Complex Adaptive Systems Initiative
Arizona State University

Sandra Day O'Connor College of Law
Arizona State University

AI and the Life Sciences: Evaluating Opportunities and Risks

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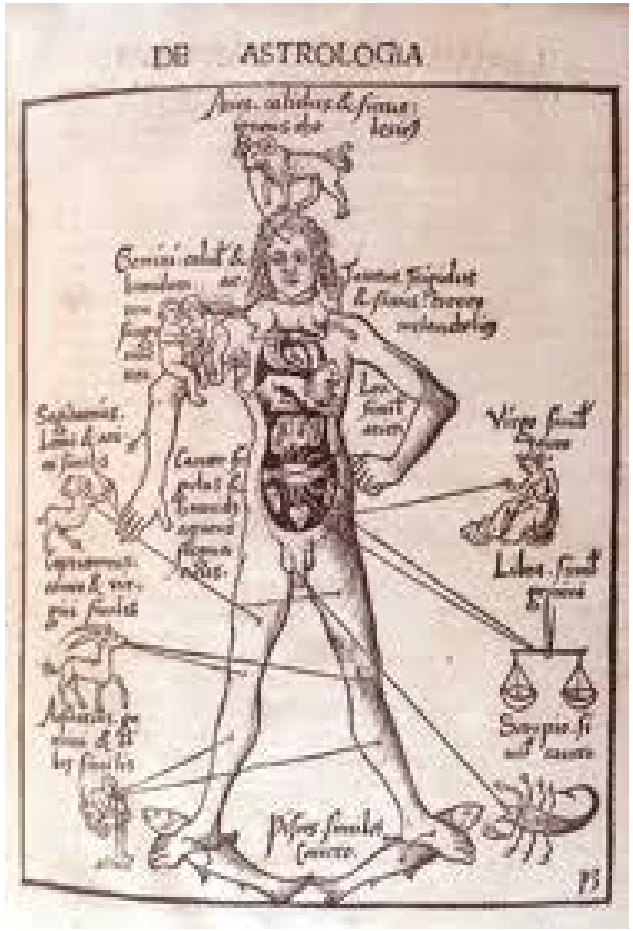
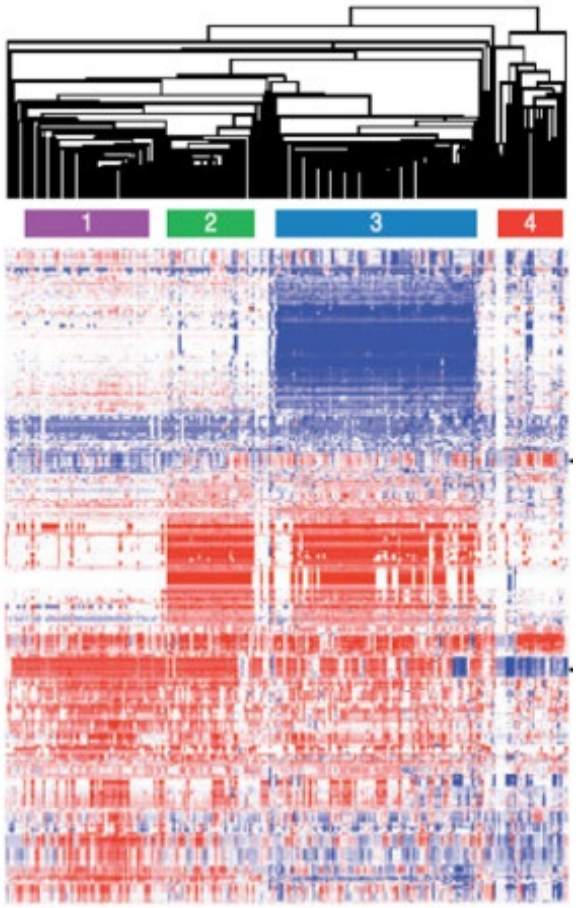
GETS Conference: Plenary Session 2
May 16, 2024
Sandra Day O'Connor College of Law, ASU
Slides Available @ http://casi.asu.edu/presentations

The Path to Precision Health:
From Superstitions to Symptoms to Molecular Signatures of Health Risk



