on era, pharmaceutical companies might use AI in an isolated manner – for instance, deploying a machine learning model to predict solubility of compounds, or an analytics tool to analyze patient data in one department. These were performed outside the core IT systems, often as standalone code or as add-ins. By contrast, **core architecture** integration means building data platforms, pipelines, and development practices that treat AI as a fundamental capability.

Several factors drove this shift. First, the sheer volume and variety of data in Pharma (e.g. high-throughput screening, omics, clinical imaging, and real-world data) reached a critical mass. Second, advances in cloud computing and high-performance computing made it feasible to train complex models on large datasets. Third, precedent-setting successes (and high-powered demonstration projects) showed AI's potential, prompting investment at the organizational level. For example, DeepMind's **AlphaFold2** achievement – predicting protein structure from sequence with high accuracy – captured imaginations in 2020. AlphaFold2 showed how AI could solve longstanding biological puzzles; its algorithms became widely used in drug target research (moneyweek.com). Similarly, companies like NVIDIA began partnering with pharma giants: at Davos 2026, NVIDIA's CEO announced that **Eli Lilly** was building an AI supercomputer for R&D scientists, planning “scientific AI agents” to design experiments (www.axios.com).

These initiatives required infrastructure changes. Instead of loading models ad-hoc, pharma companies now invest in **enterprise AI platforms** and MLOps pipelines. Industry analysts emphasize the need for Machine Learning Operations (MLOps) – the discipline of automating ML model development and deployment in sync with enterprise DevOps and DataOps (healthcarereimagined.net). As one AI executive noted, “enterprises have not established an operations management system... referred to ... as ModelOps... required to evolve AI models and data changes” (healthcarereimagined.net). In practice, this means establishing data governance, model versioning, monitoring and validation pipelines, and repeatable processes, rather than one-off model runs.

Pharma is also aligning its IT with broader digital transformation trends. After the COVID-19 pandemic spurred rapid innovation (e.g., biotech startups using *in silico* methods for vaccines), many companies resolved to upgrade core IT. Takeda's CEO observed that becoming a "digital biopharma" requires harnessing big data and AI across the *entire* value chain (www.axios.com). Bank of America's CEO (at the same forum) similarly warned legacy industries must "embrace AI and the changing digital world to remain competitive" (www.axios.com). In other words, AI in pharma is no longer a side project – it's part of corporate strategy, impacting IT architecture itself.

AI in Drug Discovery and R&D

Expanding the Discovery Toolbox

Artificial intelligence is deeply impacting pharmaceutical R&D, particularly in early-stage drug discovery. The field has long faced a huge time and cost challenge: it typically takes 10–15 years and billions of dollars to bring a new drug to market (cloud.google.com). AI promises to compress this timeline by analyzing large biological datasets and generating insights unreachable by traditional methods. Today's AI-driven discovery encompasses target identification, lead optimization, and even algorithmic molecule generation.

One clear example is **structure-based design**. Knowing a target protein's shape is critical for designing drugs that bind effectively. DeepMind's AlphaFold2 (2021) demonstrated AI's power by predicting protein 3D structures from amino acid sequences (moneyweek.com). The **Financial Times** and other sources noted this as a potential "turning point" because it addresses a fundamental bottleneck: structure determination (moneyweek.com). Pharma companies now routinely use AlphaFold predictions to narrow targets for *in vitro* testing, accelerating early R&D.

Beyond structure prediction, AI approaches also support target discovery. insitro is a machine learning-enabled drug discovery and development company. Its October 2024 announcement describes three agreements with Lilly to advance potential treatments for metabolic diseases based on targets identified using insitro's AI/ML platform ([insitro–Lilly announcement](#)). Fortune reported that about \$18 billion had been invested in ~200 "AI-first" biotech companies by mid-2023, producing ~75 clinical-stage AI-designed candidates by 2024 (fortune.com). This scale of investment reflects institutional belief in AI's transformative potential.

