AI-Based Workflows in Environmental Laboratories

Reliable Data for Sound Decision Making

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Bachelor of Science in Microbiology with a minor in Chemistry

Experience

26 Years in environmental laboratory space

- **10 Years bench chemist**
- **5 Years LIMS Admin**
- **11 Years LIMS Provider**

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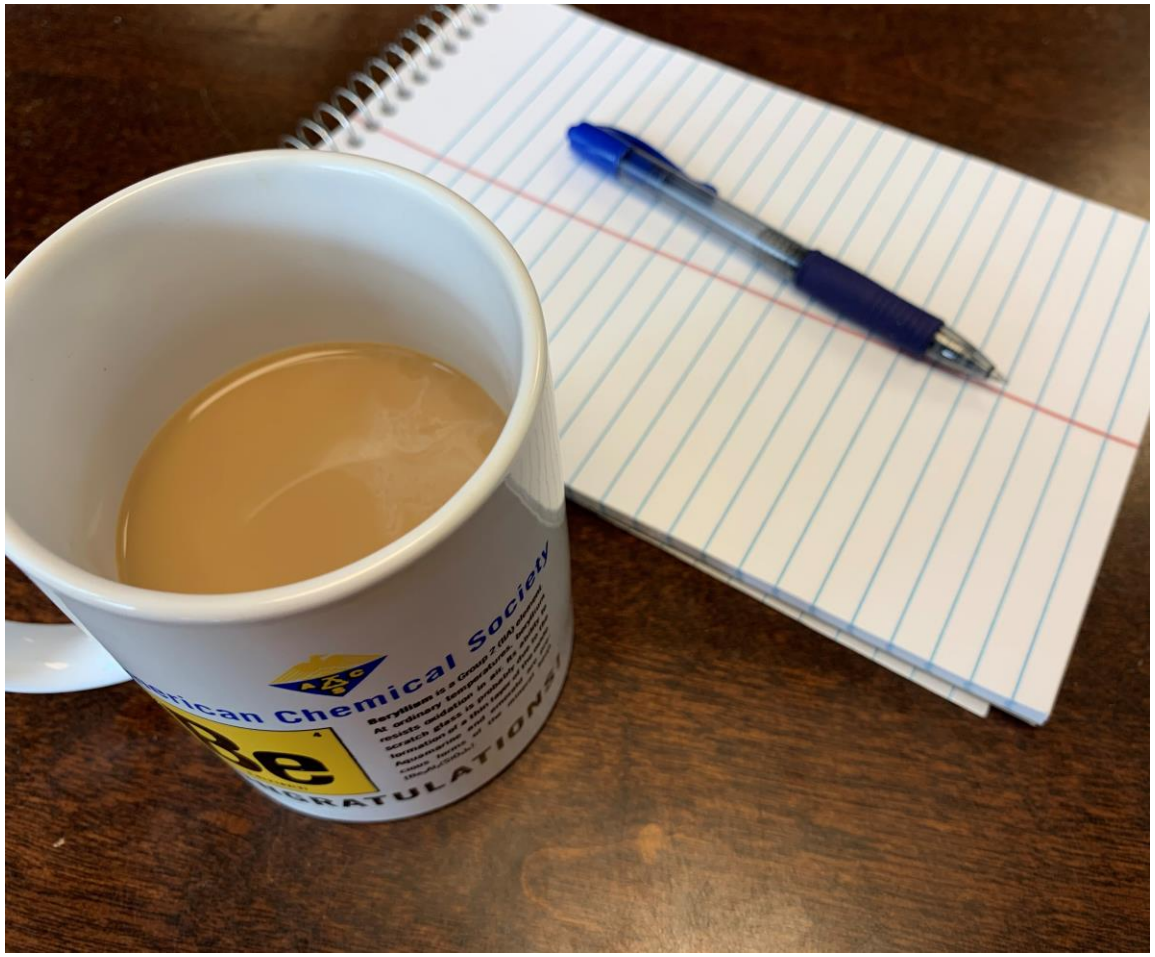
AI-Based Workflows in Environmental Laboratories

Topics

- The Basics
- Introduction to AI-Based Workflows:
  - ✓ Automating Repetitive Tasks
  - ✓ Ensuring Data Integrity
  - ✓ Enabling Insights
  - ✓ Challenges and Considerations
  - ✓ Conclusions



Quick Vocabulary Lesson

AI vs ML

AI is the broader concept of enabling a machine or system to sense, reason, act, or adapt like a human. ML is an application of AI that allows machines to extract knowledge from data and learn from it autonomously. ML is a subset of AI.