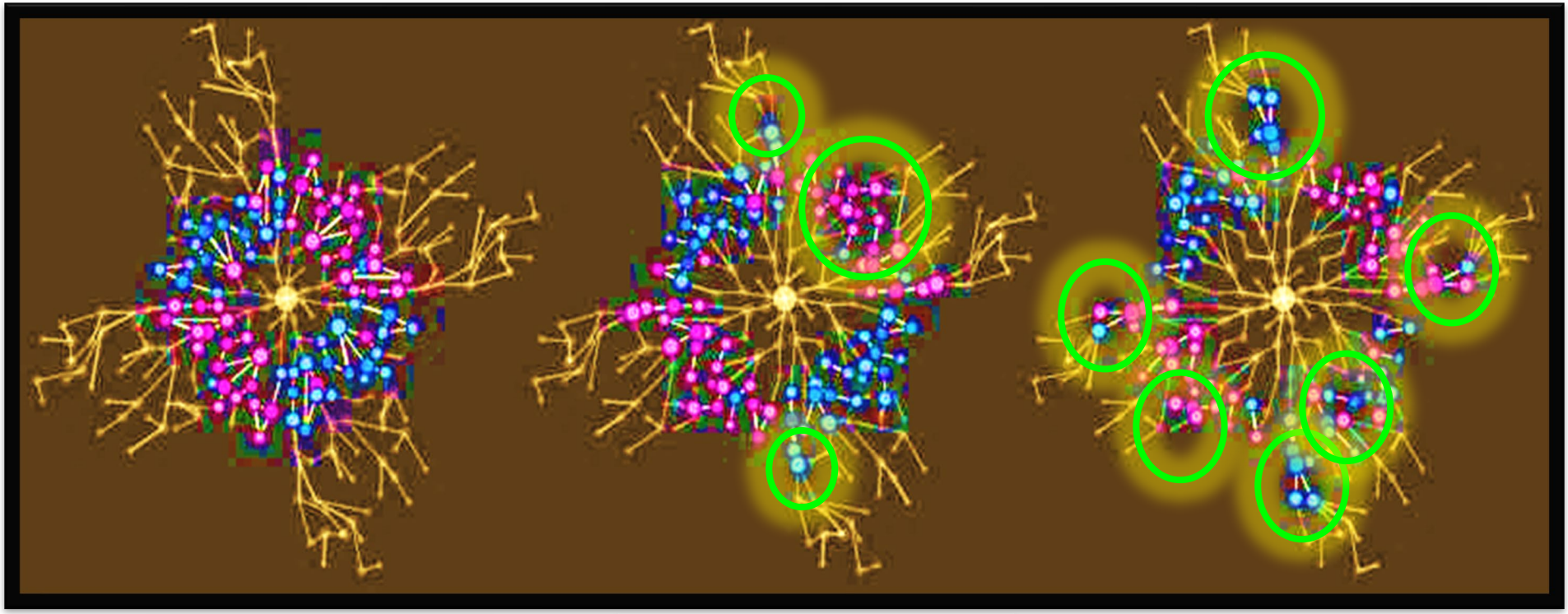


humors, astrology, shamanism, sin and divine fate

biochemistry and organ-based pathophysiology

molecular biology and multi-omics profiling

Diseases as Complex Adaptive Biological Systems: Mapping System State Shifts (Phenomes) and Cumulative Perturbations in Molecular Signaling Networks in the Health to Disease Continuum



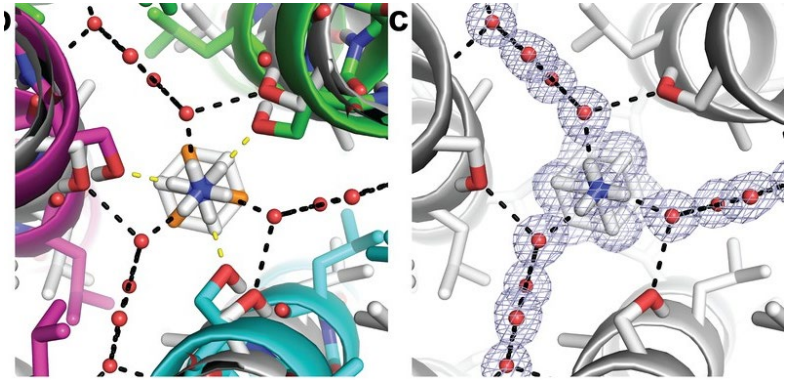
$T_{1(n)}$ health

$T_{2(n)}$ subclinical disease

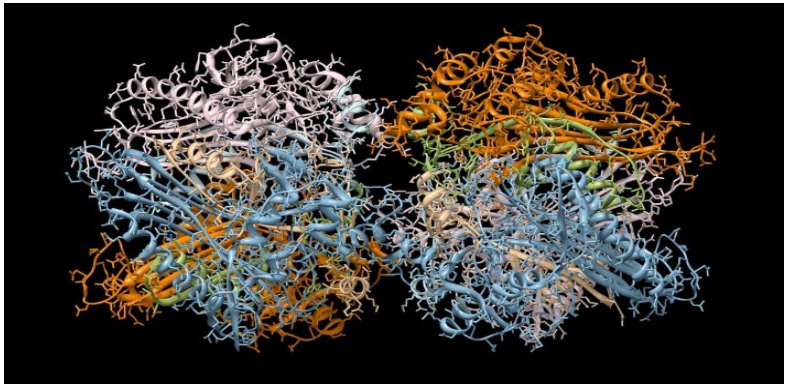
$T_{3(n)}$ overt disease

- identification of biomarkers/diagnostics and therapeutic targets in dysregulated networks
- DrugMechDB (2023) 4583 Rx indications, 5666 pathways
  32,249 molecular interaction networks across 14 biological parameters

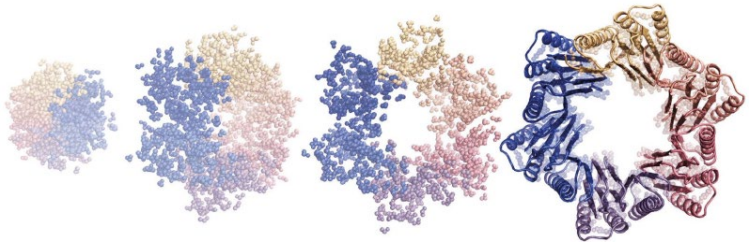
Use of ML-AI Protein Structure Prediction in Drug Discovery and Synthetic Biology



J. Park et. al. (2019) Elife doi.org/10.7554/eLife.47839



https://www.cnet.com/science/biology/googles-deepmind-ai-predicts-3d-structure-of-nearly-every-protein-known-to-science/

