# Ecosystem of Machine-Maintained Models with Automated Analysis (EMMAA)

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## Model-building machines monitor, understand, and explain complex systems at scale

## Why?

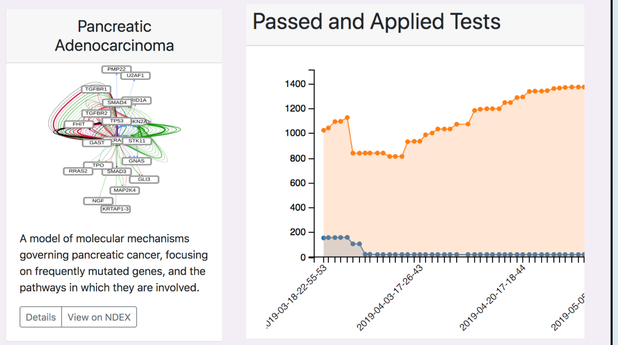
**New discoveries are** reported at a rate beyond what human analysts and scientists can integrate into models – yet we need to **react and make decisions**!

"Bottom-up" knowledge-based, causal **models** are powerful but are **difficult and time consuming** to build

"Top down" **data-derived predictive models** require large amounts of labeled data and provide **limited explanatory insight**

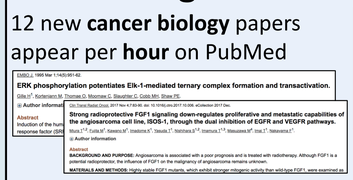
Deploy **model building machines** that collect fragmented "bottom-up" knowledge and assemble models automatically

## emmaa.indra.bio




## Monitoring & Discovery

12 new **cancer biology** papers appear per **hour** on PubMed





5000 new **news reports** appear per **hour** via NewsAPI.org

**Machine autonomously monitors new, relevant information**

## Generality

Can be applied In any domain where there is a

- stream of **new discoveries** to be integrated into models
- stream of fragmented information about **"interactions" between "agents"** of interest
- need for **interpretable, causal explanations**

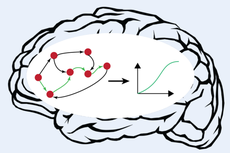
## Push science

Users **formulate their scientific/analytical questions** to define what problem they want model-driven updates on.

"Why does treatment with the cancer drug PLX-4032 lead to resistance in Patient A but not Patient B."

"In what ways could prolonged conflict lead to food insecurity in South Sudan?"

Machine gives **"push" updates** to user based on the model(s) relevant to their problem

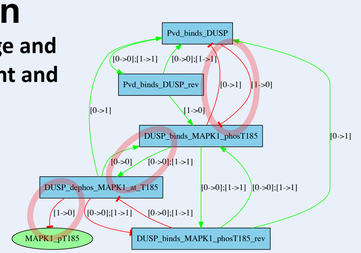


"The newly reported interaction between CALM and KRAS is part of a new explanation for PLX-4032 resistance."

## Analysis & Explanation

Automatically built models can be **large and complex** but analysis has to be **relevant and intuitive**

Machine finds explanation and **generates human-readable report with provenance** & references




## Ecosystem of Machine-maintained Models with Automated Analysis

Crisis scenario, scientific question, what if…? **question** + contribute **knowledge**

**Notify** select users about **novel conclusions**

Scientists/ Analysts

**Notifications**: novel hypotheses, analysis reports, projections, risks

**Extract** knowledge when it appears

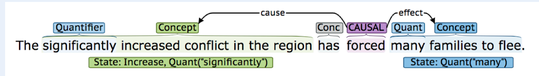
**Assemble** knowledge into model

Run relevant **analysis**

"The newly reported interaction between CALM and KRAS is part of a new explanation for PLX-4032 resistance."

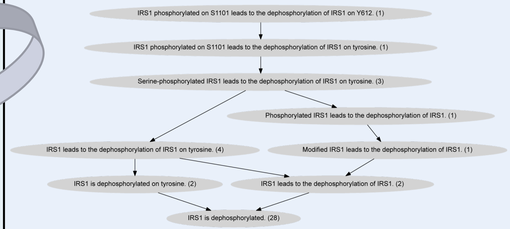
## Automated Reading & Assembly

- Natural language processing systems to extract **causal mechanisms** and **observations**




*Eidos system by Rebecca Sharp, U Arizona*

- **Assembly of fragments** of causal information at scale




INDRA
Integrated Network and Dynamical Reasoning Assembler

How to integrate novel information with existing model?

- **Redundancy**: new evidence, corroboration of existing knowledge
- **Refinement**: existing knowledge in more detail or in a specific context
- **Generalization**: existing knowledge generalized to broader context
- **Conflict**: contradicts existing knowledge
- **Novelty**: completely new information – is it reliable?

Finally, generate **executable models** from assembled knowledge