8TH ADVANCED GMP WORKSHOP 2023

Transformation through Artificial Intelligence (AI)

Imbibing Artificial Intelligence in Product Development and Commercialization

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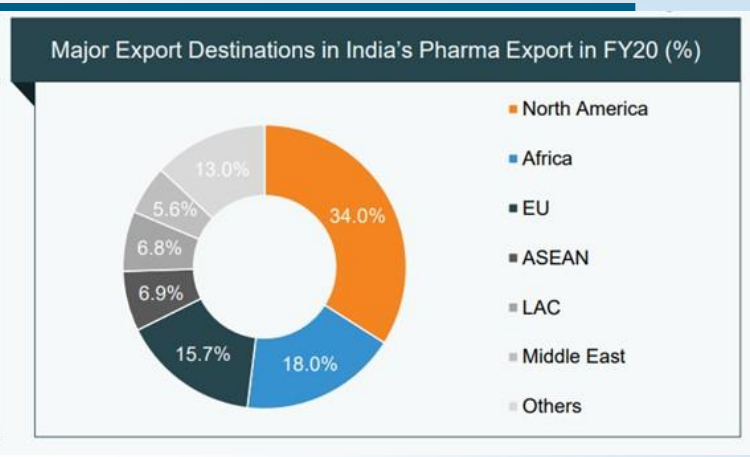
OUTLINE

- Priorities of Indian Pharma
- Understanding Technology, AI
- Success Stories, Art of Possible
- Importance of Governance
- Appeal to Indian Pharma

Pharma industry in India



Source: https://www.ibef.org/uploads/industry/Infrographics/large/Pharmaceuticals-Infographic-November-2022.pdf

The Indian Pharma Industry is poised to grow by >50% in 2021-24 and by about 100% from 2024-30

- Indian Pharmaceutical Industry serves three markets: Domestic, Regulated and Growth
- Each market presents its own challenges and opportunities
- With Exports contributing the highest to the overall pie, it is critical that the needs of the Regulated markets are adequately served

Priorities and Challenges in Different Markets

Market	Priorities	Challenges
Domestic	• High Margins • High Market Share • Inventory Visibility in Channels	• Crowded Market • Reach and Visibility • Differentiated Channels
Regulated	• Serviceability • High Margins • Quality and Compliance	• KSM / RM / PM / Labor Availability • Distributed Supply Network • Visibility in Supply Chain • Demand Fluctuation
Growth	• Market Specific Business Model • Predictability • Acceptance	• Unproven / Untested Technology • Local Challenges

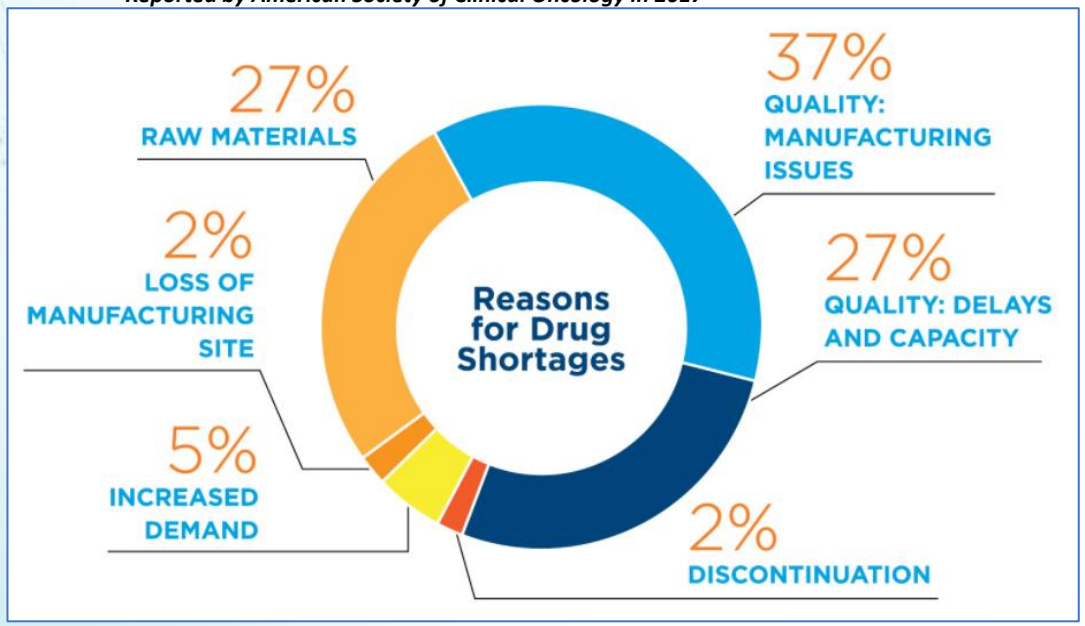
The export market is fraught with challenges, with multiple obstacles to overcome

Priorities

2017 | 2019-20* | 2022

Top Reasons for Drug Shortages

Reported by American Society of Clinical Oncology in 2017



Source: https://connection.asco.org/magazine/features/drug-shortages-enduring-effects-continued-challenges-2011-crisis

About two-thirds of the cause of shortages is related to Quality issues

Current pharmaceutical trends may add more cost, complexity, and risk, with these forces compounding one another.

Pharmaceutical industry trends and implications — Degree of impact: ○ Low ◔ Medium ● High

Trends	Implications: Complexity	Increased risk	Capability	Capital expenditure	Variable-cost increase	Savings opportunity
Advances in digital technology and user willingness	○		○			●
Diffusion of individual players' power	◔	○	○			
Environmental, social, and governance expectations	◔		○	○		
Geopolitical considerations	○	◔	◔	◔		
Labor market challenges		◔	◔		●	
New modalities	○	○	○	◔		
New work expectations	◔					
Pressure to innovate	◔	○		○		
Rising inflation		○			●	
Supply chain disruptions	◔	●				