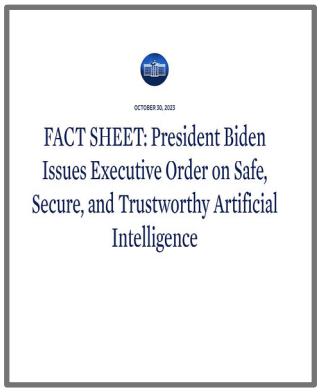


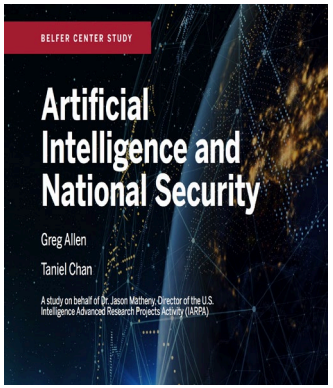
E. Callaway (2023) Nature 619:236-238; doi.org/10.1038/d41586-023-02227-y

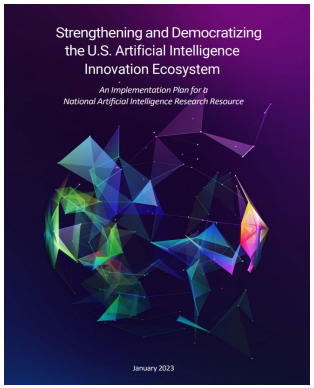
- Expanded Inventory of Novel Protein Structures
- Improved Drug-Pocket Affinities and Allosteric Sites
- Design of Protein-Protein Interactions
- Drugging the Undruggable
- Designer ADME, Targeting Systems for Drug Delivery and Cellular Therapy

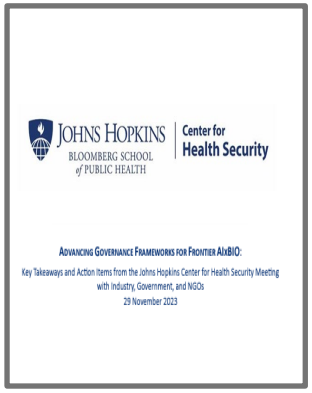
New Dual-Use Risks from the Convergence of Biotechnology, Synthetic Biology and AI (BIOxAI)

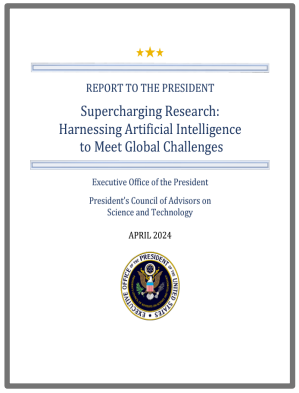
Biosecurity: Balancing Innovation with Risk Oversight