However, progress remains uneven. Despite heavy investment, many AI-driven drug candidates are still early in the pipeline; few have been approved yet (www.ft.com) (fortune.com). Similarly, a Fortune review noted that "moonshot hopes" for AI curing disease have met harsh realities: while AI can flag candidates, actual efficacy and safety still require lengthy trials (fortune.com) (fortune.com). Experts warn that limitations in biological understanding (e.g. incomplete knowledge of disease pathways) can constrain even the best algorithms (moneyweek.com) (fortune.com).

Nevertheless, the long-term picture is promising. Recent progress in **multi-omics integration** (combining genomics, proteomics, etc.) and **foundation models** is expanding AI's role. For example, Google Cloud (in partnership with pharma) launched AI suites for target identification and multi-omics analysis (cloud.google.com). These tools marry AI with cloud HPC infrastructure, enabling researchers (e.g. at Bayer,

Pfizer, Cerevel) to run sophisticated analyses previously impractical. The upshot: AI is becoming a crucial aid in hypothesis generation and narrowing experimental space, even if the final drug proof-of-concept still requires lab work ([apnews.com](#)) ([cloud.google.com](#)).

Data-Driven Target Discovery

A cornerstone of AI-led R&D is leveraging massive data sets to find new targets and biomarkers. Modern discovery processes generate huge volumes of data (high-throughput screening, cheminformatics libraries, real-world clinical data, etc.), making manual analysis impractical. ML excels at detecting patterns in this complexity. For instance, AstraZeneca's data science team reports AI "helping us turn science into medicine more quickly" by being "applied throughout the discovery and development process, from target identification to clinical trials" ([moneyweek.com](#)). They and peers use tools like convolutional networks on biological data to predict compound efficacy, toxicity, or patient subgroup responses, aiming to improve the high failure rates in R&D.

Moreover, advances in **machine learning methodology**—such as graph neural networks for chemical graphs, transformer models for sequential biological data, and reinforcement learning for molecular optimization—are increasingly tailored for pharma. Academic reviews note that *deep generative models* can propose novel molecules with desired properties ([www.sciencedirect.com](#)) ([fortune.com](#)) (see Section on Future Directions). Each year, more research papers demonstrate generative AI finding molecules that experimental chemists then validate. The integration of these models into core drug pipelines (instead of one-off experiments) is accelerating, aided by improvements in computational architecture (cloud & GPU clusters).

Use-Case Illustration: Drug target prediction. A team might feed genomic and proteomic datasets into a deep learning model to predict which proteins drive a particular cancer. AI can highlight candidates that survive filter processes to labs weeks earlier than by traditional screening. For example, if an AI model identifies a novel kinase involved in oncology, chemists can start designing inhibitors immediately. Reports suggest that such AI-led target hunts are already routine at some pharma R&D centers ([cloud.google.com](#)) ([moneyweek.com](#)), shortening the usual grunt-work of manual database searches and initial assays.

AI in Clinical Trials and Development

Improving Trial Efficiency

Once a drug candidate exists, clinical trials remain costly and time-consuming. Formation Bio describes Muse as a tool intended to accelerate preparation of patient recruitment strategies and materials ([Formation Bio: Introducing Muse](#)). This is a stated workflow goal, rather than a measured reduction in total trial cost or patient treatment duration.

For architecture planning, distinguish recruitment preparation, trial conduct and analysis, and evaluate each workflow against its intended use.

Do not extrapolate administrative efficiency to treatment duration or trial success rates without supporting study data.

Patient Selection and Real-World Data

AI also enables better use of **real-world evidence (RWE)** in trials. By mining health records and wearable/device data, ML models can identify additional safety signals or stratify populations more precisely. Pharma IT systems are integrating AI modules that continuously scan de-identified patient data (within privacy rules) to find potential trial recruits who match complex inclusion criteria. For instance, if a trial requires patients with rare genetic markers, an AI can sift through genomic databases to find candidates. These technologies have often been added as standalone tools, but increasingly pharma companies are embedding RWE analytics into their trial management platforms. Combined with 'bring-your-own-device' telemedicine, AI-supported trials can minimize onsite visits and support decentralized models.