ML (Machine Learning)

Machine learning is best for well-defined tasks with structured and labeled data. ML solves problems through statistics and mathematics.

Deep Learning

Deep learning is best for complex tasks that require machines to make sense of unstructured data. Deep learning combines statistics and mathematics with neural network architecture.

AI vs Generative AI

Traditional AI excels at analyzing data and performing specific tasks, while generative AI focuses on creating new content like text, images, and music (currently). Generative AI requires significant computational resources vs traditional AI.

AI Evolution Refresher


Image generated using Copilot via DALL-E

- 1960s-1980s - Rule-Based Systems (Early Stage)
- 1990s-2000s - Statistical Generative Models
- 2000s-2010s - Deep Learning Generative Models
- 2010s-2020 - Hybrid Models
- 2020-present - Large Language Models (LLMs) & Gen AI
  - ✓ Examples: Chat GPT, Gemini, Claude, Mistral – Capturing knowledge about vast amount of text, images, videos, code.
  - ✓ Applications: Chat Bots, Translations, Content Creation

Where does the use of AI fit the laboratory today?

Classic Lab Bottlenecks

The reality of traditional labs:

- **Manual Processes:** Repetitive tasks consume valuable time, leading to reduced efficiency and throughput
- **Data Silos:** Information exists in disparate locations hindering insight and reporting efficiency
- **Complex Workflows:** Multi-step processes creating bottlenecks and delays
- **Instrument allocation & Scheduling:** Too many method variants and too few instruments and staff

Slowed progress, potential errors, frustrated scientists

Automating Repetitive Tasks

Unleashing Your Lab's True Potential

Sample Registration

- AI can **automatically read barcodes** on samples.
- Analyze images to **extract data from labels and annotations**.
- Integrate seamlessly with LIMS for data entry.

Workflow Scheduling and Optimization

- Analyze historical data to **predict workload**.
- **Optimize scheduling** of environmental tests.
- Prioritize tasks and **minimize bottlenecks**.

Instrument Calibration and Maintenance

- **Predict equipment failures** based on sensor data.
- Automate maintenance tasks to **prevent downtime.**
- Ensure data quality through **consistent calibration**.

Your **lab resources** are your most **valuable asset**

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Ensuring Data Integrity and Quality

Anomaly Detection & Error Prevention

- Analyze data streams from instruments and/or on-line sensors in real-time.
- **Identify anomalies** and potential errors.
- Trigger alerts for corrective actions.

Compliance & Audit Trail Management

- **Automated tracking** and documentation of all testing activities.
- Ensure adherence to **environmental regulations**.
- Simplify audits with **comprehensive documentation**.

Chain of Custody and Sample Traceability

- Monitor movement of sample, inventory and other lab assets
- Track changes in sample status.
- Provide **detailed audit trails** for complete traceability.

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Reliable data is the **lifeblood** of lab operation