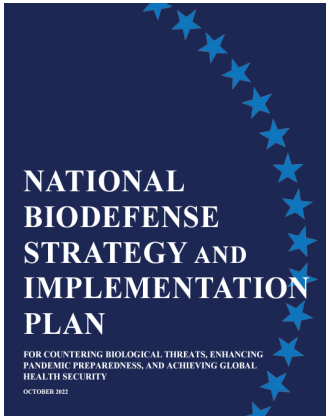


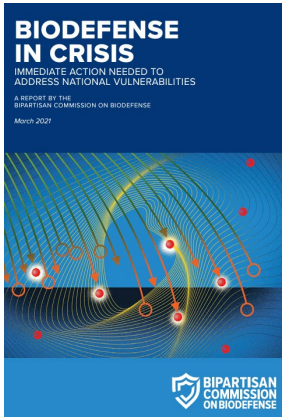


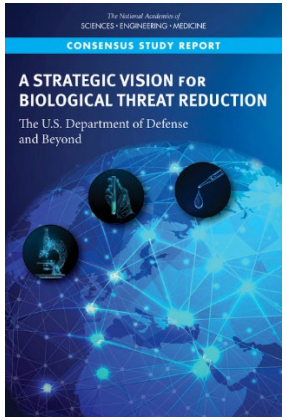


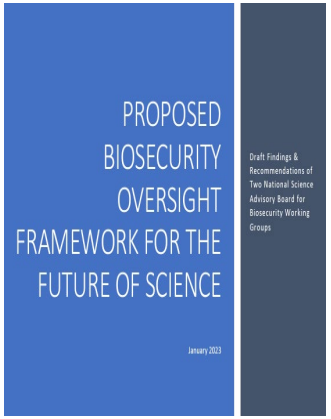


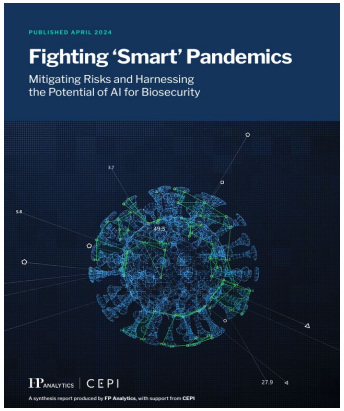


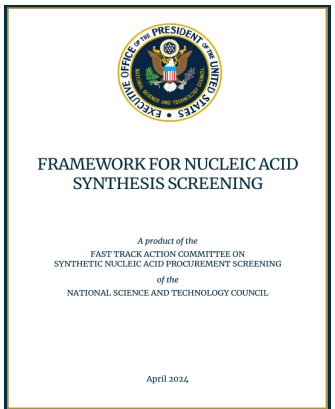


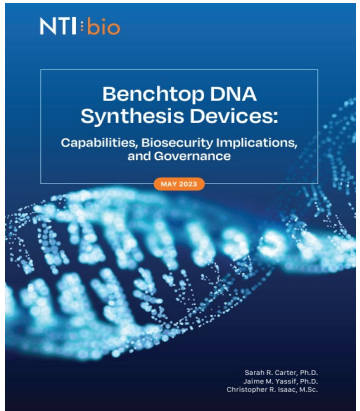






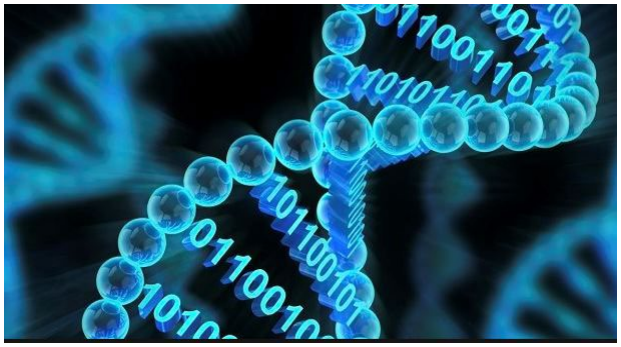




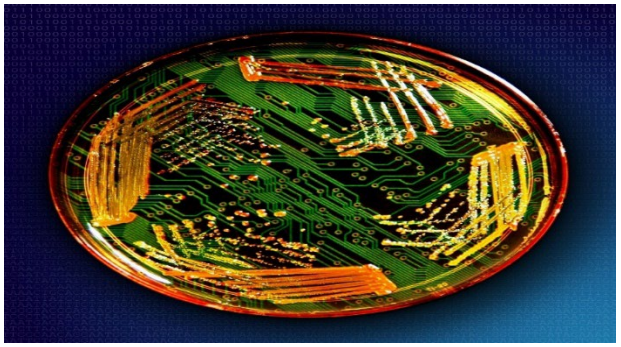


The Proliferation of Dual-Use Risks from the Intersection of Biotechnology, Synthetic Biology and AI (BIO x AI)

digital biology:
"it from bits"



