
Seize the Day
The CFN in 2025
Charles (Chuck) Black
CFN Director
May 8, 2025
The Relativistic Heavy-ion Collider is an Ion Accelerator
The Center for Functional Nanomaterials is a Nanoscience Accelerator
The National Synchrotron Light Source II is an Electron Accelerator

The CFN aspires to accelerate the most important nanomaterial discoveries of the 21st century

Stone Age

Bronze Age

Iron Age

20th Century: e.g., Silicon, Steel, Plastics, …

?

21st Century

What will these materials be?

Why is nanoscience interesting?

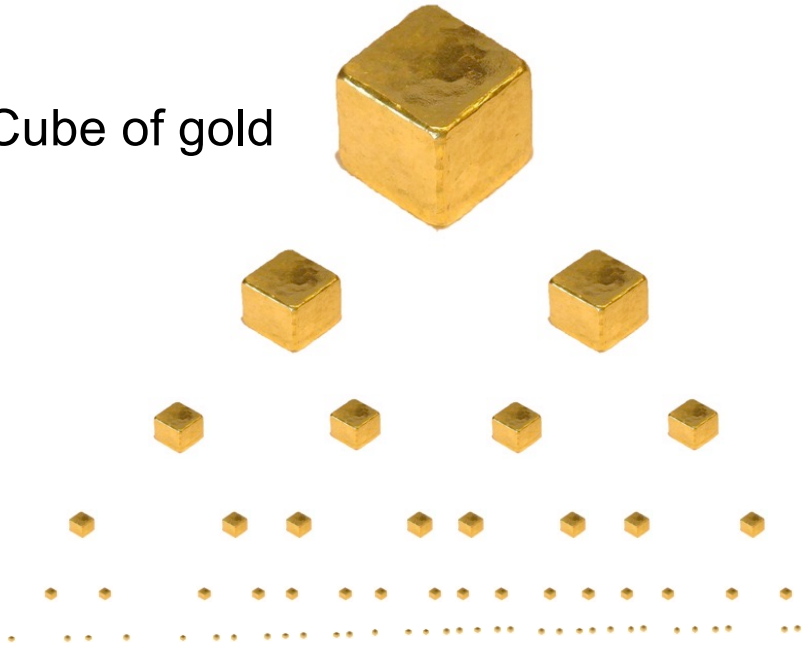
Materials with nanometer sizes are different from their larger versions, and sometimes better

Cube of gold

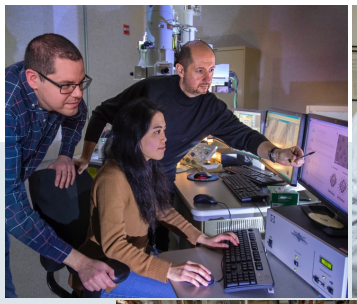
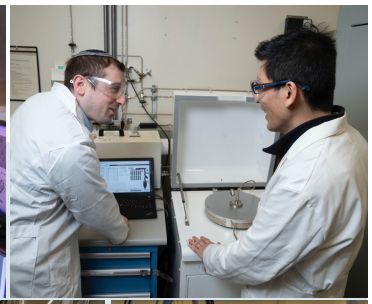
Is this still gold?

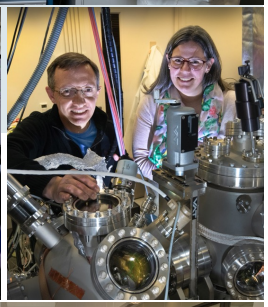
What about this?

???



CFN fosters team camaraderie through open discussions of our values and mission




Who we are:

We believe in **collaboration**.

Our skill and expertise **brings value to our users**.

We **balance** our support for user science and achieving our personal goals.

We strive for **excellence**.

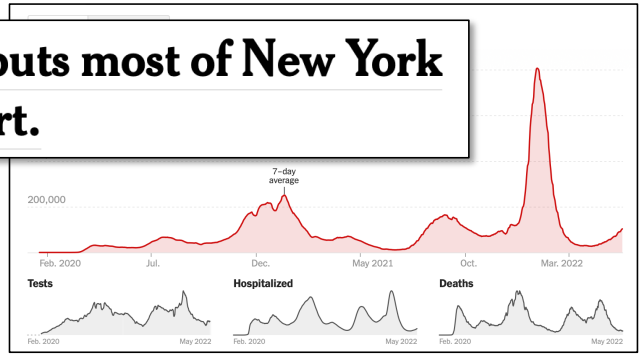
We are **resilient**. We use challenges as opportunities to get better.

We believe we're doing **work that matters**.

In accomplishing our mission, **we serve the nation** and the world.

It can be easy to feel our world is awash in impossible problems

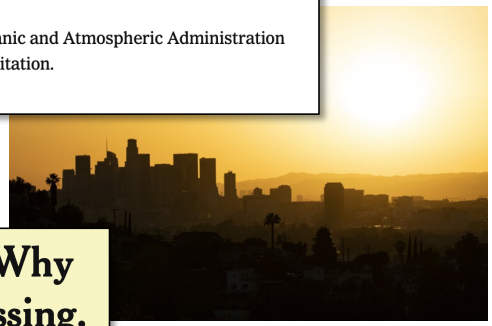
A surge in cases puts most of New York State on high alert.



Hot Times Ahead

During its monthly climate call, the National Oceanic and Atmospheric Administration warned of increased temperatures and low precipitation.

2d ago · By HENRY FOUNTAIN



Trash or Recycling? Why Plastic Keeps Us Guessing.

Why This Could Be a Critical Year for Electric Cars

Are You Concerned About Violence in America?