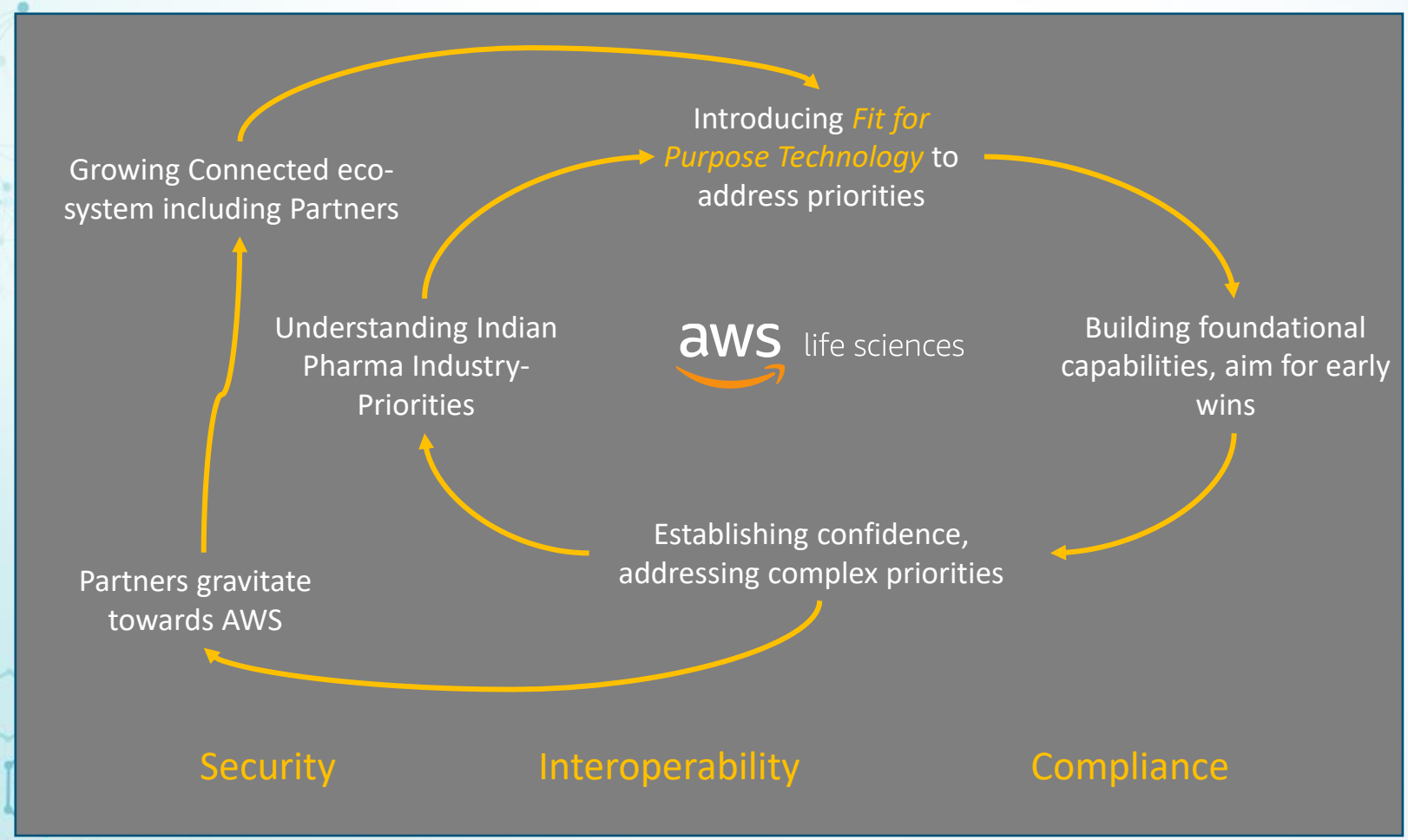
Source: https://www.mckinsey.com/capabilities/operations/our-insights/emerging-from-disruption-the-future-of-pharma-operations-strategy

*Findings of the *Drug Shortage Task Force* suggest that the industry may require help to address shortages. Root causes for shortages or poor quality seem to arise from lack of incentives to produce less profitable drugs, lack of recognition of mature quality systems and logistical and regulatory challenges to overcome a disruption.

Source:
https://www.fda.gov/drugs/drug-shortages/report-drug-shortages-root-causes-and-potential-solutions

Purpose-built technology intervention can help address many such challenges

Technology Fly Wheel for Indian Pharma



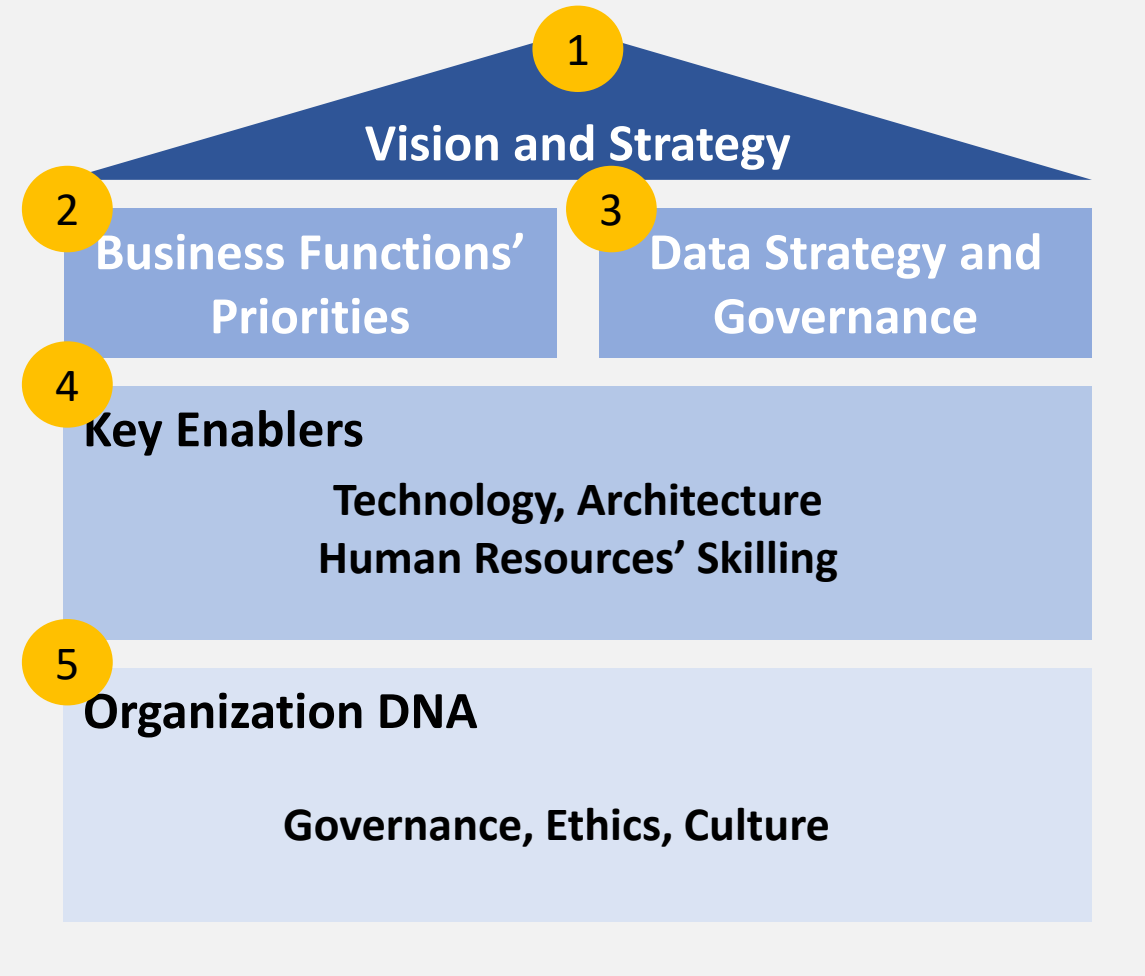
Fit for Purpose Technology for Indian Pharma

