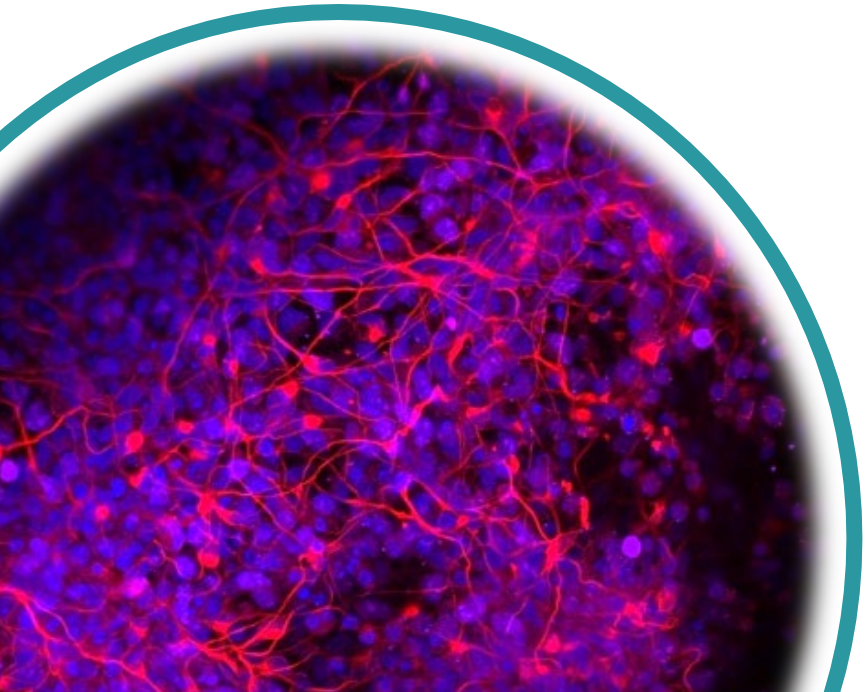
AI for Real-Time Precision Health

predictive biology from cell classification to acute trauma care

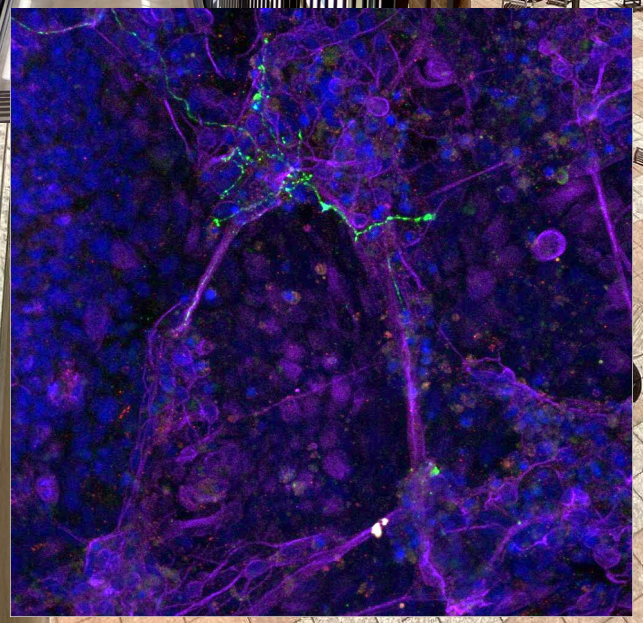
February 2, 2025



US-Kuwait Precision Medicine Workshop

Session II: AI and the Future of Precision Medicine

Amina Ann Qutub, PhD



palo bio

TRAUMA RESEARCH AND COMBAT CASUALTY CARE COLLABORATIVE
An initiative of The University of Texas System

SAN ANTONIO MEDICAL FOUNDATION

NSF NIH AIM AHEAD

Amina Ann Qutub, PhD

Burzik Professor in Engineering Design
Associate Professor, Biomedical Engineering, UTSA
Co-Director, Center for Precision Medicine
Director, UTSA-UT Health Graduate Group in Biomedical Engineering
Assistant Director, AI MATRIX | Brain Health Consortium