Globalization Is Over. The Global Culture Wars Have Begun.

Inflation Hits Fastest Pace Since 1981, at 8.5% Through March

What's the Best Way to Cope in an Anxious World? Do Something.

It can be easy to feel our world is awash in impossible problems

Let's resist the urge to say: "*Those problems are too big for me*."

Mission: NASA's OSIRIS-REx is the first U.S. mission to collect a sample from an asteroid and return it to earth.

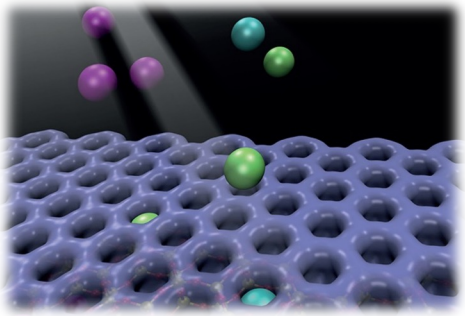
https://science.nasa.gov/mission/osiris-rex/

OSIRIS-REx mission so far: 2016-23

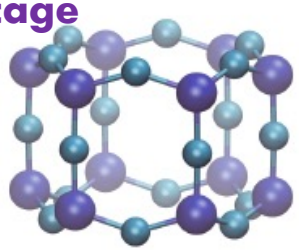
What's the Best Way to Cope in an Anxious World? Do Something.

Catching Noble Gases

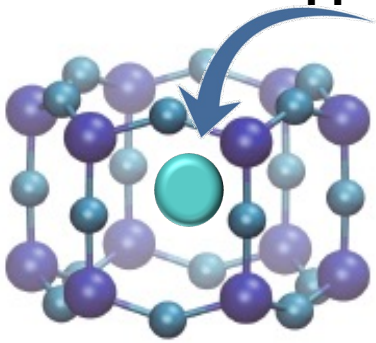
In 2016, CFN scientist Anibal Boscoboinik discovered that porous materials he synthesized could trap single atoms of Argon, and other noble gases



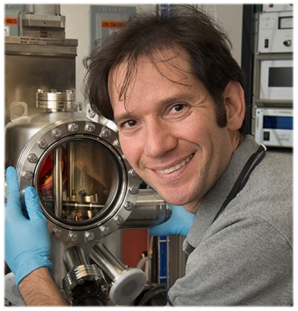
Silica
Nanocage



Noble gas:
Argon, Xenon, Krypton, Radon



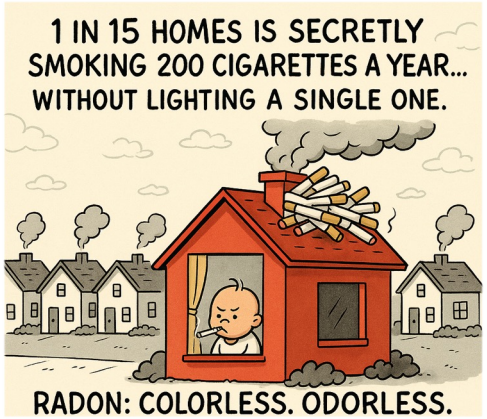
Trapped noble gas



- Noble gases are not so easy to trap, because they are non-reactive. The work resulted in several **scientific publications** and **US patent 12,005,391**
- The team is continuing work to develop higher surface area materials to trap noble gases.

Catching Noble Gases

- Radon is a hazardous gas.
- The second leading cause of lung cancer worldwide
  - 21,000 deaths annually in the US
- Current methods to detect & remediate Rn need improving



- Student-led **Radon remediation business plan** won the MSI Connect competition in 2024, based on CFN patent
- Founded **RadonLock Innovations** in 2025; seeking development funding

A Recent ”Deep Dive” podcast about the CFN

- A recent 20-minute podcast about the CFN (!!)
- Let’s listen to a 2-minute snippet to hear what they have to say about us

Here’s a secret:

+ This podcast was created by Artificial Intelligence (!!!).
+ AI is an incredible new tool with potential to **change the world, and improve the way science is done.**
+ It’s an exciting time! ☺

It's an especially exciting moment to be alive

In our lifetimes, we'll all experience a few instances when something happens that changes the world

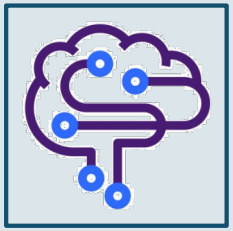
1980s: PCs

1990s: World Wide Web

2000s: iPhone

[thefacebook]