1. **Data Sharing Models made easy** enabling Security in storage and transit, Standardization allowing interoperability and Innovative Commercial / Pricing models
2. **Industry Cloud Solutions** with fit for purpose Analytics, maintaining a Connected eco-system with stakeholders and Targeted Stakeholder Management
3. **Blockchain** providing Security and Collaboration through Distributed Ledger Technologies, integrating Industry, Suppliers and Regulators
4. **Disruptive IT** defining new Business Models through Automation at scale, Modernization and Innovation in deployment
5. **Cyber AI and LLMs** addressing multiples needs such as anticipating and eliminating Security threats and Generative AI running workflows for auto-validation

More information on relevance of these technologies for Pharma::
https://www2.deloitte.com/us/en/pages/life-sciences-and-health-care/articles/life-sciences-technology-trends.html

There is a method to introduce technology into the product development process

Technology



1. **Vision and Strategy** provides top-down direction; alignment towards which is provided by other blocks

2. **Priorities of Business Functions** are designed for realization of vision; shared accountability across functions is a critical consideration (Connected Enterprise, Continuous Visibility)

3. **Data Strategy and Governance** frames the fundamentals of Technology and Architecture adoption to build a Connected Enterprise

4. **Key Enablers** required to fulfill Business Priorities

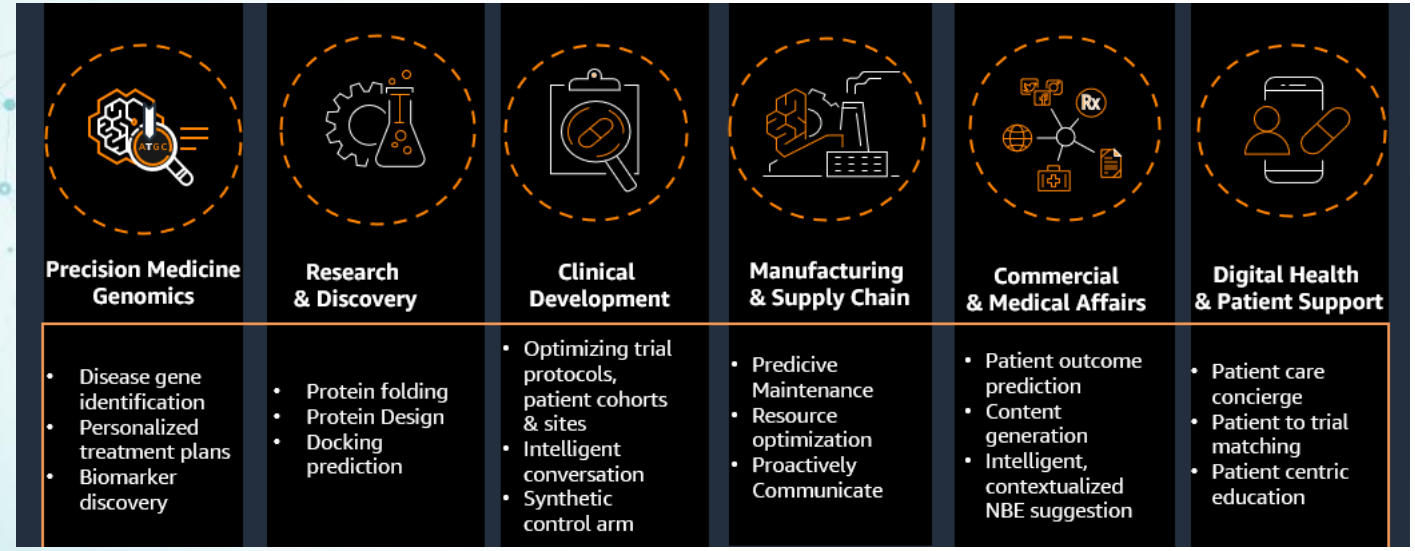
5. **Organization DNA** encompasses soft skills and other leadership qualities to succeed and sustain

Focus for further discussion today

As a *Key Enabler*, *Fit for Purpose* Technology should serve Business Priorities, following Data Governance Principles