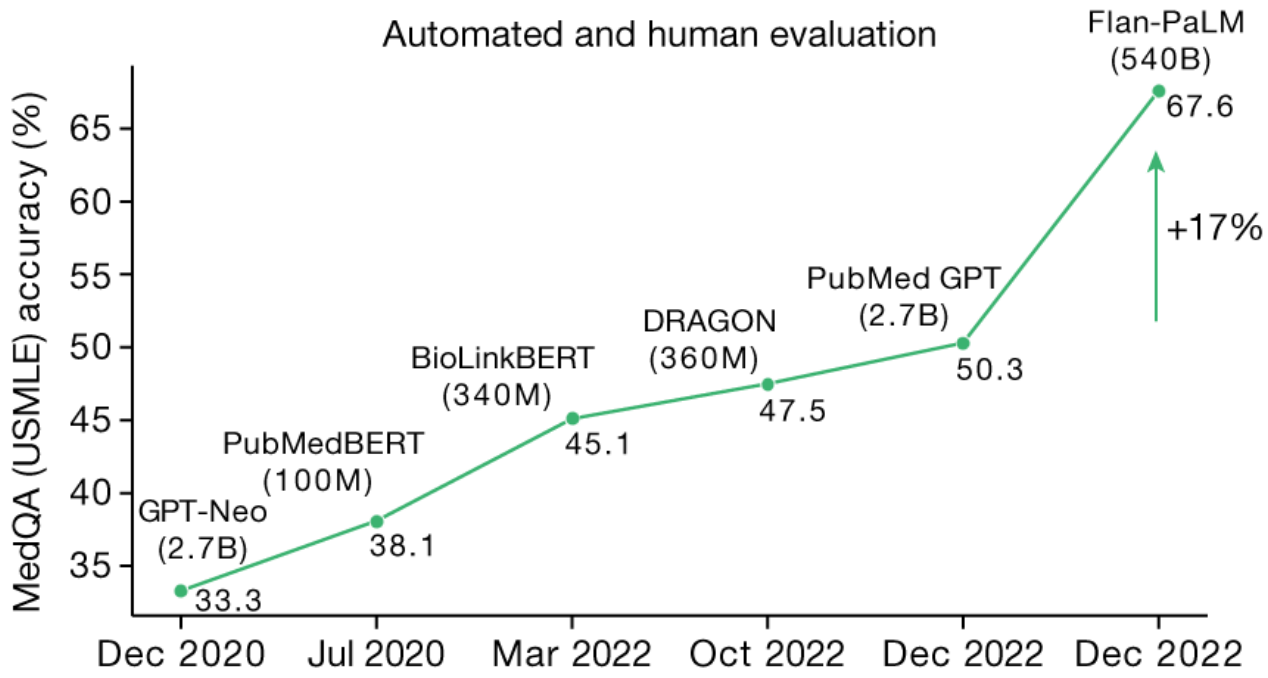
Intro & Disclosures

Large language models encode clinical knowledge

Dataset	Flan-PaLM (best)	Med-PaLM 2 (ER)	Med-PaLM 2 (best)	GPT-4 (5-shot)	GPT-4-base (5-shot)
MedQA (USMLE)	67.6	85.4	**86.5**	81.4	86.1
PubMedQA	79.0	75.0	**81.8**	75.2	80.4
MedMCQA	57.6	72.3	72.3	72.4	**73.7**
MMLU Clinical knowledge	80.4	**88.7**	**88.7**	86.4	**88.7**
MMLU Medical genetics	75.0	92.0	92.0	92.0	**97.0**
MMLU Anatomy	63.7	84.4	84.4	80.0	**85.2**
MMLU Professional medicine	83.8	92.3	**95.2**	93.8	93.8
MMLU College biology	88.9	95.8	95.8	95.1	**97.2**
MMLU College medicine	76.3	**83.2**	**83.2**	76.9	80.9

Singhai et al, Nature, 2023
arXiv:2305.09617v1, 2024

Dataset	GPT-4 (5-shot)	GPT-4-base (5-shot)
MedQA (USMLE)	81.4	86.1
PubMedQA	75.2	80.4
MedMCQA	72.4	**73.7**
MMLU Clinical kno	86.4	**88.7**
MMLU Medical gen	92.0	**97.0**
MMLU Anatomy	80.0	**85.2**
MMLU Professional	93.8	93.8
MMLU College biol	95.1	**97.2**
MMLU College med	76.9	80.9