Case Example: Formation Bio describes Muse as a tool intended to accelerate preparation of patient recruitment strategies and materials ([Formation Bio: Introducing Muse](#)). The cited announcement describes recruitment-preparation goals rather than measured trial cost, duration or staffing results.

AI in Manufacturing and Operations

Smart Manufacturing (Industry 4.0)

Pharmaceutical manufacturing traditionally relies on strict process controls. AI and automation now form the backbone of “smart factories” in pharma. Machine learning algorithms monitor equipment and process data (temperature, flow rates, sensor outputs) to predict and prevent deviations. For example, computer vision systems inspect tablets or vials on the production line to identify defects far faster than human inspection. Predictive maintenance uses IoT sensors and ML to schedule equipment servicing before failures occur, minimizing costly downtime.

These AI functions are increasingly integrated into the core manufacturing execution systems (MES) and manufacturing execution tools. Rather than adding a separate AI inspection camera, companies embed ML routines into the control software that runs the plants. One industry report notes that using AI in biomanufacturing improves yields and reduces waste via anomaly detection (www.sciencedirect.com). In fact, digital twins of plants – virtual models linked to real-time sensor data – are now in use. Gerresheimer, a medical packaging firm, pioneered embedding digital twins to track quality and ensure traceability (each package's twin contains its history and real-time condition) (ondrugdelivery.com) (ondrugdelivery.com). The company reports that digital twins bring “quality improvements throughout the supply chain and easy access to certifications at various stages” (ondrugdelivery.com). This highlights how AI-driven digital models have moved from R&D planning to shop-floor execution, enabling immediate response to production anomalies.

Example – Digital Twin & Blockchain: A 2023 white paper on pharma supply chains describes how integrating AI with blockchain ledgers enhances operations. AI “allows simulation of manufacturing processes, identifying potential issues before they occur,” while blockchain tracks product lots securely (www.sciencedirect.com). These technologies are no longer in pilot labs only: some pharmaceutical companies are deploying integrated AI-based monitoring in their manufacturing pipelines to meet regulatory requirements and sustainability goals.

Quality Control and Compliance

Quality control (QC) is another area where AI transforms pharma IT architecture. Traditional QC often involves manual lab tests for each batch; AI is being embedded into laboratory information management systems (LIMS) to prioritize tests. For instance, an ML model could flag batches that likely meet spec, reducing re-tests. Spectroscopy and sensor data from inline monitoring can be analyzed by AI to predict final quality outcomes, allowing early intervention. These AI tools are integrated into core QA workflows. FDA's nonbinding data-integrity guidance states that production and control records, including audit trails, must be reviewed and approved by the quality unit ([FDA data-integrity guidance](#)). Automation should support that review and oversight.

Crucially, adopted AI in QC must comply with regulatory data integrity rules (21 CFR Part 11, etc.), so pharma IT departments are building validation workflows for AI models. Consider audit trails and model documentation within the intended-use validation and change-control process. Electronic records and audit trails can support CGMP requirements; the intended CGMP workflow must be checked through validation ([FDA data-integrity guidance](#)). Logging alone should not be presented as proof of compliance. This type of integration of AI into core quality systems (rather than separate R&D analysis) exemplifies the “architectural” shift.

AI in Supply Chain and Logistics

Predictive Analytics and Demand Forecasting

Pharmaceutical supply chains are notoriously volatile: demand can spike unexpectedly (as in pandemics or shortages), and product shelf-life/sensitivity adds complexity. AI-driven supply chain systems have moved from pilot projects into central planning functions. Traditional demand forecasting used statistical models on historical sales. Modern platforms, by contrast, apply machine learning on diverse inputs. AI systems now consume real-time sales data, physician prescription trends, social media sentiment, and even epidemiological forecasts via IoT – and continuously adjust predictions. An industry analysis describes how AI now “process[es] real-time data from various sources, such as social media, IoT devices, and weather forecasts, to deliver more precise predictions” of drug demand (www.sciencedirect.com). These AI-enabled forecasts are then fed into inventory management, logistics, and production planning systems, which coordinate globally to prevent stockouts or waste.