2010s: Social Media



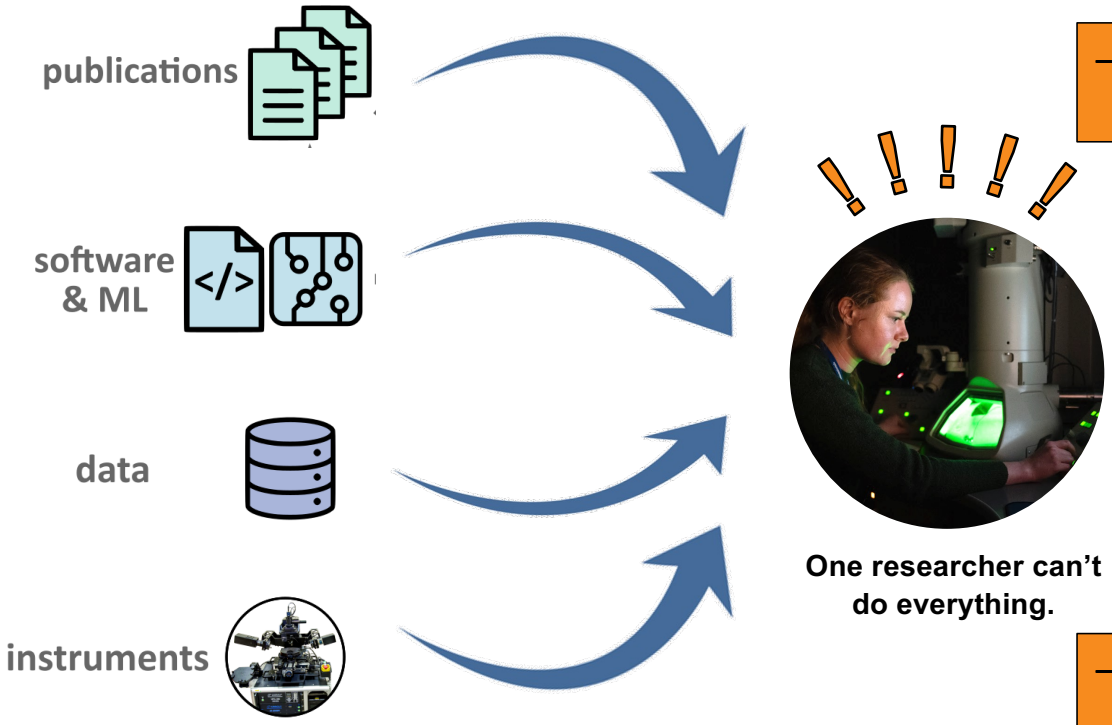
2020s: AI

It is **thrilling** to be working at this moment in time!

AI is poised to <u>fundamentally change</u> the way science is done (for the better!)

CFN aspires to be at the **leading edge** of this revolutionary change

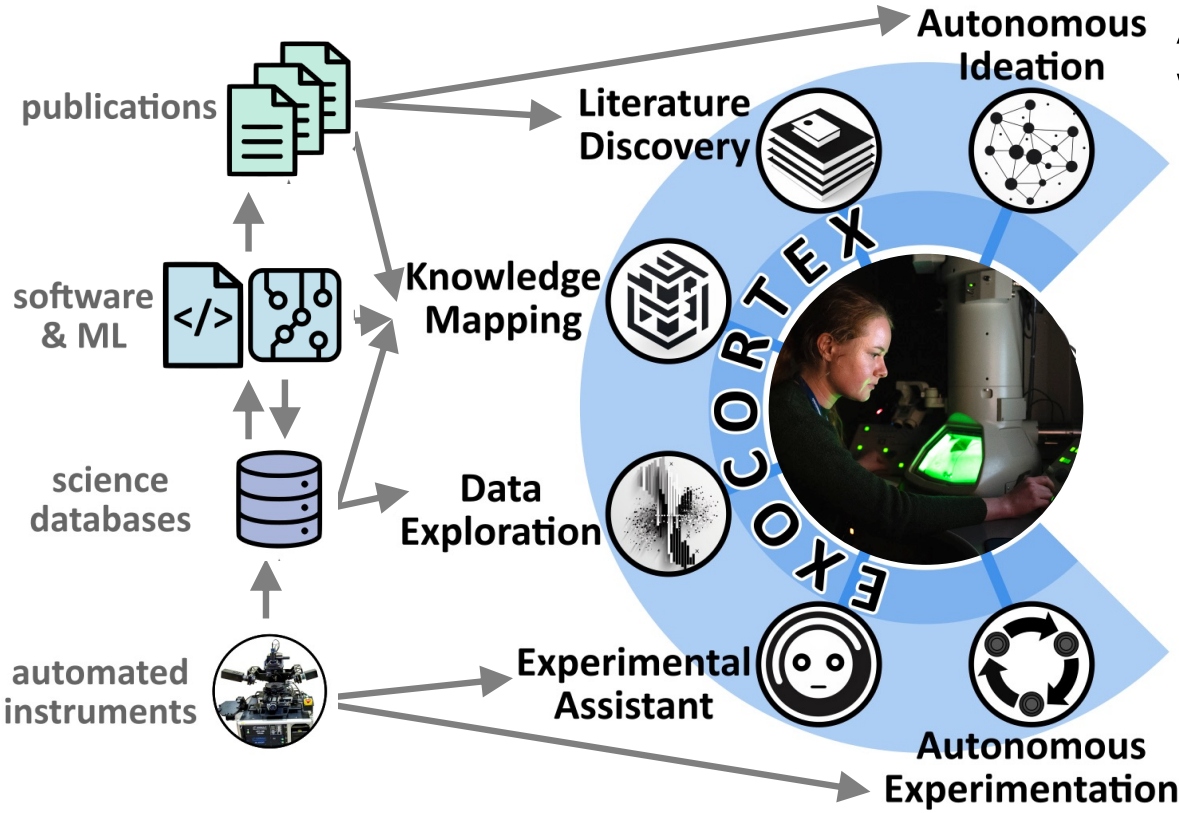
Today's researchers are limited by the amount of knowledge and skill that any one person can have



One researcher can't do everything.

- Too many **scientific papers** out there; no time to read them all
- **Software**, and machine learning tools we don't know how to use, or aren't even aware of
- Scientific **data** that's related to our research, but that we don't know about and can't access
- **Instruments** we don't know how to operate; **techniques** we don't know exist

CFN is building an AI “nanoscience exocortex”



A team of AI agents will extend what researchers can do

Our AI team will help us:

- Find and understand papers
- Use software
- Glean science databases
- Operate instruments
- …and even suggest new research ideas (!!!)