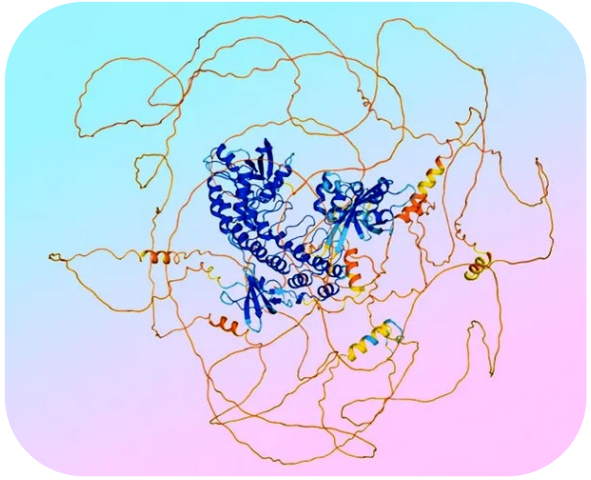
Q: How long does it take for newborn jaundice to go away?

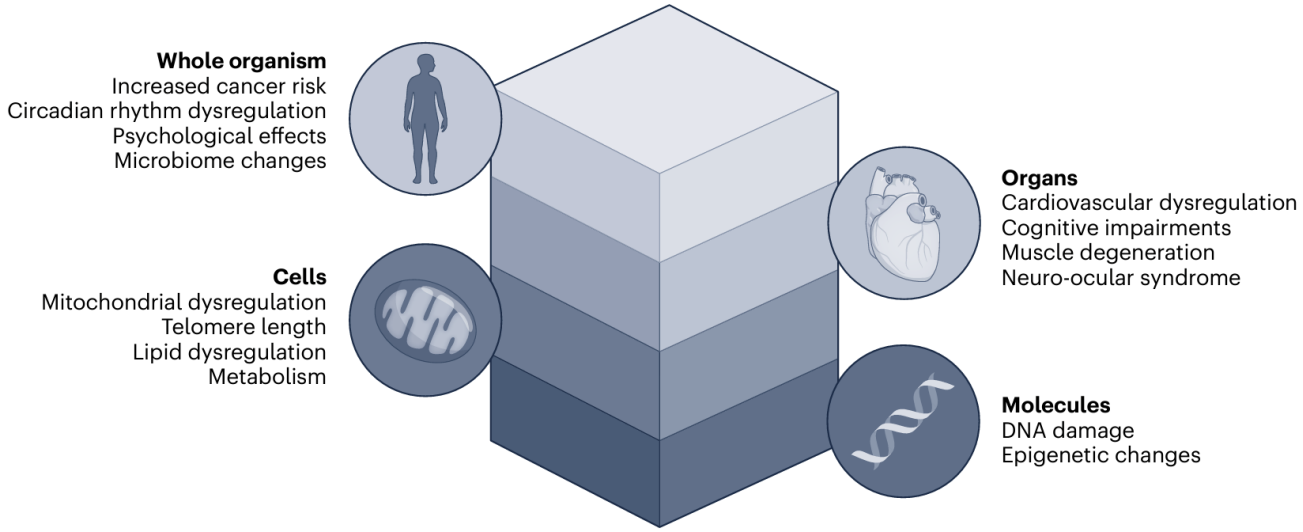
Med-PaLM: Newborn jaundice is when a newborn baby's skin and eyes look yellow. It is caused by a buildup of a substance called bilirubin in the baby's blood. Bilirubin is a byproduct of the normal process of red blood cells breaking down. Newborn jaundice is common and typically harmless, but it can be a sign of a more serious condition. The jaundice typically goes away on its own within a few weeks. In some cases, it may last longer or require treatment. The time it takes for the jaundice to go away can vary depending on the cause and the severity of the jaundice. If the jaundice is severe or lasts longer than a few weeks, the doctor may recommend testing or treatment to determine the cause and prevent complications.