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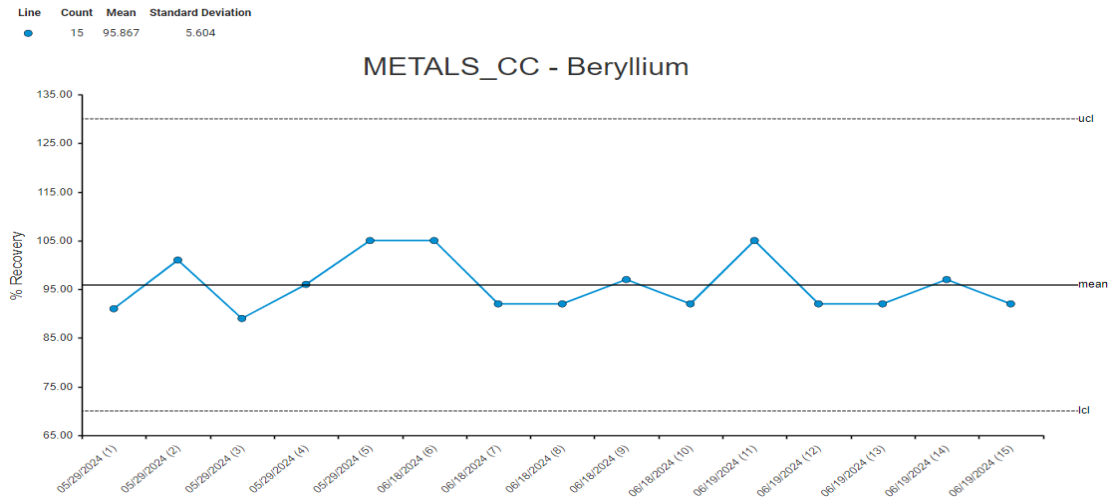
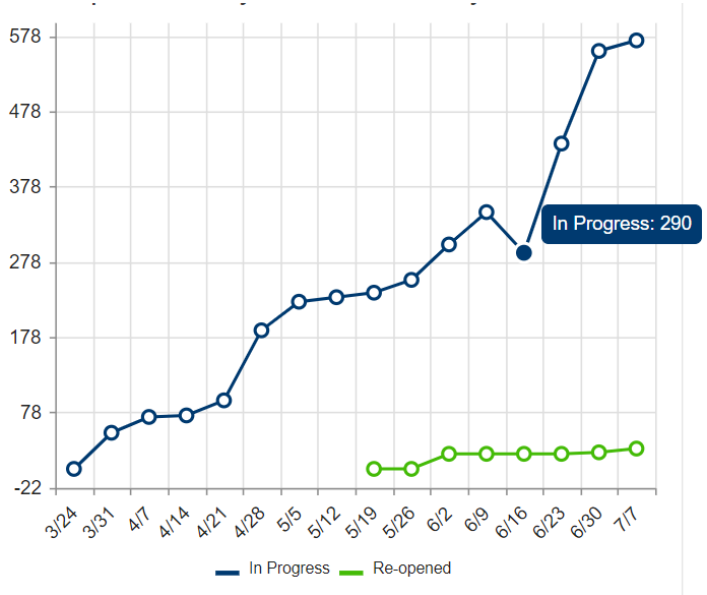
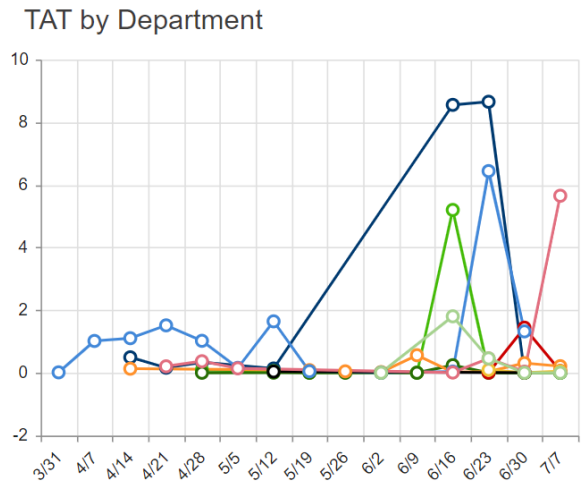
Enabling Insights







Identifying Trends and Patterns

- Analyze small or large datasets to discover hidden patterns.
- **Identify correlations** between factors.
- Insure better data by immediate notifications of variances.

Challenges and Considerations

Data Quality and Availability

- Successful AI implementation depends on high-quality, accessible data.
- Data silos and inconsistencies can hinder AI analysis.
- ***Strategies:***
  - ✓ Standardize data collection and storage practices.
  - ✓ Harmonize on naming conventions
  - ✓ Implement robust LIMS for centralized data management.