Technology

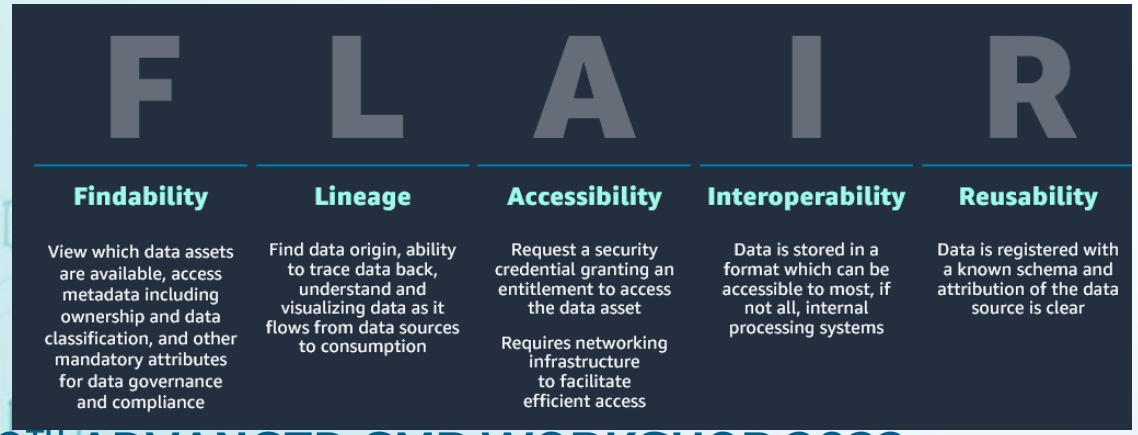
Business Priorities – Sample View



Examples for Today's Discussion

- Quality Assurance – Monitoring Packaging Line
- Procurement Analytics to enable Spend Optimization
- Regulatory Compliance – Change Management in Global Labeling Function
- Lights out Manufacturing