Med-PaLM performs encouragingly
on consumer medical question answering

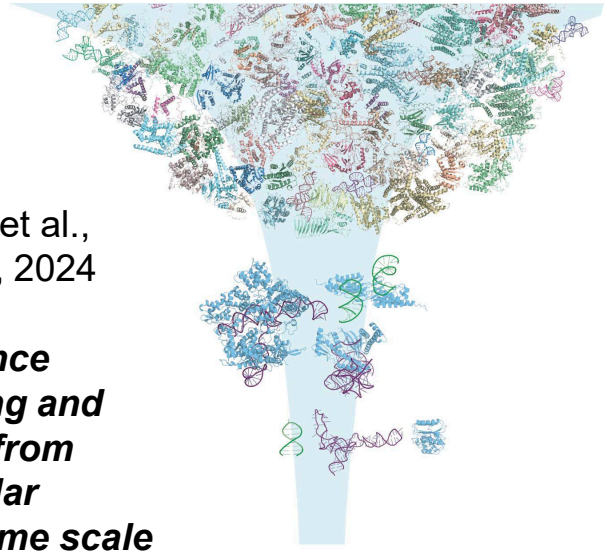
Abramson et al, Nature, 2024

Alpha-Fold3



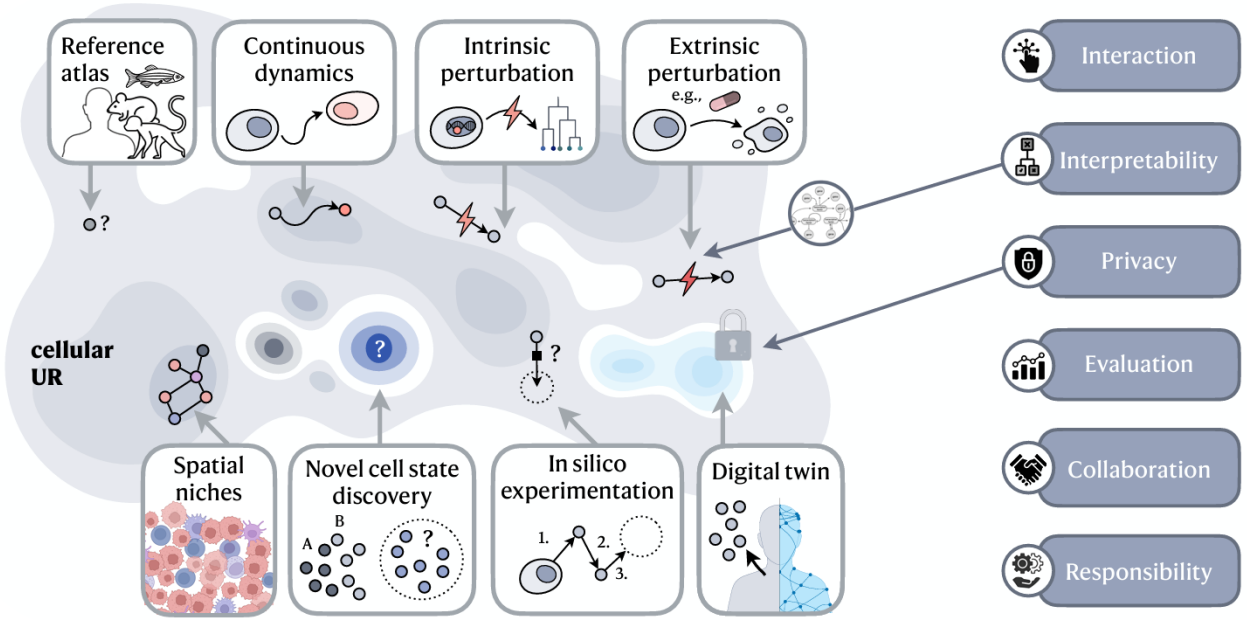


Sanders et al., Nature Machine Learning, 2023 "***Biological research and self-driving labs in deep space supported by artificial intelligence***"



Nguyen et al., Science, 2024

"***Sequence modeling and design from molecular to genome scale with Evo***"



Bunne et al., Cell, 2024 "***How to build the virtual cell with artificial intelligence***"

Where AI and automation are transforming the biosciences:

- AI breaks reliance on knowns & priors
- AI and automation speed up experiments
- AI is reinventing how R&D is performed
- Enables remote access to labs 24/7
- Augments decision-making
- Enables bridge between digital and physical worlds
- Enables scientists' time to be spent on experimental planning and thought

National Academies Workshop, 04.2024

Emerald Cloud Lab facility (Austin, TX; Photo: Business Wire)

DALL·E3 depiction of Frances Arnold's directed evolution

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National Academies Workshop, 04.2024

Emerald Cloud Lab facility (Austin, TX; Photo: Business Wire)