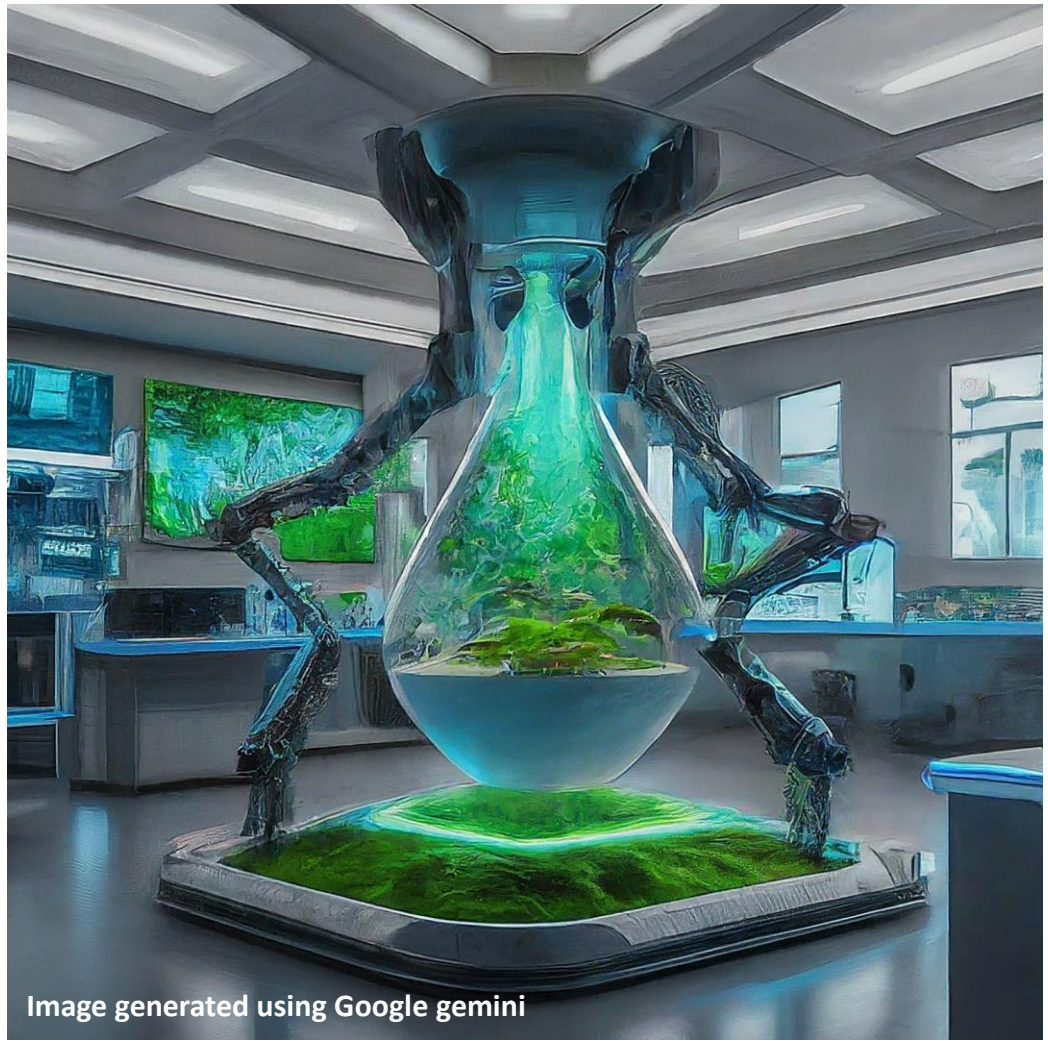
Security and Privacy

- Secure storage and access control are crucial for sensitive environmental data.
- Ethical considerations regarding data privacy need to be addressed.
- ***Strategies:***
  - ✓ Implement robust cybersecurity measures.
  - ✓ Define clear data governance policies.

Model Transparency and Explainability

- Environmental researchers and professionals need to understand how AI models arrive at conclusions.
- **Transparency builds trust** and ensures the scientific validity of AI-driven insights.
- ***Strategies:***
  - ✓ Employ interpretable AI models.
  - ✓ Provide clear explanations of model reasoning.