This integration is moving AI from a separate “planning department tool” to an embedded function. For example, some companies have built AI-driven supply chain control towers: centralized dashboards where ML models continuously optimize supplier orders and distribution schedules. As an illustrative architecture, a forecast could support proposed changes to production orders and inventory allocation for human review. According to one study, AI-based predictive analytics in pharma can markedly improve responsiveness and efficiency (www.sciencedirect.com). It notes that AI “advanc[es] demand forecasting, risk management, and operational resilience,” enabling managers to adapt to “evolving disease patterns, resource constraints, and supply chain disturbances” (www.sciencedirect.com).

Table 1: Selected AI Applications in Pharma

Application Area	Examples & Benefits	Notable Initiatives / References
Drug Discovery & R&D	Accelerated target ID, molecular design via deep learning; e.g. AlphaFold2 predicts protein structures (moneyweek.com); generative models suggest novel compounds (fortune.com).	DeepMind AlphaFold (protein structures) (moneyweek.com); insitro ML-based target discovery (Lilly agreements) (insitro–Lilly announcement).
Clinical Trials	Recruitment strategy and material preparation with AI.	Formation Bio describes Muse's recruitment-preparation goals (Formation Bio: Introducing Muse).
Manufacturing & Quality	Predictive maintenance, defect detection, and digital twins for production. AI inspection yields QC; digital twins improve traceability (ondrugdelivery.com).	Gerresheimer digital twin for package traceability, quality (ondrugdelivery.com); AI simulations identify production issues beforehand (www.sciencedirect.com).
Supply Chain & Logistics	Demand forecasting with ML (real-time data integration), dynamic inventory optimization, anti-counterfeiting (blockchain+AI).	AI-driven forecasting using IoT/social data (www.sciencedirect.com); pharma blockchain + AI traceability (www.sciencedirect.com).
Commercial Operations	Sales analytics, personalized marketing, dynamic pricing. E.g. MLOps-enabled real-time price optimization (insights.axtria.com).	Axtria's commercial MLOps (dynamic pricing, segmentation) (insights.axtria.com); AI analytics for KOL targeting (routine in CRM tools).

Table 1: Representative examples of how AI applications are evolving from standalone features into core functions across pharmaceutical R&D, manufacturing, and operations (sources cited).

Transparency and Traceability

Another core benefit is enhanced transparency: AI combined with traceability systems (like blockchain) helps ensure product integrity throughout the network. As one review notes, integrating AI with blockchain and digital twin can offer “significant optimization possibilities” for making supply chains more efficient, transparent and adaptable (www.sciencedirect.com). For example, an integrated system might automatically assign a digital identity to each drug batch and use AI monitoring to detect anomalies (e.g. unexpected temperature excursions in transit), with blockchain providing an immutable ledger of events (www.sciencedirect.com). Treat this as an illustrative architecture. AI alerts could support human assessment of shipment routing and product-quality concerns; retain appropriate approval and quality responsibilities for consequential actions.

Data, Cloud, and AI Infrastructure

Unified Data Architecture

At the heart of AI's integration is data architecture. Pharma organizations are investing heavily in consolidating their data silos into unified platforms — often cloud-based — to serve as the foundation for AI. A *PharmaLex* analysis emphasizes that “corporate data is one of the most valuable assets” and that unlocking it requires a coherent strategy (www.pharmalex.com). Leading companies are building enterprise data lakes where research data, clinical info, manufacturing logs, and sales figures coexist with standardization and quality controls (www.pharmalex.com). By making data “available and interoperable,” firms create the raw material for

AI innovation (www.pharmalex.com). For instance, a major Pharma might ingest millions of genomic records alongside drug assay data, then apply ML across the combined dataset to identify biomarkers of drug response.