DALL·E3 depiction of Frances Arnold's directed evolution

Predictive Biology for

- Therapies
- Discovery

AI for Real-Time Precision Health

Human-Centric AI Tools for Biomedicine

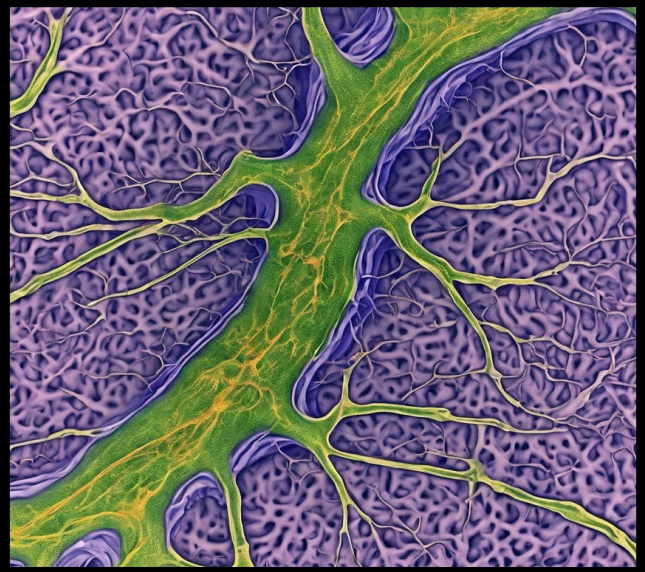
We are developing novel artificial intelligence approaches to handle diverse biomedical and social data, and make AI tools accessible, robust and friendly to clinical researchers and clinicians.

Improving Trauma Care through AI

Our collaborative teams of trauma surgeons, neurologists, AI researchers and biomedical engineers are developing AI assistants for trauma researchers and emergency first responders to improve outcomes for trauma patients.

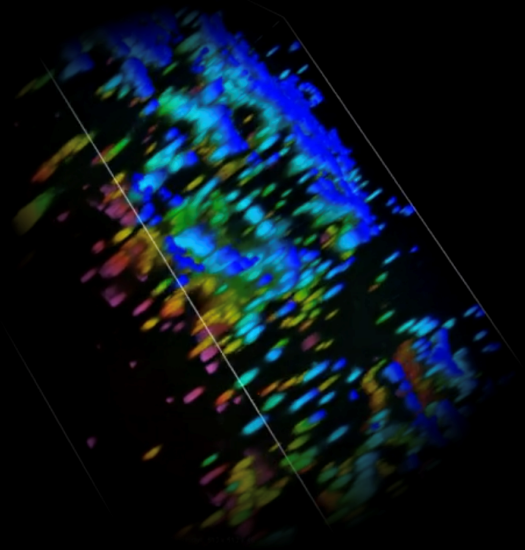
Decoding the Brain's Immune System

A study to uncover how the brain's meningeal lymphatics regulate risks for dementia as a function of metabolic factors



Brain Models for Biomedicine

We are developing patient-specific cellular models to understand how the brain responds to environmental stresses and identify therapies to enhance neuroregeneration. These experimental & computational models mimic brain regions regulating sensory response and circadian cycles.



Predictive Biology for

Therapies

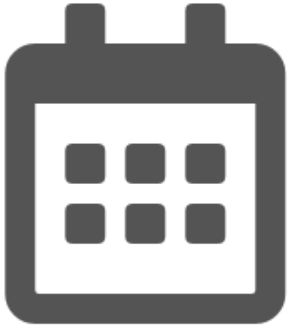
Discovery

AI for Real-Time Precision Health

Improving Trauma Care through AI

Our collaborative teams of trauma surgeons, neurologists, AI researchers and biomedical engineers are developing AI assistants for trauma researchers and emergency first responders to improve outcomes for trauma patients.

The Why



Years of Potential Life Lost before Age 65:
25.42 M Years

Source: CDC

Fatal Injury Rate (per 100,000)
79.65

Number of Deaths
1,378,840

For every 1 person who died:

11 People hospitalized

76 People treated and released from ED

Cost in 2022:
Total Injury: **$4.98 T**
Fatal Injury: **$3.00 T**

The Why

- Unintentional injuries are the leading cause of death in people in the U.S. Aged 1-44
- Accidents are the 3rd leading cause of death in the U.S.
- Time to care varies
- Quality of life depends on acute, precise trauma care