The Future of Environmental Laboratories with AI



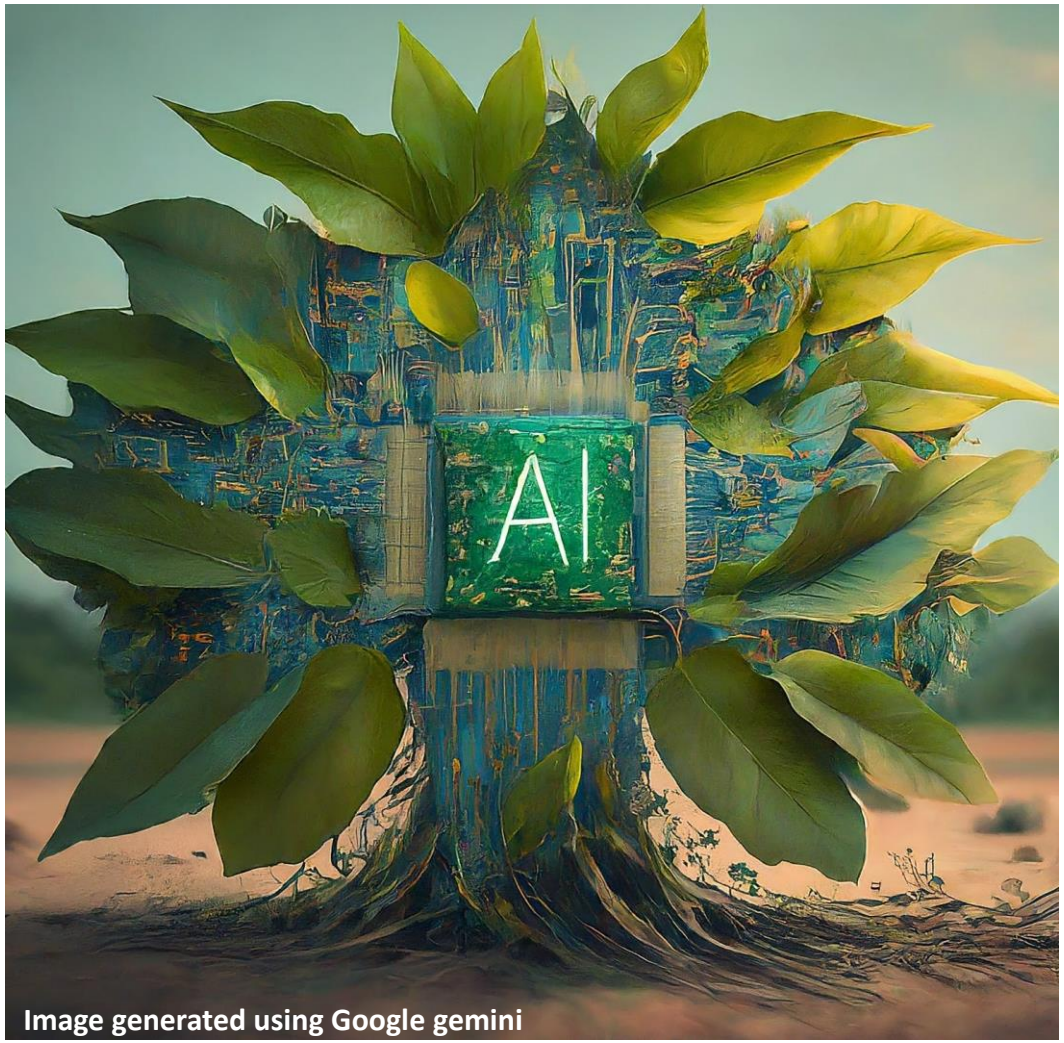
- AI is **revolutionizing environmental** laboratories, automating tasks, and improving data quality and operational efficiency

- As AI capabilities continue to evolve, we can expect even more **transformative applications** in environmental sciences:
  - ✓ Development of **self-optimizing** laboratories that autonomously manage workflows and resources.
  - ✓ Real-time environmental monitoring and **predictive modeling** for proactive environmental protection.
  - ✓ Integration of AI with environmental sensors for **continuous data collection** and analysis.

Conclusions

- AI offers a powerful toolkit for environmental laboratories to:
  - ✓ **Enhance efficiency and productivity**.
  - ✓ Ensure data quality and integrity, as well as compliance.
  - ✓ Generate valuable scientific insights, including predictions.
- By embracing AI, environmental laboratories can:
  - ✓ **Accelerate** research and discovery.
  - ✓ Contribute to a **deeper understanding** of our environment.
  - ✓ **Develop innovative solutions** for environmental challenges.

Clinisys roadmap includes Gen AI-powered LIMS
To be at the forefront scientific innovation



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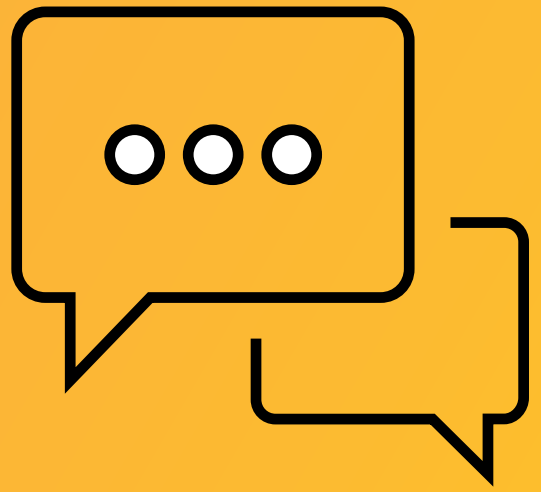

Thank you

Any Questions?

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