The move to cloud platforms has accelerated this. Azure, AWS, and Google Cloud now offer specialized life sciences platforms: pre-configured environments with multi-modal data warehousing, compliance features, and AI tools. Examples include Google's Vertex AI for genomics or AWS HealthLake. These shared platforms not only host data, but also the AI models and pipelines, making AI a built-in service. Rather than pharma IT teams hosting on-prem HPC clusters themselves (which was common a decade ago), many now deploy workload on the cloud. A Google Health blog highlights customers like Pfizer and Bayer using cloud-based "Target and Lead Identification" AI suites (cloud.google.com) — indicating that drug companies are no longer running these tools in isolated labs, but on scalable cloud infrastructure that IT manages as core resources.

To illustrate this shift: consider how data integration used to be a patchwork of ETL jobs between applications. In the new paradigm, pharma firms implement API-driven ecosystems. For example, data from a patient registry might flow automatically into an R&D analytics platform, while manufacturing execution data streams into quality-control ML models in real time. PharmaLex similarly notes that emerging "agentic AI" and other tools will depend on high-quality, stewarded data from R&D processes (www.pharmalex.com). Companies are therefore embedding data governance mechanisms (metadata catalogs, automated data lineage) as core layers in their IT.

MLOps and ModelOps Integration

Key to making AI a core architecture element is adopting **ModelOps/MLOps** discipline. This means formalizing how models are built, tested, approved, and retrained. In practice, pharma IT departments are unifying ML development with existing DevOps practices. Tools like Kubernetes, MLflow, and DataRobot are being configured to operate alongside traditional ERP/CRM platforms.

Industry experts emphasize the importance of ModelOps. As one analysis notes, enterprises often lack an "operations management system" for AI, leading to low production throughput of AI models (healthcarereimagined.net). Modern pharma companies are resolving this by establishing centralized AI CoEs (centers of excellence) and standardized pipelines. For instance, a pharmaceutical enterprise might implement a CI/CD pipeline that automatically tests a new ML model on historical clinical data and, if validated, deploys it to production monitoring systems – all under change control. This end-to-end automation is a hallmark of "core" AI architecture: models are no longer one-off scripts run on a scientist's PC, but governed assets in the digital fabric.

MLOps architecture planning encompasses a managed model lifecycle with intended-use validation, audit trails and change control. FDA guidance discusses validation of intended CGMP workflows ([FDA data-integrity guidance](#)).

High-Performance and Cloud Computing

The compute backbone is also evolving. Drug discovery and AI models require massive computation. Traditionally, pharma firms ran calculations on in-house clusters. Today, the shift to elastic cloud HPC is pronounced. NVIDIA's highlight of Eli Lilly's supercomputer alliance (www.axios.com) exemplifies this: they are

architecting an AI-first supercomputer to serve as Lilly's core research "lab." Similarly, Google Cloud's introduction of specialized AI product suites (cloud.google.com) implies that life science HPC use is moving into cloud-based managed services.

This change affects IT architecture: instead of fixed server rooms, pharma IT is investing in secure cloud environments (often hybrid to satisfy data residency/GxP needs). HHS states that its Office for Civil Rights does not endorse, certify or recommend specific technology or products ([HHS cloud guidance](#)). Assess cloud configurations against the applicable requirements rather than assuming inherent compliance. Within these, companies run containerized AI workloads that spin up on-demand and use specialized AI accelerators (GPUs/TPUs). Developers allocate these resources via self-service portals, similarly to how software development teams request compute for other enterprise apps. In essence, high-performance compute itself is becoming a core part of pharma's architecture, managed by IT rather than by discrete research groups.

AI in Commercial and Marketing Operations

Beyond R&D and manufacturing, AI is penetrating pharma's commercial functions. Sales and marketing have traditionally relied on statistical forecasting and manual analysis of physician networks. Now, AI and ML are embedded in CRM and analytics platforms. For example, predictive models identify which doctors are most likely to prescribe a new drug, enabling personalized engagement strategies. Natural language processing parses customer feedback and social media to guide marketing content. Real-time analytics adjust sales operations; an AI model might optimize stock allocations to sales reps based on territory performance.