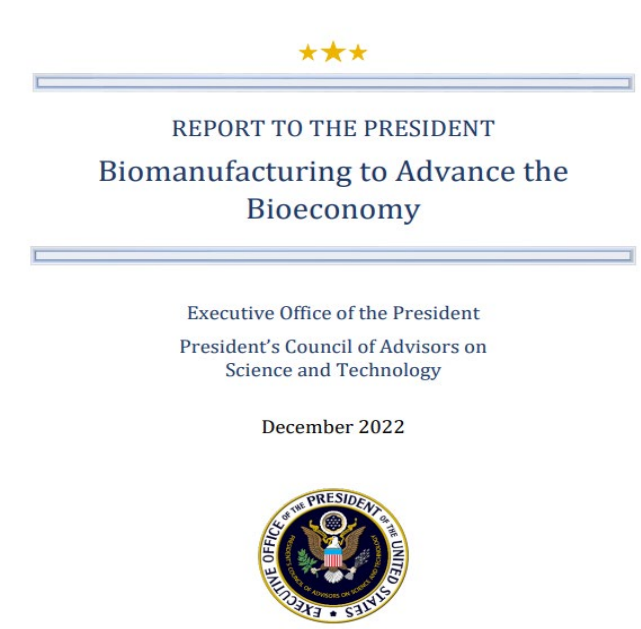
de novo
synthesis of organisms

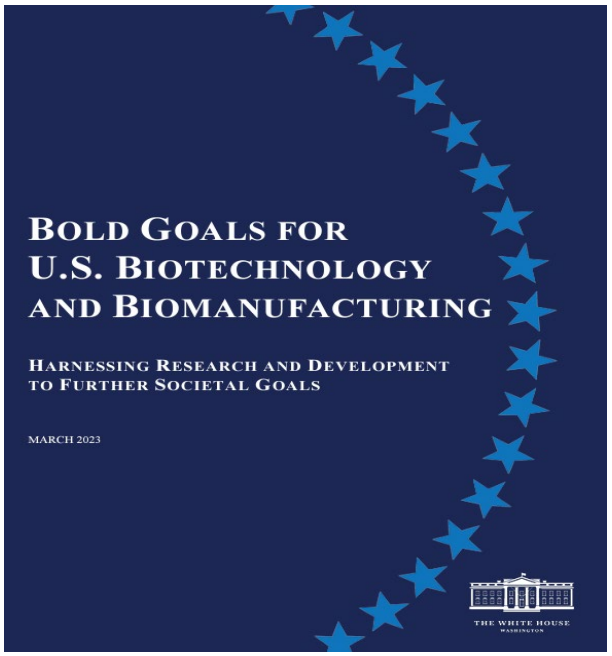


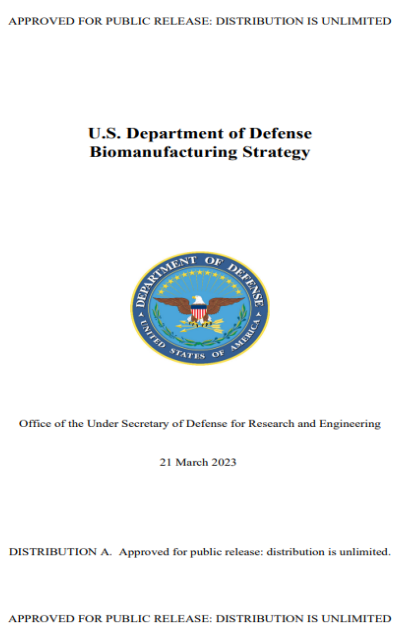
engineered
virulence

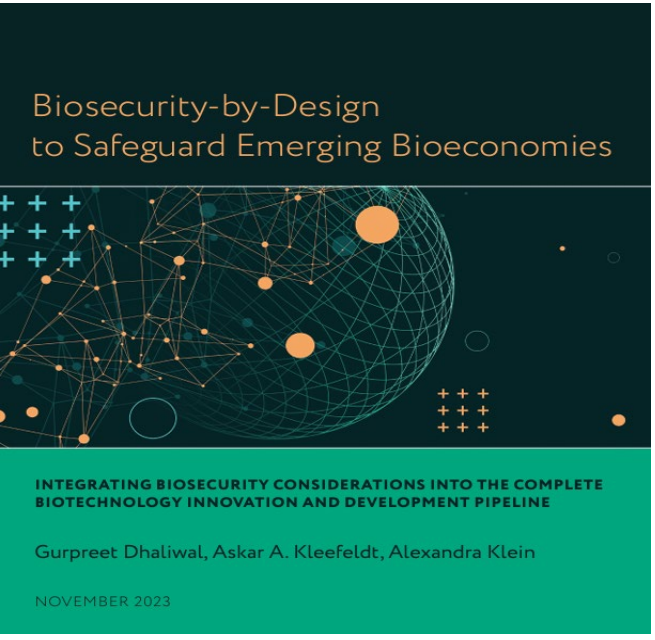
Beyond Bugs:
targeted modification of any biological pathway in any organ in any species

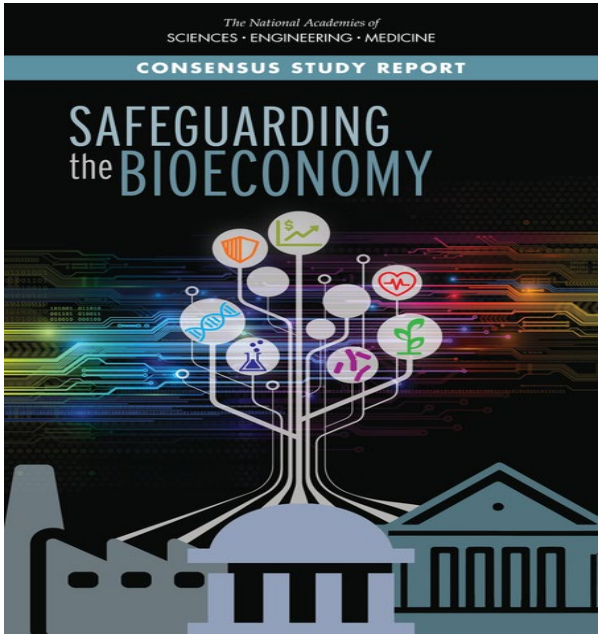
The Geopolitical Race for Commercial and Military Superiority in Applications of Biotechnology, Synthetic Biology and Artificial Intelligence