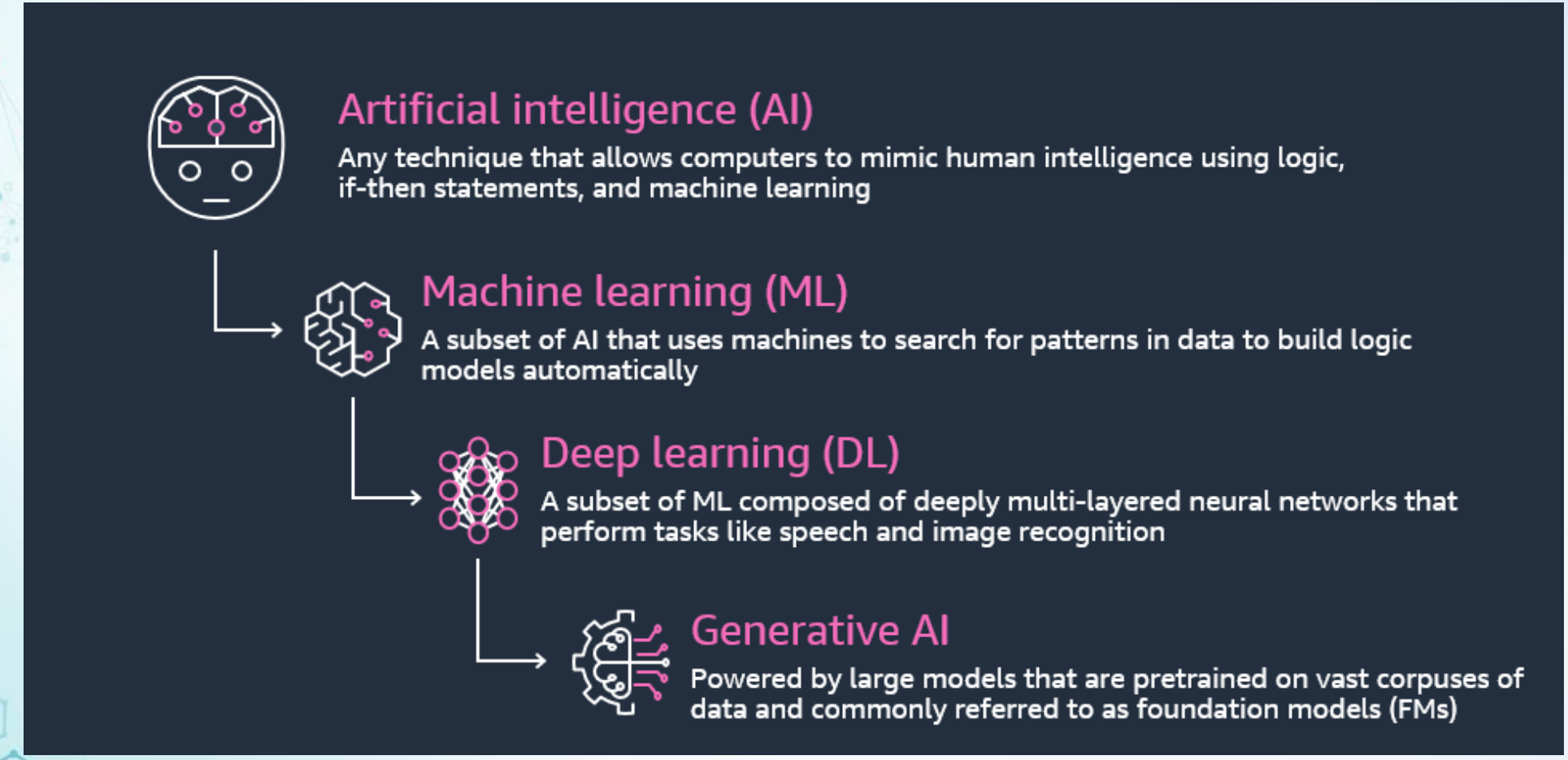
Data Governance Principles: FLAIR



Context Relevant to GMP

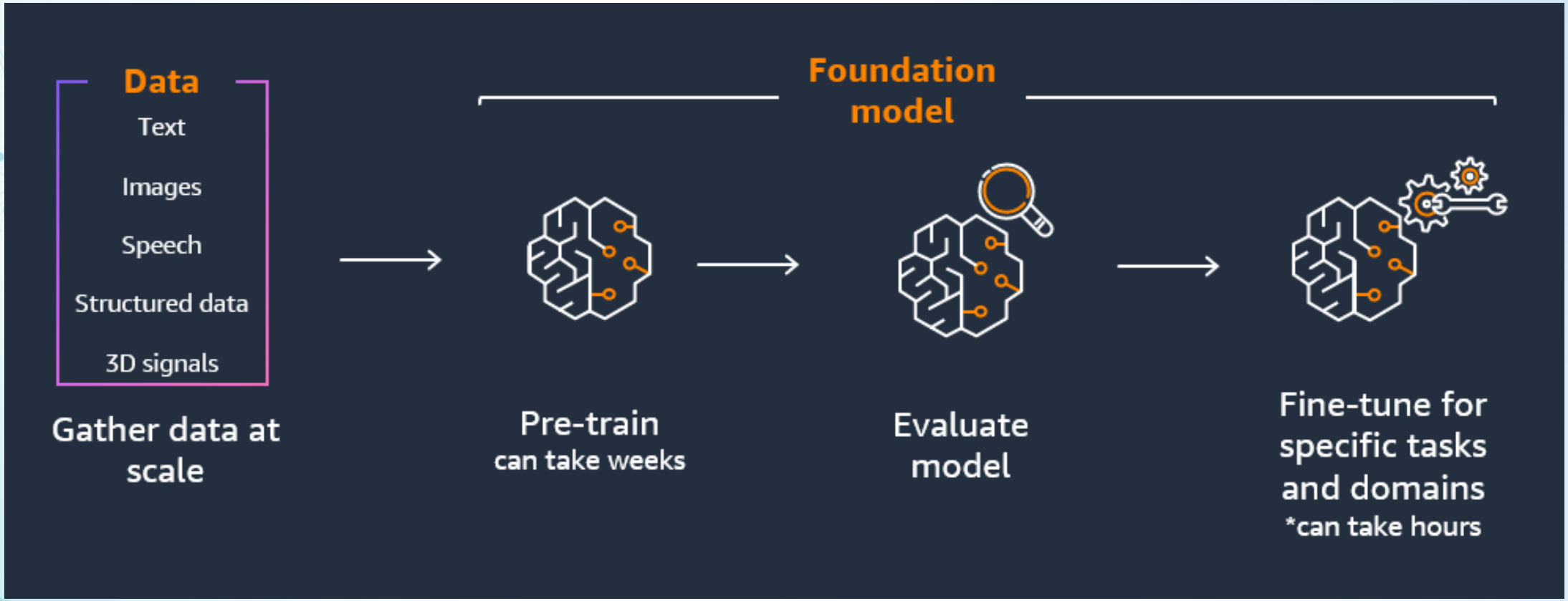
- Findability – Search capabilities, responding to Queries
- Lineage – Regulatory conditions / limitations related to country of origin for KSM / RM / API
- Accessibility – Role enabled responsibility
- Interoperability – Building internal / external connected ecosystem
- Reusability – Enabling Productivity, Minimizing Errors

Decoding Technology and Artificial Intelligence

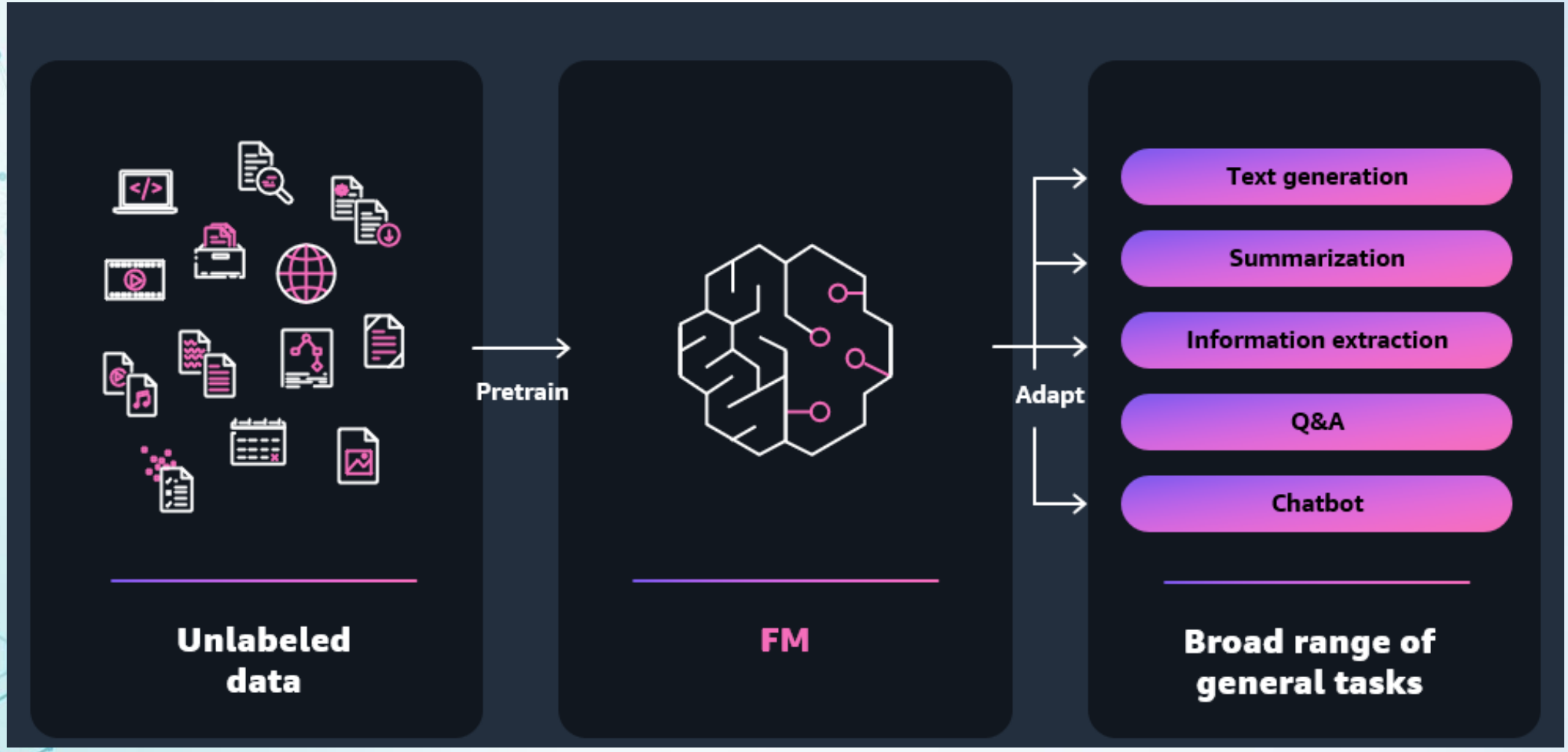


Note: Given the topic of Artificial Intelligence (AI) for today's workshop, definition of Technology is limited to AI and further advances on AI