One industry consultancy highlights **dynamic pricing** as an emerging AI use case: by continuously analyzing market conditions and competitor pricing, pharma companies can adjust prices in real time to maximize revenue (or improve access) ([insights.axtria.com](#)). This is facilitated by integrating pricing algorithms into the ERP/policy engines – again moving from one-off analytics to continuous, embedded operations. Axtria, a known pharma analytics firm, points out that MLOps platforms now enable this kind of agility ([insights.axtria.com](#)). For instance, Axtria describes MLOps-driven pricing algorithms that respond immediately to supply-demand shifts, as well as advanced CRM segmentation tools feeding into marketing automation.

AI is also being applied to regulatory intelligence and pharmacovigilance in the commercial domain. Text-mining systems continuously scan literature and social forums for adverse event signals, integrated into the company's safety database (a core IT system for compliance). Similarly, chatbots and virtual assistants – powered by large language models – are entering internal support roles (e.g. answering regulatory or medical information queries). These digital assistants are being woven into enterprise platforms, granting employees on-demand AI help.

Organizational Perspectives and Challenges

Big Pharma vs. Biotech Startups

The debate on who benefits most from AI has been prominent. Some argue AI favors small, agile biotech teams; others assert that incumbent large pharma will leverage AI best. A *MoneyWeek* article cites a Causeway Capital report, which posits that AI will "play into the hands of [big pharma's] largest incumbents,"

even as tech entrepreneurs speculate that future drugs could be built by small teams wielding AI ([moneyweek.com](#)). Indeed, big firms have resources to invest in cutting-edge IT (e.g. supercomputers, data platforms) and to integrate AI into existing processes. For instance, **AstraZeneca** and **Pfizer** have publicized multi-year AI strategies and cloud partnerships to build enterprise-wide capabilities ([moneyweek.com](#)) ([cloud.google.com](#)). In contrast, most small biotechs lack the infrastructure scale and thus often outsource or partner their AI work.

Nevertheless, the cost of AI tools is falling. Cloud-based models (LLMs as a service, etc) and open-source frameworks mean even smaller players can experiment cheaply. Several AI biotech startups have indeed emerged: Insitro (AI-driven biotech) and Recursion (AI-enabled drug discovery and development; [Recursion FAQ](#)) are prominent examples. These firms often spin out promising candidates or technologies that large pharma then licenses or acquires. Thus, the current landscape is mixed: big pharma leads integration, but startups contribute innovation. The table of industry initiatives above reflects how both sides are active.

Regulatory and Security Considerations

Integrating AI into core pharma IT raises new concerns. Regulators have taken notice: in early 2025, the FDA issued a draft guideline on AI/ML in drug submissions ([www.fda.gov](#)). The agency highlighted the need for “agile, risk-based frameworks” and noted AI’s “transformative potential” once proper safeguards are in place ([www.fda.gov](#)). FDA Commissioner Califf underscored that AI in medicine must meet existing safety and quality standards, signaling that companies must bake compliance into AI systems. For example, if an AI model predicts patient outcomes in a trial submission, the company needs to document the model’s validation – a technical requirement requiring IT systems that track model versions, training data, and performance.

Data privacy and security are paramount. Kiteworks’ June 2025 cross-industry survey of 461 cybersecurity, IT, risk-management and compliance professionals reported that 17% of organizations had technical controls capable of preventing sensitive data from entering public AI tools ([Kiteworks survey](#)). The statistic should not be generalized to pharmaceutical companies or to the absence of all AI safety controls. HHS notes that encryption reduces unauthorized viewing risks but cannot alone safeguard ePHI confidentiality, integrity and availability ([HHS cloud guidance](#)).