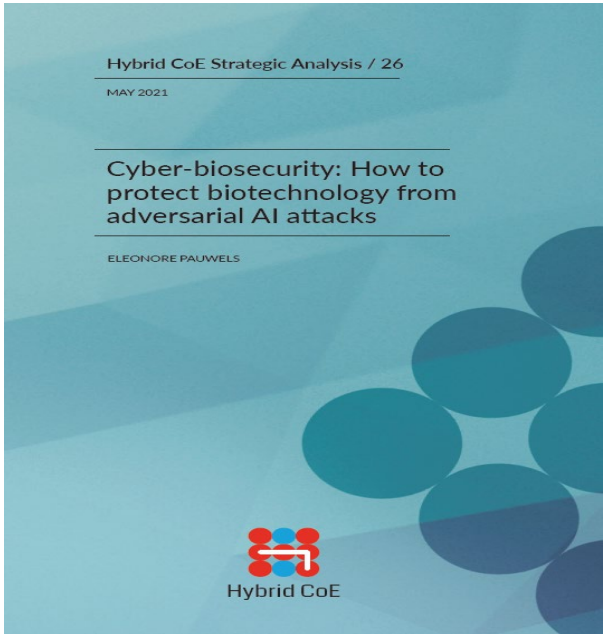










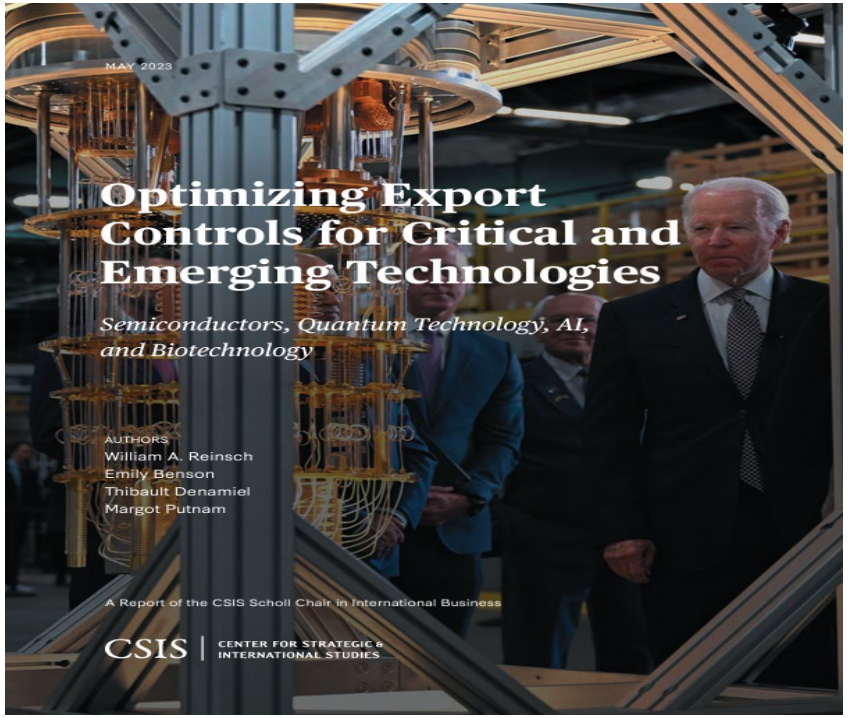


华大基因学院

BGI college

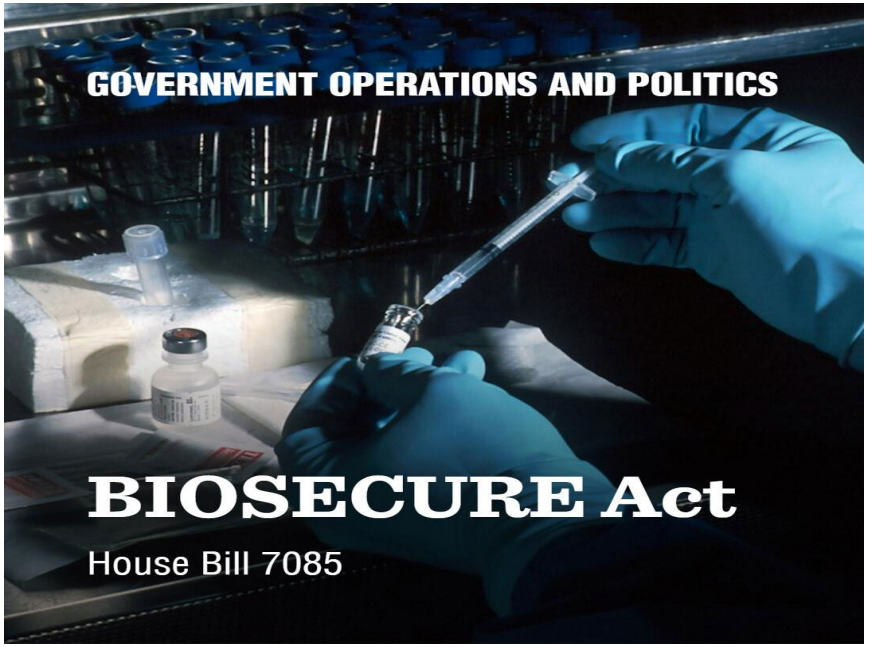
华大基因研究院

BGI research



Department of Commerce Export Controls for Biological Equipment and Technology

Chemical and Biological Controls Division
Office of Nonproliferation & Treaty Compliance



Gain-of-Function (GOF) Research on Modification of Microbial Pathogens

May 2024
IMPLEMENTATION GUIDANCE
for the
United States Government Policy for Oversight of Dual Use Research of Concern and Pathogens with Enhanced Pandemic Potential

- value of responsible GOF research in providing insight into potential future evolutionary pathways for pathogens
  - inform proactive development of Dx/vaccines/MCMs
- US legislative actions to tighten oversight of GOF research
- low probability of harmonization of international standards without robust transparency and enforced inspection (trust but verify)

Global Expansion of High Biosafety Level (BSL-3/4) Laboratories

- COVID-19 pandemic highlighted gaps in preparedness resources for handling high-risk pathogens
  - conventional public health (BSL-3)
  - expanded capabilities for translational research (Rx, vaccines)
- plans announced to build 27 new BSL-4 facilities
  - Russia (15), PRC (4), India (4), Kazakhstan, Singapore, Philippines, US (1)
- long lead times for construction and certification
- high operational costs ($15-20 million/year)
  - maintenance, air handling, security
- staff training and (re)certification in stringent-biohazard containment protocols to limit risk of biosecurity breach

Large Language Models and AI-Based Dual-Risk

A Framework to Evaluate the Risks of LLMs for Assisting CBRN Production Processes

CNS Washington, DC Office
NONPRO NOTES
FEBRUARY 2024

Ian Stewart

Middlebury Institute of International Studies at Monterey
James Martin Center for Nonproliferation Studies

OpenAI

Preparedness Framework (Beta)

We believe the scientific study of catastrophic risks from AI has fallen far short of where we need to be.

To help address this gap, we are introducing our Preparedness Framework, a living document describing OpenAI's processes to track, evaluate, forecast, and protect against catastrophic risks posed by increasingly powerful models.

December 18, 2023

RAND

Research Report

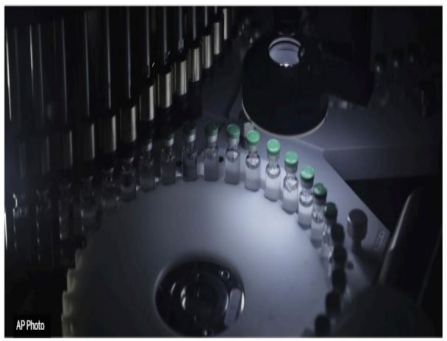
CHRISTOPHER A. MOUTON, CALEB LUCAS, ELLA GUEST

The Operational Risks of AI in Large-Scale Biological Attacks

A Red-Team Approach

https://www.rand.org/pubs/research_reports/RRA2977-1.html.

HARVARD Kennedy School
BELFER CENTER



POLICY BRIEF

Biosecurity in the Age of AI: What's the Risk?