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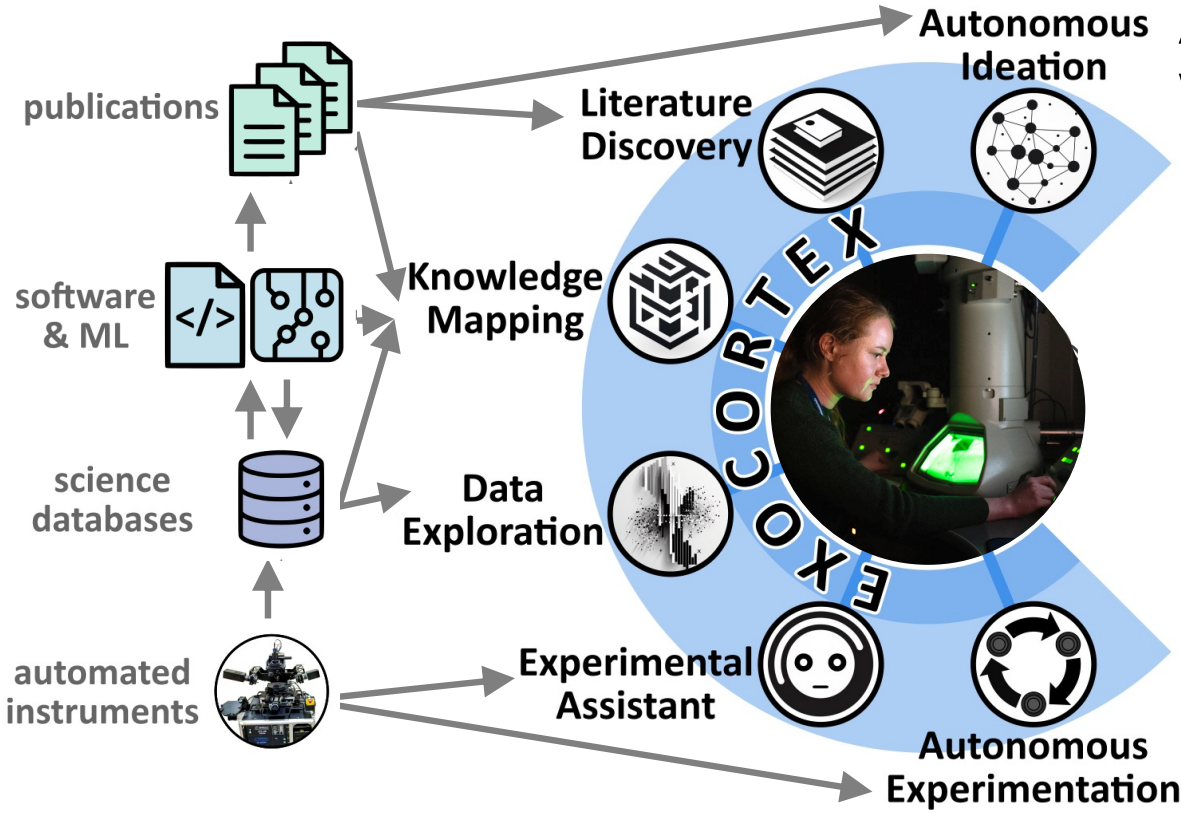

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Our team of AI agents will work together, **surfacing ideas** and **engaging us** for key decisions

“inspiration”

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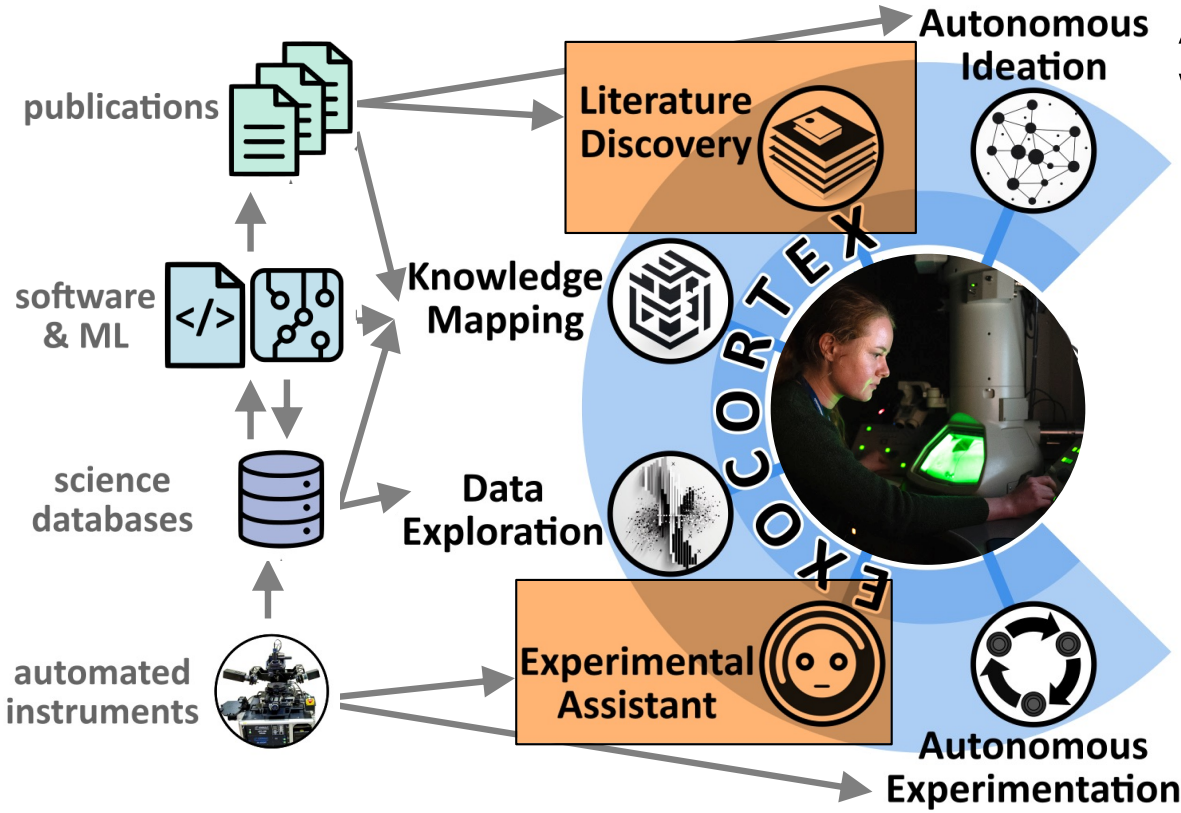