Thus, privacy and validation concerns are being built into the AI architecture. Many companies are adopting “**explainable AI**” tools and logging infrastructure so that model decisions can be audited. Digital “immune systems” for AI (monitoring for model drift or adversarial attacks) are emerging as well. Assess cloud controls for each intended use and applicable regulatory scope. Industry sources stress that data integration and quality control are prerequisites for leveraging AI. As PharmaLex puts it, data must be “instrumental in driving scientific discovery,” but only if companies ensure top-tier data quality and stewardship ([www.pharmalex.com](#)).

Workforce and Cultural Change

Finally, shifting to a core AI architecture entails human factors. Companies are investing in re-training (data science teams, AI literacy programs). Organizationally, digital product managers and AI governance boards are being created to oversee cross-functional efforts. Executives speak the language of “digital transformation,” but effective change requires bridging the gap between IT and research labs. Fortunately, many see the ROI: McKinsey and Deloitte studies indicate that early AI adopters in pharma achieve higher productivity in R&D

and operations. For example, AstraZeneca's chief data scientist credits AI with not only speeding discoveries but "higher probability of success" in turning science into medicine ([moneyweek.com](https://www.moneyweek.com)). This business pressure ensures continued investment in embedding AI within core operations.

Case Studies and Examples

- **Formation Bio (clinical workflow tools):** Formation Bio describes Muse as a tool intended to accelerate preparation of patient recruitment strategies and materials ([Formation Bio: Introducing Muse](#)). Planned recruitment improvements are distinct from measured changes in trial duration or cost.
- **insitro (ML for discovery):** insitro is a machine learning-enabled drug discovery and development company. Its October 2024 announcement describes three agreements with Lilly to advance potential treatments for metabolic diseases based on targets identified using insitro's AI/ML platform ([insitro–Lilly announcement](#)).
- **Eli Lilly and NVIDIA (AI supercomputer):** At Davos 2026, Nvidia's Huang highlighted Lilly's collaboration to build a drug-discovery supercomputer. This on-prem/high-performance AI cluster will host models for research and manufacturing, exemplifying how core IT (supercomputing infrastructure) is dedicated to AI tasks (www.axios.com) (www.axios.com).
- **AstraZeneca (AI target discovery):** AstraZeneca's April 2019 announcement describes a collaboration with BenevolentAI to use AI and machine learning for discovery and development of treatments for chronic kidney disease and idiopathic pulmonary fibrosis ([AstraZeneca announcement](#)).
- **GSK (R&D and manufacturing investment):** On 17 September 2025, GSK announced plans to invest \$30 billion in US R&D and supply-chain infrastructure over five years, including \$1.2 billion for advanced manufacturing facilities, AI and advanced digital technologies ([GSK investment announcement](#)).
- **Pfizer (Target/Lead AI suite):** As part of Google Cloud's program, Pfizer is using AI tools to boost workflows. Google's press material notes Pfizer among early users of its new AI for target identification (cloud.google.com). This implies Pfizer's R&D data systems now plug into these AI products, turning them into core digital infrastructure.
- **Gerresheimer (Digital Twin packaging):** The ONdrugDelivery article shows a concrete example of connecting primary package (syringes) to a digital twin (ondrugdelivery.com). Gerresheimer's initiative is pioneering how AI and connectivity can make even packaging a "smart object" in the pharma ecosystem.

Implications and Future Directions

AI's integration into pharma IT heralds several long-term impacts:

- **Accelerated Innovation:** By embedding AI in core platforms, new drug pipelines could shorten significantly. Both small biotech and big pharma will see faster R&D turnovers, as predictive models guide experiments and de-risk choices. Over the next 5–10 years, we may witness the first fully AI-

discovered drug approvals. In fact, industry optimists quip about asking ChatGPT-level AI to “cure cancer” – rhetoric echoed by tech leaders (fortune.com) – and while the reality is more nuanced, the trend toward AI-designed therapies is clear (fortune.com) (moneyweek.com).