Working of a Foundation Model



Generating output from Foundation Models



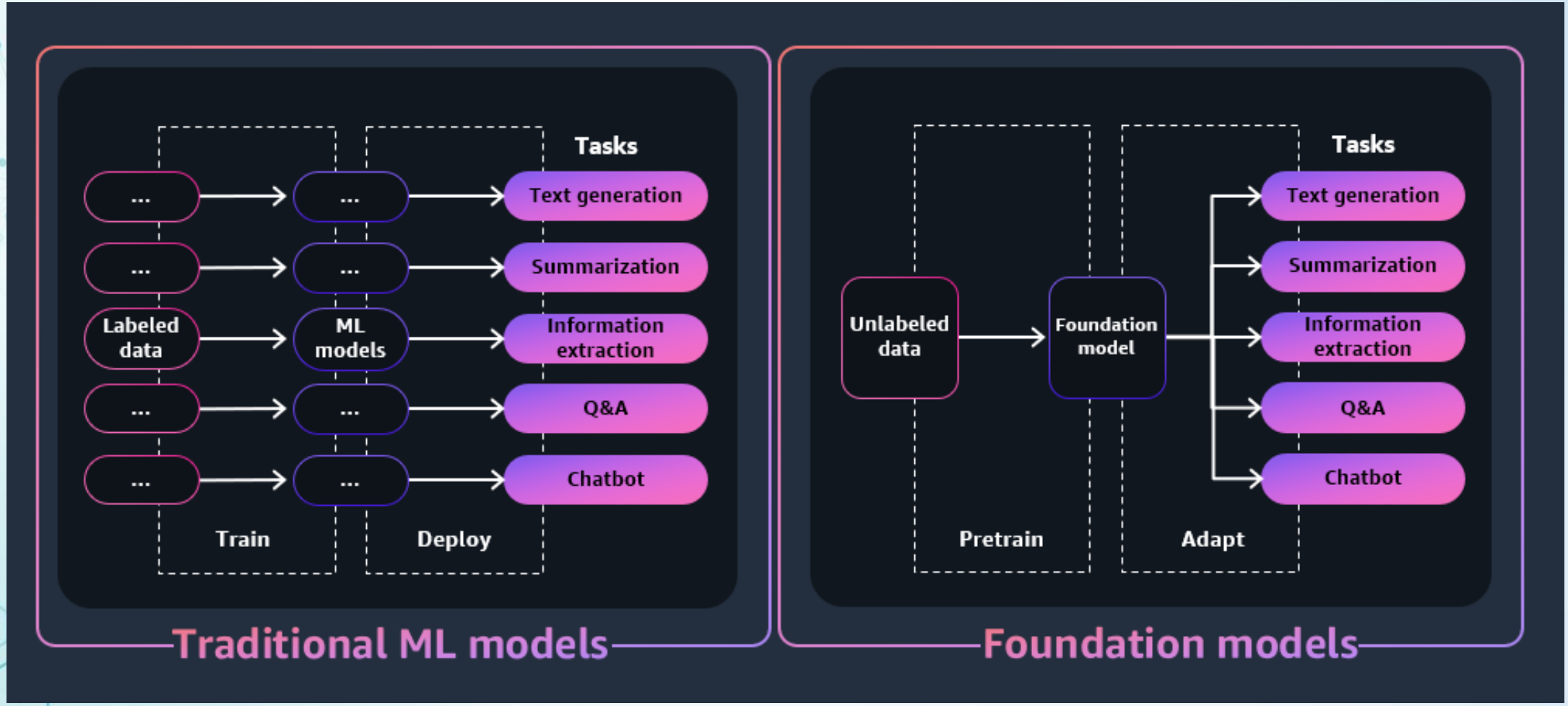
Working of Generative AI

Text input	→	Foundation model	→	Output
"Summarize this article ……."		Text generation model (also known as large language model - LLM)		[Text] "……."
"a photo of an astronaut riding a horse on mars"		Image generation model		[Image] 
"A young couple walking in rain." "Children singing nature songs" "Write Python code to sort array …"		Video Audio Code generation model		[Video]  [Audio]  [Code] 

Types of Foundation Models

Input	FM	Output
"Summarize the articles on impact of walking on heart health"	**Text-to-text** Generate text from simple natural-language prompts for various applications	"Ten thousand steps per day is optimum for maintaining a healthy heart"
"hand soap"	**Text-to-embeddings** Generate numerical representation of text for applications like search and finding similarities between documents	Numerical representation of "Hand soap refills Hand soap dispenser Hand soap antibacterial"
"a photo of an astronaut riding a horse on mars"	**Multimodal** Generate and edit images from natural-language prompts	

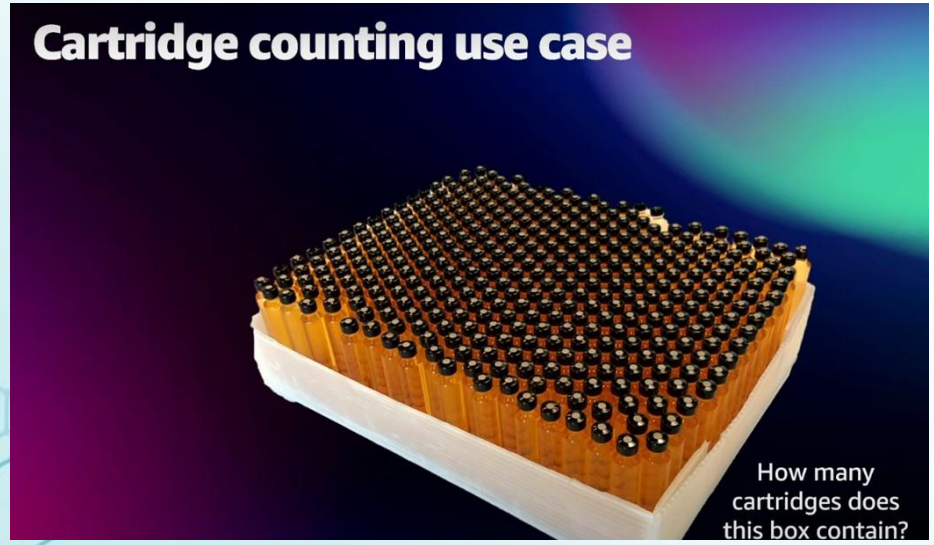
Advantage of Foundation Models over Traditional Models