The Solution

- **Fund and build a Tiger Team** of trauma experts, AI researchers, biomedical engineers, psychologist and data analysts
- **Launch collection of coordinated trauma datasets** and data access across Texas, shared across 7 leading hospitals
- **Develop an AI prototype** and exemplar for applying AI to trauma care across the nation
  - AI analysis of trauma outcomes to **identify causes of delay**
  - AI-augmented presentation of data to inform real-time clinical decisions to **optimize patient outcomes**
  - Inform policy decisions

iRemedyACT: Identification & Remediation of Delays to Definitive Care of Critically Injured Patients in the Texas Trauma System (**iRemedy**) with Advances in AI to Improve Care for Trauma (**ACT**)

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[matrix]

https://ai.utsa.edu/iremedyact/

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AND COMBAT CASUALTY
CARE COLLABORATIVE
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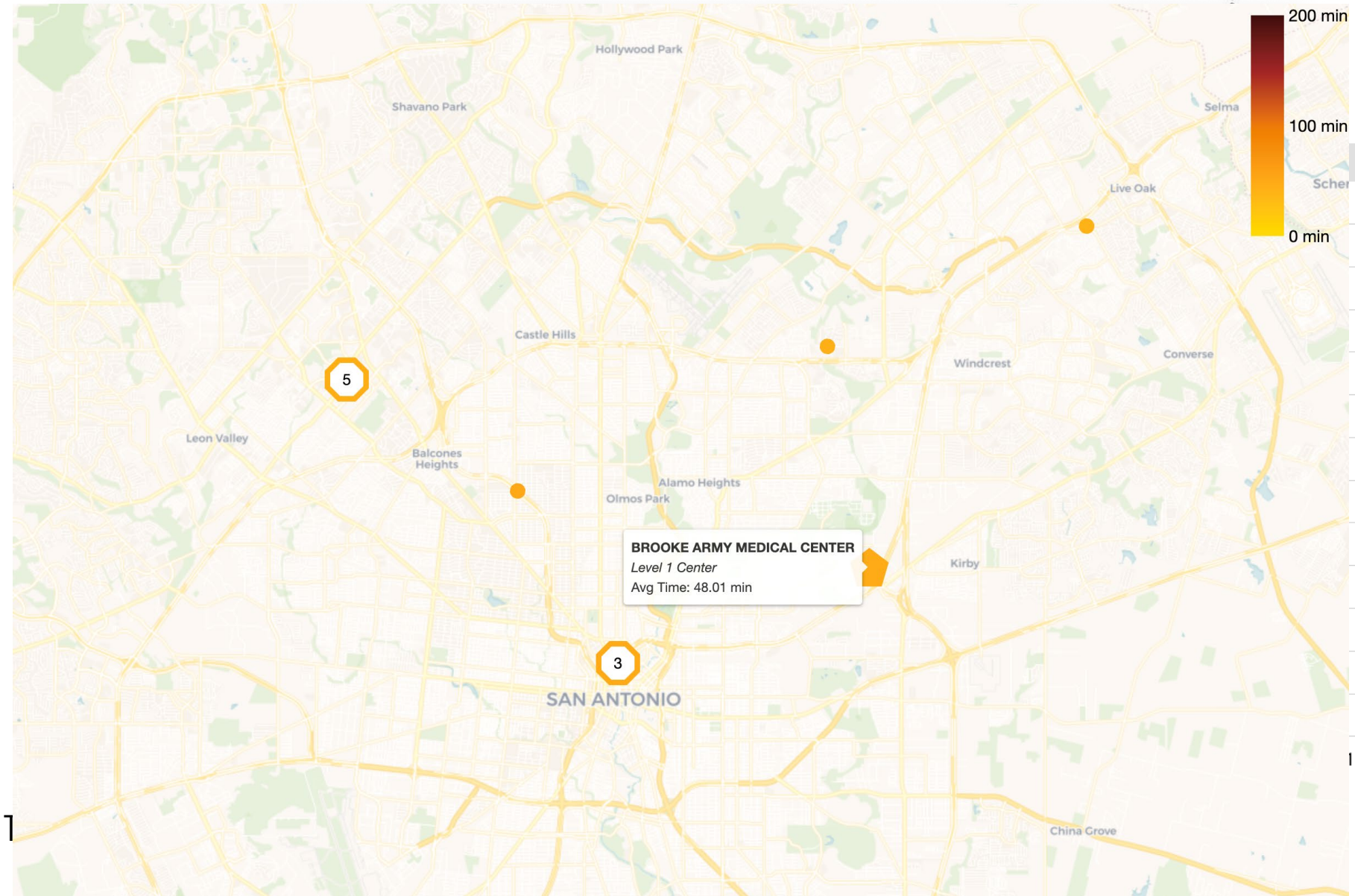
7 Hospital Sites