- **Organizational Change:** Pharma companies will continue evolving their IT cultures. Data literacy and AI expertise become strategic assets. We expect increases in roles like “AI product manager” or “ML engineer” within pharma, alongside traditional drug R&D positions. IT governance will incorporate AI ethics rules and bias audits, making these part of core compliance functions.
- **Regulatory Landscape:** Frameworks will emerge for validating AI models as part of drug submissions. FDA’s 2025 draft guidance is likely just the beginning. Companies must architect their AI pipelines to produce audit-ready evidence. We may see biotech/IT consortia developing standards (e.g. Good Machine Learning Practices in biopharma) for system architecture and model documentation, similar to GLP/GMP standards.
- **Technology Convergence:** AI will merge with other cutting-edge tech. Quantum computing may tackle the next class of computational chemistry problems. Advanced IoT devices will feed richer real-time data into AI. Virtual and augmented reality could combine with AI to create digital twin labs or training simulators. In software architecture terms, the “core” systems will become digital twins of entire R&D organizations, continuously optimized by AI agents.
- **Challenges Ahead:** Kiteworks’ June 2025 cross-industry survey of 461 cybersecurity, IT, risk-management and compliance professionals reported that 17% of organizations had technical controls capable of preventing sensitive data from entering public AI tools ([Kiteworks survey](#)). Addressing such risks requires investment in secure data pipelines and governance – tasks that are central to the new IT architecture. Similarly, bias and explainability concerns in clinical applications will demand transparent model design, again a requirement for core integration. Overcoming legacy culture and technical debt (old code, siloed data warehouses, etc.) is essential.
- **Impact on Patients:** The potential patient benefit of workflow efficiencies depends on whether they translate into lower development costs and wider patient access. Formation Bio describes Muse as a tool intended to accelerate preparation of patient recruitment strategies and materials ([Formation Bio: Introducing Muse](#)).

Conclusion

In summary, AI is no longer a niche innovation in pharma IT – it is becoming a defining axis of digital transformation. The phrase “from bolt-on to core architecture” aptly captures this shift: What began as specialized projects is now driving wholesale reengineering of data platforms, R&D processes, manufacturing systems, and commercial intelligence. Pharmaceutical firms are thus evolving into technology-driven enterprises, where AI models and data flows are embedded at the heart of operations.

Clinical workflow claims need careful qualification. Formation Bio describes Muse as a tool intended to accelerate preparation of patient recruitment strategies and materials ([Formation Bio: Introducing Muse](#)). Leaders like NVIDIA and Google are partnering with pharma to build dedicated AI supercomputers and software suites (www.axios.com) (cloud.google.com), underscoring a trend where advanced computing is

treated as core infrastructure. Meanwhile, regulatory agencies and industry groups are rushing to develop guidelines and standards (e.g. FDA's AI framework (www.fda.gov)) to ensure these architectures are safe and effective.

The road ahead will require careful governance as well as innovation. But the trajectory is clear: AI will continue moving from the periphery to the backbone of pharma IT. For practitioners and stakeholders, this means investing not just in AI algorithms, but in the end-to-end ecosystems (data, computing, processes, and people) that make AI a reliable part of the core architecture. The outcome promises a new era of drug development and patient care, transformed by AI at every level of pharma's IT infrastructure.

References: Authoritative sources include industry news (TIME, Fortune, Axios), scientific literature, and regulatory releases cited throughout. References cited in the article include both primary and secondary sources (time.com) (moneyweek.com) (www.sciencedirect.com) (www.pharmaceuticalonline.com) (www.fda.gov). Additional details and data points can be found in the cited reports and studies, which offer extensive evidence for the trends discussed.

Source links

Links cited in this article, in order of first appearance. Full addresses are provided for readers using extracted text.

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2. <https://moneyweek.com/investments/tech-stocks/how-will-ai-impact-the-pharma-industry>
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AI consulting and adoption

Our AI enablement services cover readiness assessments, use-case selection, governance and policies, team workshops, adoption measurement and ongoing advisory support. We help organizations structure the information layer behind AI: source material, context, permissions and maintained knowledge that make generated answers useful and reviewable. Private LLM inference and hosted AI options support teams evaluating how to operate AI with appropriate control over their data and infrastructure.

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