Customer Success Story: Visual Inspection at Novo Nordisk

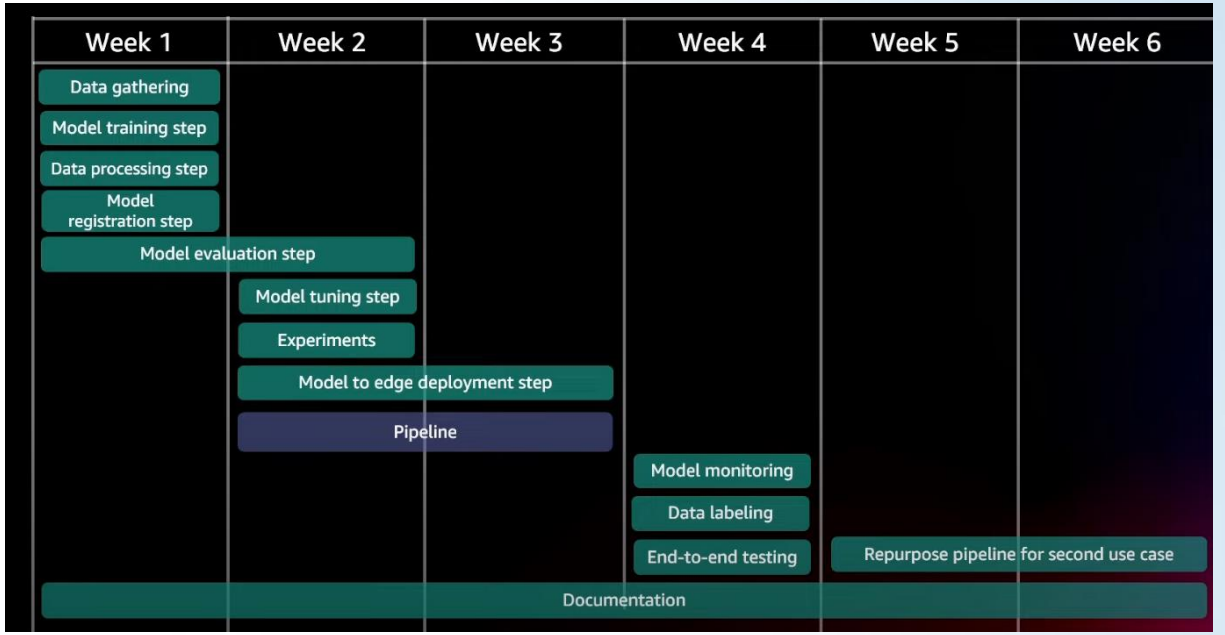
Novo Nordisk Priorities Computer Vision + ML

- Automation of manual work
- Real-time anomaly detection
- Real-time quality control
- Process optimization



Novo Nordisk Priorities Computer Vision + ML

Prototype Building Engagement



https://www.youtube.com/watch?v=uTxVXSkXTyk 18,16 – 22,30

Customer Success Story: Procurement Analytics at Novartis

End to end visibility and insights with *Buying Engine*

The Process

- Bring supplier catalogue from myriad of suppliers
- Build front end experience of an internal product registry
- Provide recommendations, collaborative filtering, price comparisons
- Integrate with procurement platform
- Application of ML models to the downloaded supplier catalogue aids in creating a knowledge graph
- Intranet application to search the knowledge graph
- Customer Example of Intelligent Procurement (13,48 – 19,41)

Benefits

- **Reduce Procurement Costs by 5%**, with increase volumes for purchase of SKUs across regions
- **Purchase the right product** for a given task
- **Purchase products that are related** through the task
- Provide an **Amazon-like experience** for lab technicians

https://www.youtube.com/watch?v=eb_jkC1H8pU

Architecture

https://www.youtube.com/watch?v=vp8oPiHN4cA

Customer Success Story: Regulatory Compliance at Merck
Change Management in Global Labeling Function

Current Process

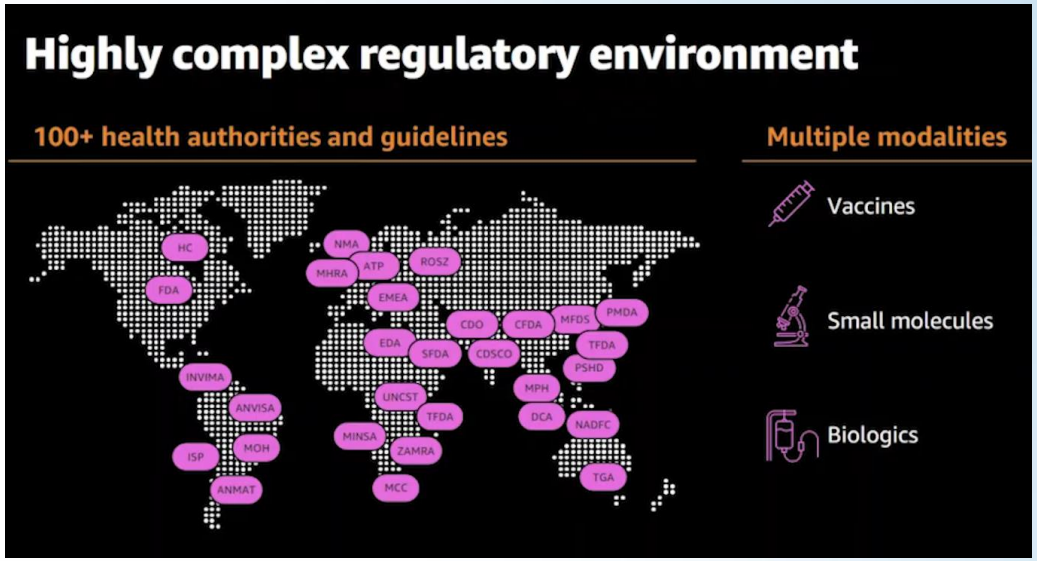
- Multiple change proposals generated annually, need to be read and the change interpreted, reviewed, approved
- Research across multiple systems, repositories is required as part of the process to understand the markets impacted and the type of impact in each market