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“inspiration”

Building a trustworthy nanoscience ChatBot

CFN scientist Kevin Yager

The CFN has built a nanoscience ChatBot

- Grounds answers in trusted publications, eliminating the hallucinations common in general AI ChatBots.

The nanoscience ChatBot can answer user questions by **referring them to appropriate past, published work that used CFN facilities**

Which CFN instruments are best for certain measurements?

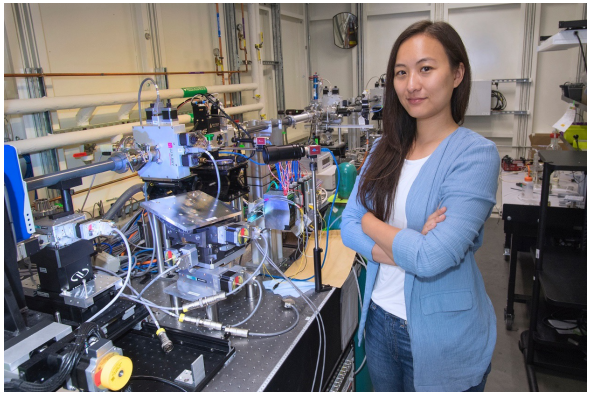
Have past CFN users worked on a material similar to mine? What types of studies did they do?

Can you help me think about what I could learn about my material by bringing it to CFN?

K. G. Yager, *Digital Discovery* **2**, 1850 (2023).

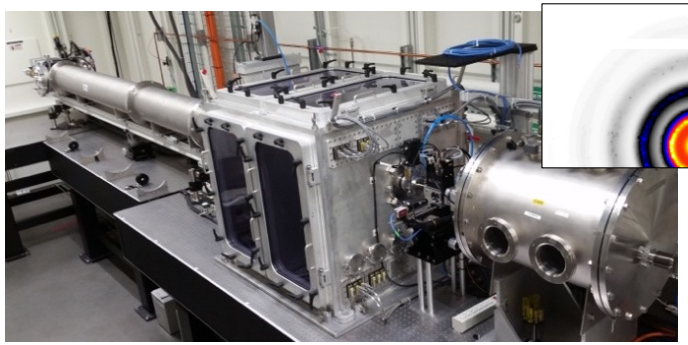
VISION: an AI virtual scientific companion

CFN scientist Esther Tsai is developing a virtual scientific companion for synchrotron X-ray experimentation



Marvels Comics “The Vision” is an android with immense superpowers, aligned with the forces of good.

VISION will support natural-language interactions between scientist & instrument
i.e., we’ll operate instruments by talking to them



You can already operate CMS by talking to it (!!)

Potemkin, Soto, Li, Yager, Tsai *arXiv* **2024**, 2312.17180

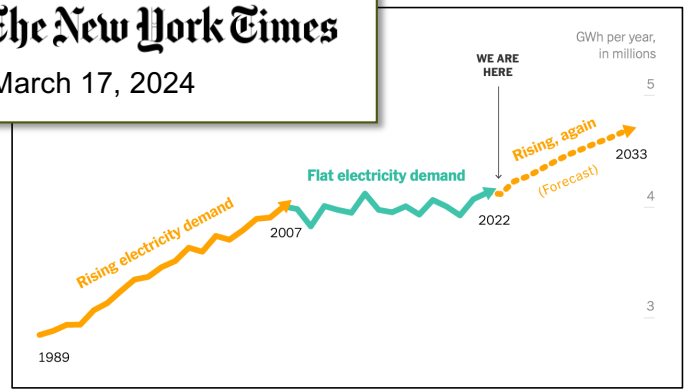
Society's ambitions (including for AI) require creative solutions for more scalable microelectronics

By 2035, general computing is projected to consume >30% of total planetary energy production!

www.src.org/about/decadal-plan/

The New York Times

March 17, 2024



Why Microsoft made a deal to help restart Three Mile Island

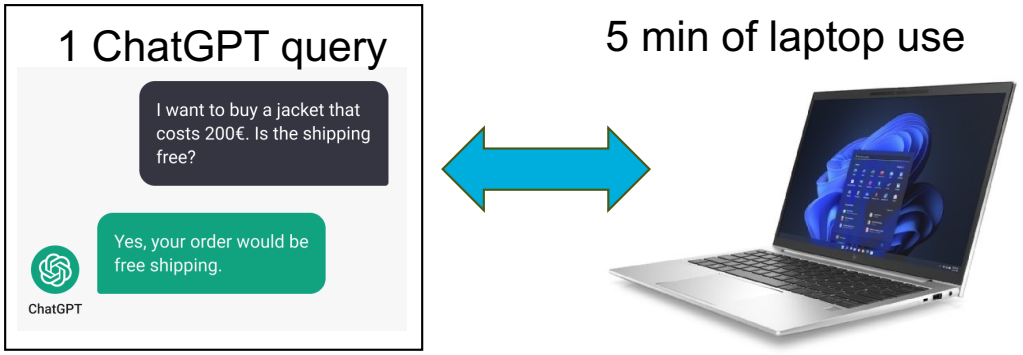
A once-shuttered nuclear plant could soon return to the grid.