Authors: Janet Egan, Eric Rosenbach | Nov. 06, 2023

Congressional Research Service
Informing the legislative debate since 1914

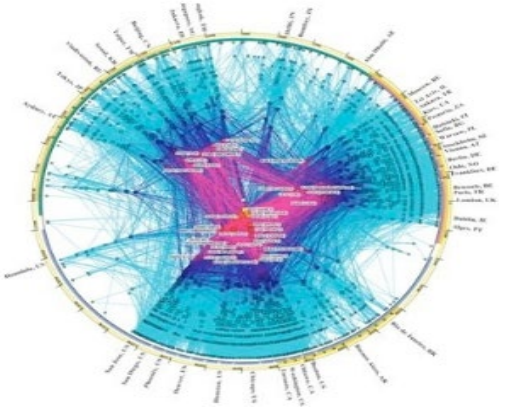
Artificial Intelligence in the Biological Sciences: Uses, Safety, Security, and Oversight

November 22, 2023

FACT SHEET: DHS Advances Efforts to Reduce the Risks at the Intersection of Artificial Intelligence and Chemical, Biological, Radiological, and Nuclear (CBRN) Threats

Apr 29, 2024

Large-Language Models and Generative Artificial Intelligence: A Looming Paradigm Shift in Scientific Discovery



Isolated Data	Complex Networked Data	Complex Computational Data

- availability of ever larger multimodal data and GAI-based LLM analytics
  - exabyte data scale (and beyond)
- automated combinatorial hyperdimensional analysis
  - large N parameters X large N entities (biospecimens, individuals, populations)
- paradigm shift from current dominance of hypothesis-driven research to hypothesis-free large scale data mining

Dual-Use Risks from the Intersection of AI, Biotechnology and Synthetic Biology

- LLM training sets require data
  - unless adversaries have access to unique data robust intelligence analysis and monitoring should identify risks and potential nefarious actors/actions
- theoretical expanded risk spectrum nonetheless requires adaptive risk monitoring tools
  - supply chains, multi-INT monitoring of laboratories of concern
  - advances in automated synthesis instruments (integrated gene-to-protein) and foreign purchase

Large-Scale Automation of Biomedical Laboratory Research

Building an AI Scientist.

Our 10-year mission is to build semi-autonomous AIs that can scale scientific research, to accelerate the pace of discovery and to provide world-wide access to cutting-edge scientific, medical, and engineering expertise.

WikiCrow: Automating Synthesis of Human Scientific Knowledge

FutureHouse

Dual-Use Biosecurity Risks from AI

- expanded cyber threats and corruption of databases/communication systems
  - public health/medical infrastructure
  - health records
  - biopharma manufacturing and product safety
- dissemination of disinformation/misinformation
  - erode public trust in institutions/decision-makers
  - amplify public concerns on safety of new technologies (GMO crops, mRNA vaccines, AI)
- targeted espionage and theft of innovation/IP (academia, industry)
  - PRC targeting of mRNA COVID vaccine companies

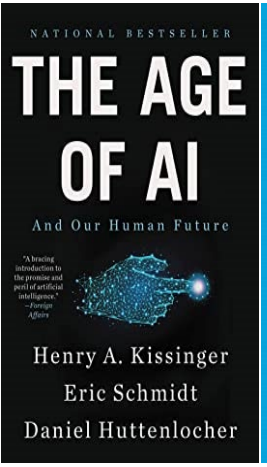
RUSI

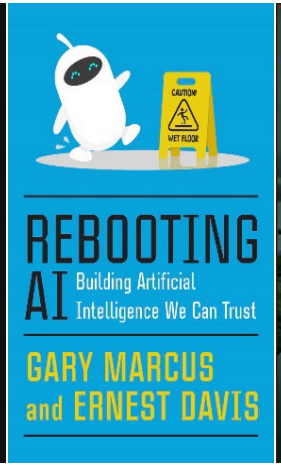
3 May 2024

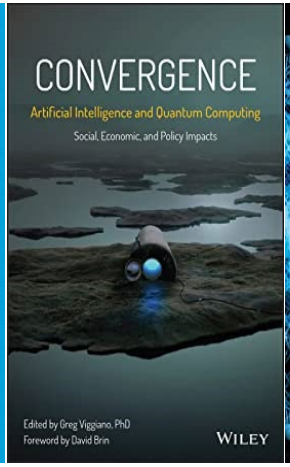
Xi Jinping's Information Support Force: A New Force for a New Era

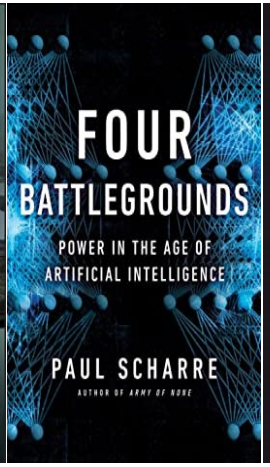
Digital Biology and a New Landscape for Dual-Use Technology Risk Assessment and Mitigation

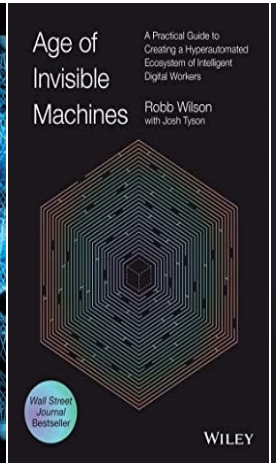
- understanding ‘rule sets’ the design and behavior of information networks complex biological systems
- engineered modulation with predictable outcomes
- expanding substrate for proliferation of dual-use risk for nefarious applications of targeted network modulation
- governance, oversight and regulatory challenges to limited dual-use abuse
  - detection, containment, attribution