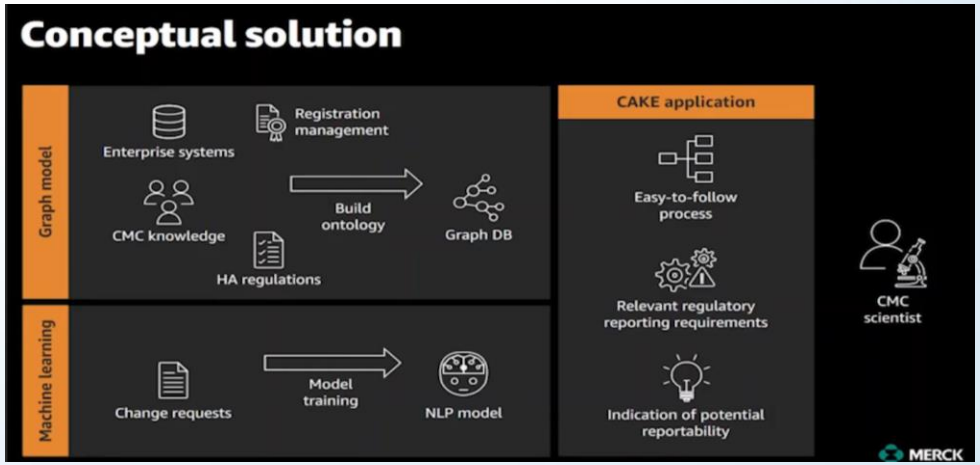
Solution

- Automated solution (made possible through knowledge graphs) to streamline the above manual process; once regulatory reportability is determined, trigger workflow for evaluation and execution
- The knowledge graph contains information on supply chain, mfg recipes, products, regulatory guidelines, Merck knowledge base; NLP models trained on change requests
- Customized front end; almost instantaneous feedback on regulatory reportability upon keying in the change request

Benefits

- **Up to 90% reduction** in duration, **30-70% reduction** in effort, **Higher Compliance**





Customer Success Story: Personalized Medicine at Multiply Labs

Multiple dosages in one unit, lights out manufacturing

Success Stories

Problem Statement

- Daily drug regimens can be challenging and complex, with patients taking multiple prescription drugs to treat different medical issues
- Multiply Labs strives to solve this problem by manufacturing a single daily capsule containing a patient's entire prescription—with a dosage individualized to a patient's needs
- Manual paper work to address regulatory requirements

Solution

- AWS Robomaker to automate deployment of updated code to its robot application, based on Robot Operating System

https://www.therobotreport.com/multiply-labs-20m-pharmaceutical-automation-system/

Benefits

- **Nine robot systems managed in parallel** from QC software
- **Maximize uptime** with simulation tests
- **With digital storage of batch records**, repeatable and traceable way to store data

AWS Life Sciences is exploring new opportunities to address critical opportunities in Indian Pharma

Ongoing discussions / engagements aimed at improving Availability, Serviceability and the overall heath of Global Pharma Supply Chain

- **Increasing the likelihood of First Cycle Approval of ANDAs**
- **Predicting drug shortages, arranging alternative supplies**
- Automating and prioritizing pipeline candidates in Generics R&D
- Reimagining Generics R&D for a robust development and scale up
- Expanding collaboration partners and eco-system for enhanced visibility

First Cycle Approval of ANDAs

First Cycle Approval Rates

- **4 is the average number of cycles** for approval
- **1.4% to 12% First Cycle Approvals** from 2009-14 to 2015-17; however, for NDA, the approval success went from 43% to 90%+ in the same time period
- Anecdotal evidence suggests that months are lost in satisfying ***Reviewers' curiosity***

Sources
US GAO, Activities Report of the Generic Drug Program

First Cycle Approval Enhancement – Solution Construct

Automated verification of ANDA thoroughness

- Understand the basis of questions from past reviews (different reviewers, different product types, and any other possible segmentation of data from the past)
- Understand what constitutes a thorough response for each such question and addressing those *a priori*
- Continuous learning and refining the model
- Solution improvement, including auto-creation of ANDA

Commercial products' shortages

Art of Possible

Drug Shortages Key Statistics

(Survey conducted in Jun / Jul 2023 of 1,123 participants, of which 85%+ were from hospital pharmacies)

- At the end of the second quarter of 2023, there were **309 active, ongoing drug shortages** — the highest number in nearly a decade and close to the all-time high of 320 shortages
- **Severity of shortages were classified as critical (32%) and moderate (63%)**, implying having an effect of patient care, which could potentially cancel or delay critical treatment and / or procedures

Source:
https://www.ashp.org/-/media/assets/drug-shortages/docs/ASHP-2023-Drug-Shortages-Survey-Report.pdf

Addressing drug shortages – Solution Brief

- National Drug Codes (NDCs) that are likely to experience shortages in the next 10-90 days
- Comparable NDCs in the market
- Duration of shortages and comparable market NDCs
- Production decisions to address new market realities
- Enabled through the collective intelligence capabilities of Opus Digital Network Platform

Source:
https://www.tracelink.com/products/intelligence-and-analytics/product-availability-intelligence-drug-manufacturers

AI Governance: State of the Industry, Looking Forward

Compliance burden scales with size and resources

Maturity Scale

- Recommendation is for Pharma industry to operate at least at Level 3, Level 4 to be aspirational
- Integrate AI governance with main-stream product development, manufacturing, supply chain

Level 1

- No governance or oversight
- No technical standards or documentation; driven bottom up
- Potential scaling issues

Level 2

- Self-managed with best practices
- Tools for AI QC support
- Standards for documenting details about the AI system
- Structured AI product discovery process

Level 3

- Dedicated internal overseer
- Contribution from Safety, Compliance, Security, Legal and Privacy teams to provide secondary level of defense
- Accountability for responsible development

Level 4

- Ability to assess risk of any use case
- Establishment of an Ethics Committee with representation from Development, Ethics and Legal
- Internal communication for lessons learned
- Sacrifice of speed for risk mitigation

Level 5

- Independent third party / external oversight
- Mandatory documentation, internal processes and standards
- Enforcement of specific AI policies to ensure AI safety requirements
- Organizations creating physical AI agents require this level of maturity

Source
https://www.forbes.com/sites/forbeseq/2023/07/26/ai-governance-maturity-index-a-comprehensive-assessment-framework/?sh=54d776dd4155

Pharma industry has to be decisive in how it adopts technology to serve its current and future needs

- Business Strategy and Priorities should dictate Technology Strategy; Governance should not be an afterthought
- Ability to discern where to *prioritize competitive advantage* vs. where to *promote collective industry development* will enable faster decision making
- The future requires nurturing and sustaining the eco-system of partners and stakeholders; growth cannot happen in isolation

Thank You!

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