An exciting time for nanomaterial research!

AI is an Energy Guzzler!

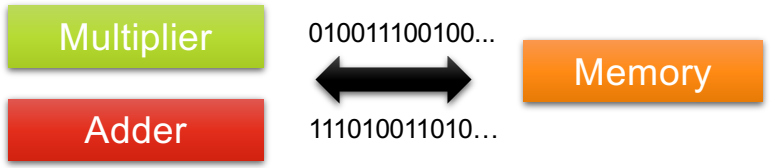
One ChatGPT query costs about ~3 Wh (including the LLM training)

That amount of power can run your laptop for about 5 min!



Why does AI use so much energy?

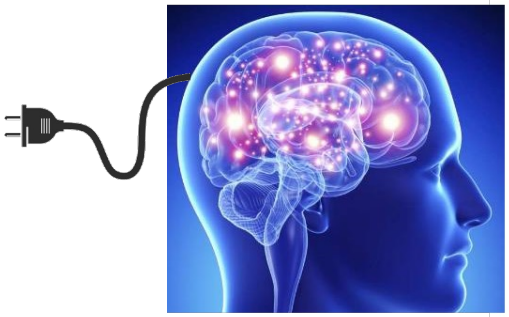
- AI computations involve a LOT of vector matrix multiplication
- Doing this sort of math with traditional computing architectures is highly inefficient



Data shuffling costs a lot of energy

Neuromorphic (i.e., 'brain-like) computing

Our brains are extremely efficient and powerful computers



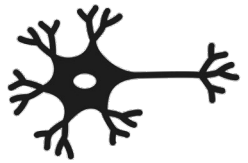
Our brains can perform 10^{18} calculations/s on ~10W power (i.e., a few cheeseburgers)

A supercomputer can also perform 10^{18} calculations/s but needs ~10MW power (i.e., a power plant)

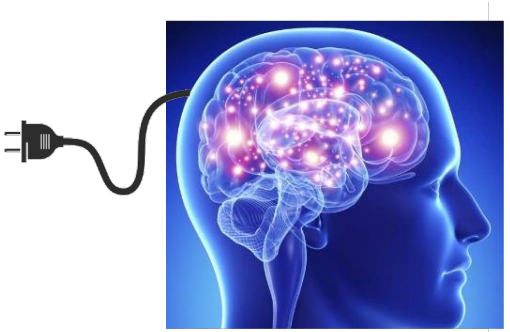
Brains aren't better than CPU-based computing at all calculations, only some kinds:

e.g., Pattern matching = ☺! Multiplying large numbers = ☹.

CFN scientists (and many worldwide) are researching new computing materials and architectures that mimic the way the brain does calculations



Our brains are excellent ‘pattern matching’ computers!



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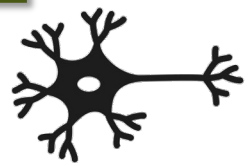
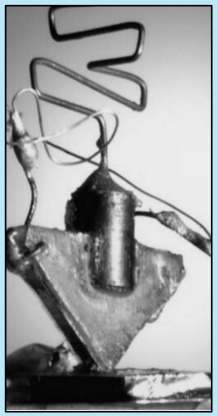
In May, CFN Drceitor Cuhck Blcak vtsieid wtih the Bkaohveern Lab Cmunomity Advoisry Cmoimttee to tlak aubot how nancosicene can mkae a bteetr fturue.



Motivation: Materials Science has underpinned the classical information technology revolution



The first transistors were **Germanium….**

…but our world runs on **Silicon** technology

What are the electronic materials that will enable ‘brain-like’ circuits for low-power AI?

No one knows yet. ☺

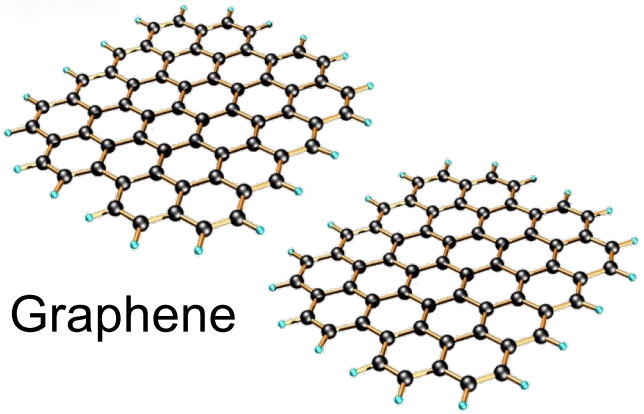
The properties of materials depend on how atoms are arranged

The promise of nanoscience is creating materials with new arrangements of atoms, with new and better properties

Coal

Diamond

Graphite



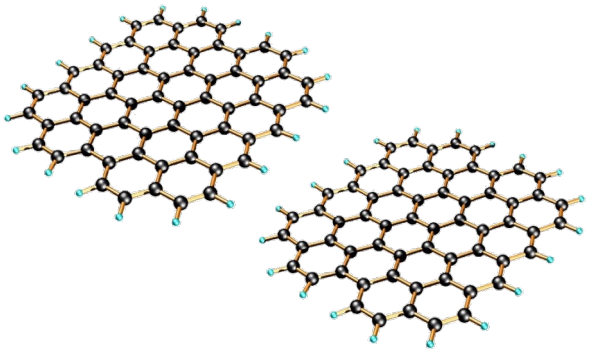
Graphene

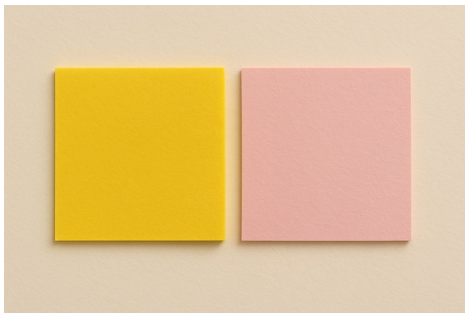
Graphene is:

- Near completely transparent
- Incredibly strong, yet flexible
- A fantastic electrical conductor

Two stacked graphenes can have properties different from <u>any known material</u>

Twisting 2D materials



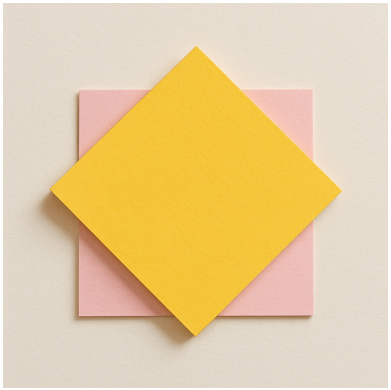


Post-in notes

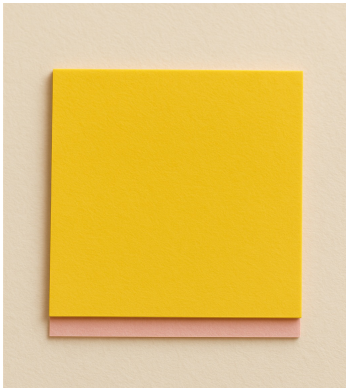
Why does this happen?

- Changing the angle between layers alters atomic alignment and electrical properties

Twisting the graphene layers gives the material new properties

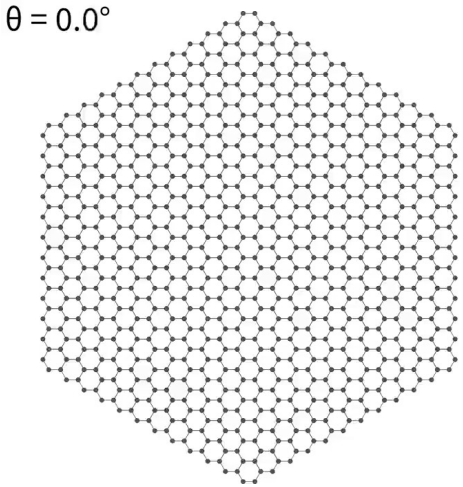


“Metal”



“Insulator”

“Superconductor”



The Quantum Material Press

QPress

The QPress is a unique-in-the-world instrument to help scientists robotically design and assemble materials from 2D layers

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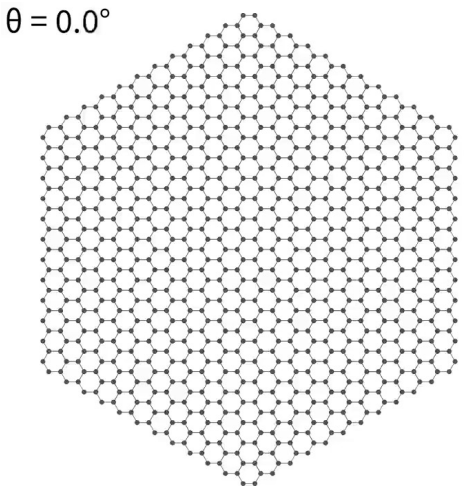

What's the Best Way to Cope in an Anxious World? Do Something.

But what happens when you go 'All-In,' and things don't work out?

Because Doing Science is Hard. And Losing Hurts!

In science, we deal with setbacks **all the time**:

- Our experiments or calculations don't work the way we think they should. ☹
- Our instruments break. ☹
- Our journal submissions get rejected. ☹
- Our proposals aren't funded. ☹
- Our patent applications are denied. ☹

When we lose, we can become apprehensive about taking on the next challenge.

How can we stay optimistic after setbacks, so we keep striving to do important things?

Don't do this.

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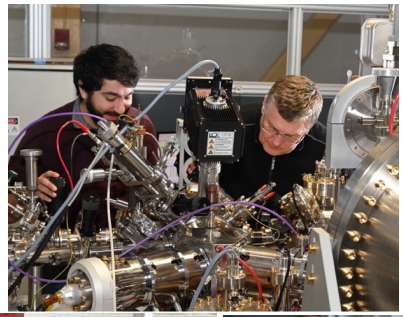
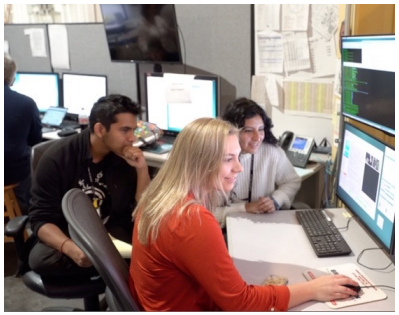
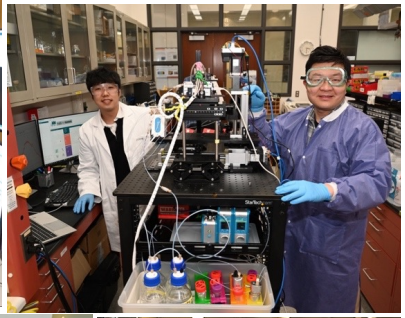
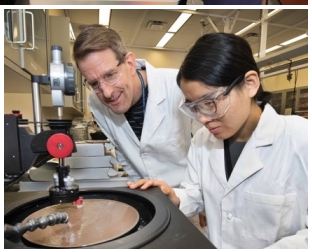
Do this!