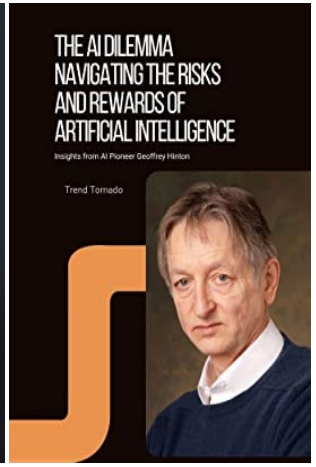


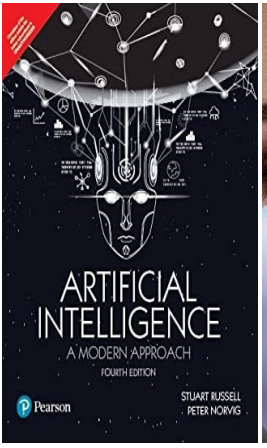


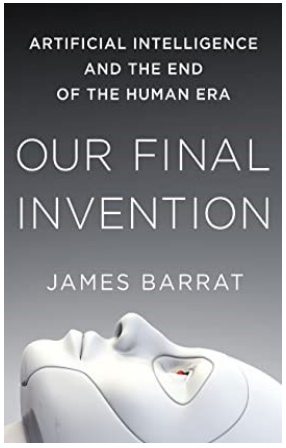


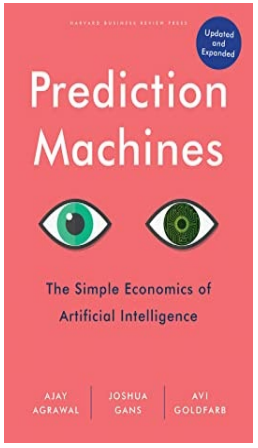


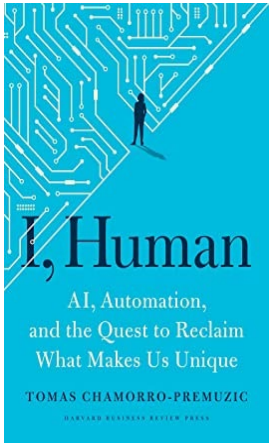


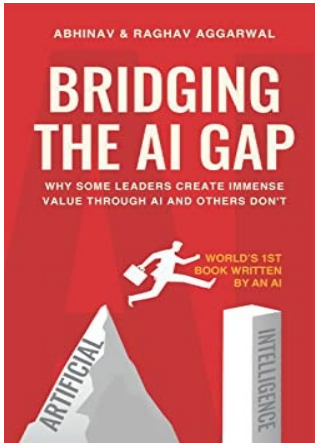


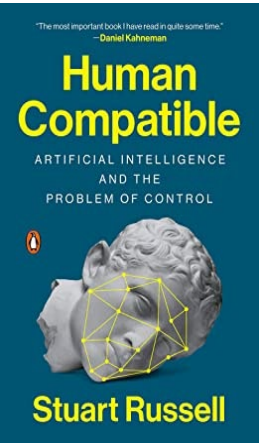


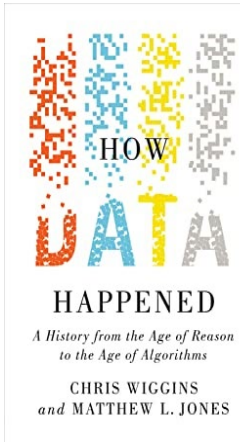


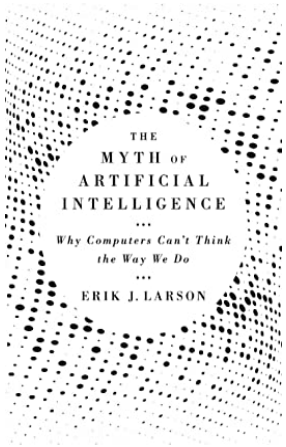


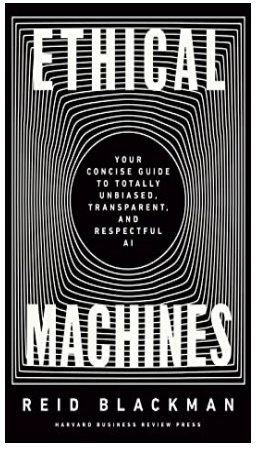


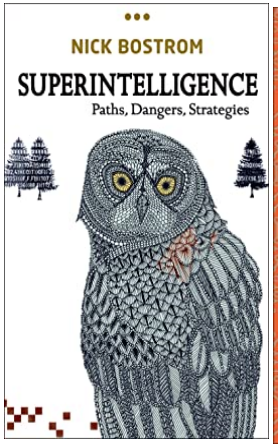


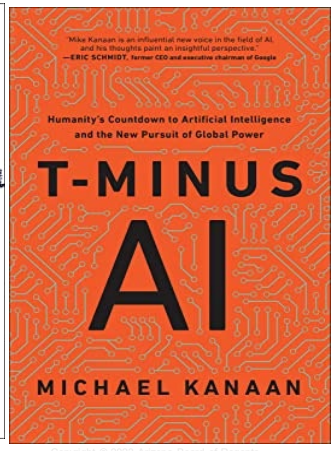












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Predicting and improving complex beer flavor through machine learning

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The perception and appreciation of food flavor depends on many interacting chemical compounds and external factors, and therefore proves challenging to understand and predict. Here, we combine extensive chemical and sensory analyses of 250 different beers to train machine learning models that allow predicting flavor and consumer appreciation. For each beer, we measure over 200 chemical properties, perform quantitative descriptive sensory analysis with a trained tasting panel and map data from over 180,000 consumer reviews to train 10 different machine learning models. The best-performing algorithm, Gradient Boosting, yields models that significantly outperform predictions based on conventional statistics and accurately predict complex food features and consumer appreciation from chemical profiles. Model dissection allows identifying specific and unexpected compounds as drivers of beer flavor and appreciation. Adding these compounds results in variants of commercial alcoholic and non-alcoholic beers with improved consumer appreciation. Together, our study reveals how big data and machine learning uncover complex links between food chemistry, flavor and consumer perception, and lays the foundation to develop novel, tailored foods with superior flavors.

Slides Available @ http://casi.asu.edu/presentations