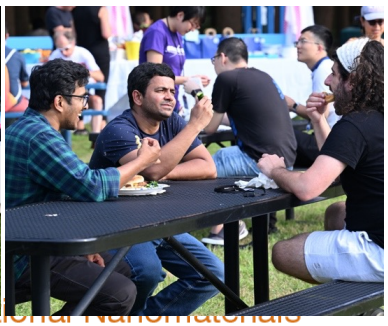







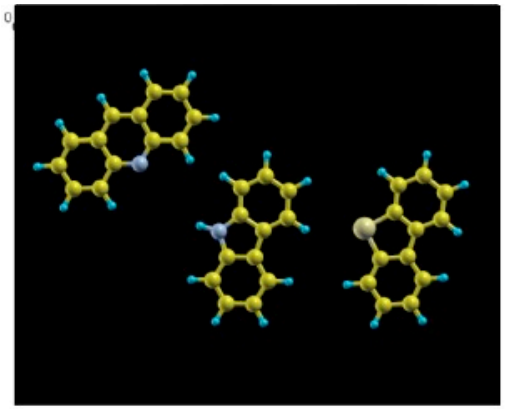
The collaborative culture is a kind of infrastructure — it sustains us when things get difficult.

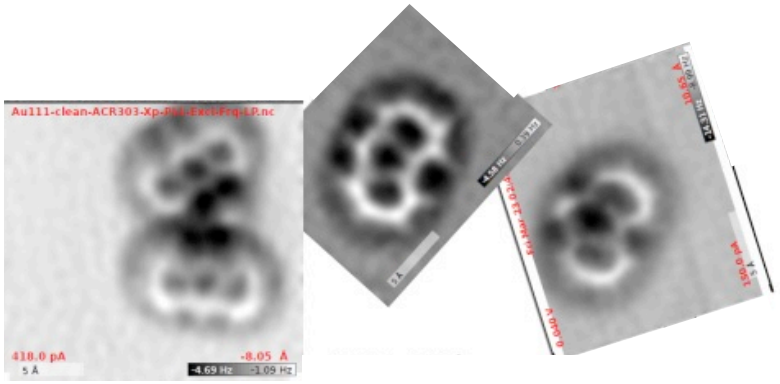





Seeing individual hydrocarbon molecules

CFN operates a highly specialized, low-temperature microscope that is one of only ~few in the world that can see individual, polyaromatic hydrocarbon molecules





Acridine Dibenzothiophene

Carbazole

ExxonMobil

Energy lives here™

CFN scientist Percy Zahl

Seeing hydrocarbon molecules found in “Stardust”

- The Murchison meteorite fell in Australia in 1969
- Rich in organic compounds
- One of the most highly studied meteorites

The New York Times

NEW YORK, WEDNESDAY, DECEMBER 2, 1970

December 2, 1970

Meteorite Hints Space Life Is Possible

By RICHARD D. LYONS
Special to The New York Times

WASHINGTON, Dec. 1— he freshest and strongest clues to the existence of conditions suitable for the possible evolution of life beyond the earth were reported today by a team of American scientists.

mordial ooze of chemicals present after the crust solidified, but also that f it happened here it could have occurred elsewhere in the universe.

In the last several years, radio astronomers using in-

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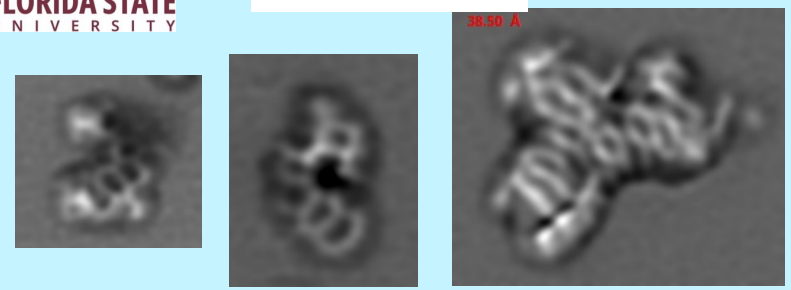

These are images of the **largest extra-terrestrial hydrocarbon molecules** ever found and identified (!!!)

Seeing hydrocarbon molecules found in “Stardust”

Mission: NASA’s OSIRIS-REx is the first U.S. mission to collect a sample from an asteroid and return it to earth.

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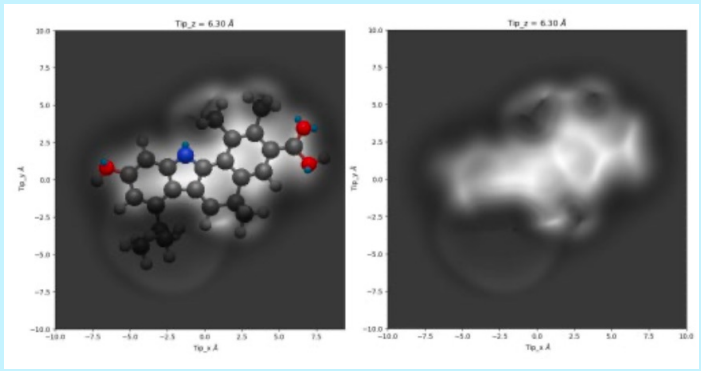

- These are hydrocarbons found on the asteroid Bennu (!!).
- These types of molecules may have never before existed on earth.
- This work may help us **understand how life started on earth**. (good grief!!)

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