Time-to-Care Varies as a Function of Trauma Type, Location, Demographics and Clinical Decisions



Time_to_Care
93.83
92.55
91.62
88.38
88
87.26
86.83
82.25
78.18
77.28
77.23
76.71
75.26

1 - 32 / 32

Texas State 1

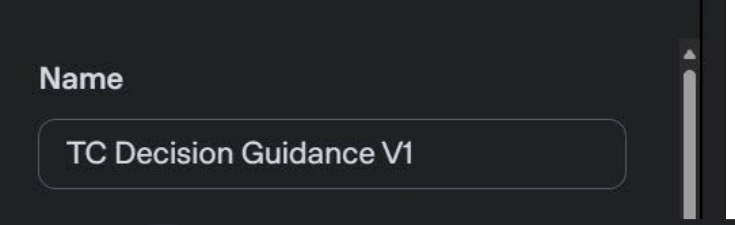
Example AI real-time support for researchers - LLM comparisons

Chat-GPT-o1

Bottom Line

- If the child is **neurologically stable**, has **no high-risk findings** on exam, and you have the **resources for pediatric imaging, sedation, and orthopedic care**, it is often safe to keep and manage the child at a Level IV facility.
- If there is any doubt about the child's neurological status, if the fracture is complex (e.g., needs urgent operative management), or if your facility **cannot** provide the needed pediatric imaging/orthopedic/sedation services in a timely fashion, **transfer to a higher-level pediatric-capable center** is safer.

As always, when in doubt, consult your on-call pediatric trauma or orthopedic specialist, follow established transfer guidelines, and prioritize the child's safety and definitive care.



Chat-GPT-4o-mini assistant fine-tuned with trauma-specific data (red/blue criteria) + functions

4 **Recommendation:** Given the signs and symptoms presented, including the history of brief LOC, transferring the child to a Level 1 or Level 2 trauma center for further evaluation and management is advisable. The higher trauma center can provide comprehensive evaluation, including neurosurgical assessment if needed.

In conclusion, it is recommended to transfer the child to a higher echelon of care for better management of potential traumatic injuries.

[1][2]

Predictive Biology for

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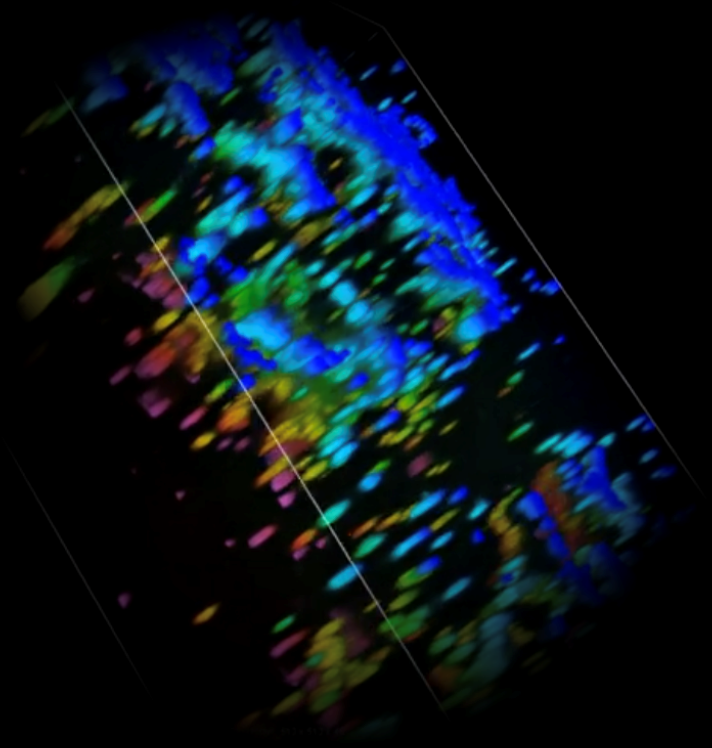


>100 M

Children and adults in the U.S. who have a neurological disorder

- US Neurological Disorders Collaborators, JAMA Neurology 2021

>40%

Cases of dementia that are attributed to environment (environmental stress, lifestyle factors)

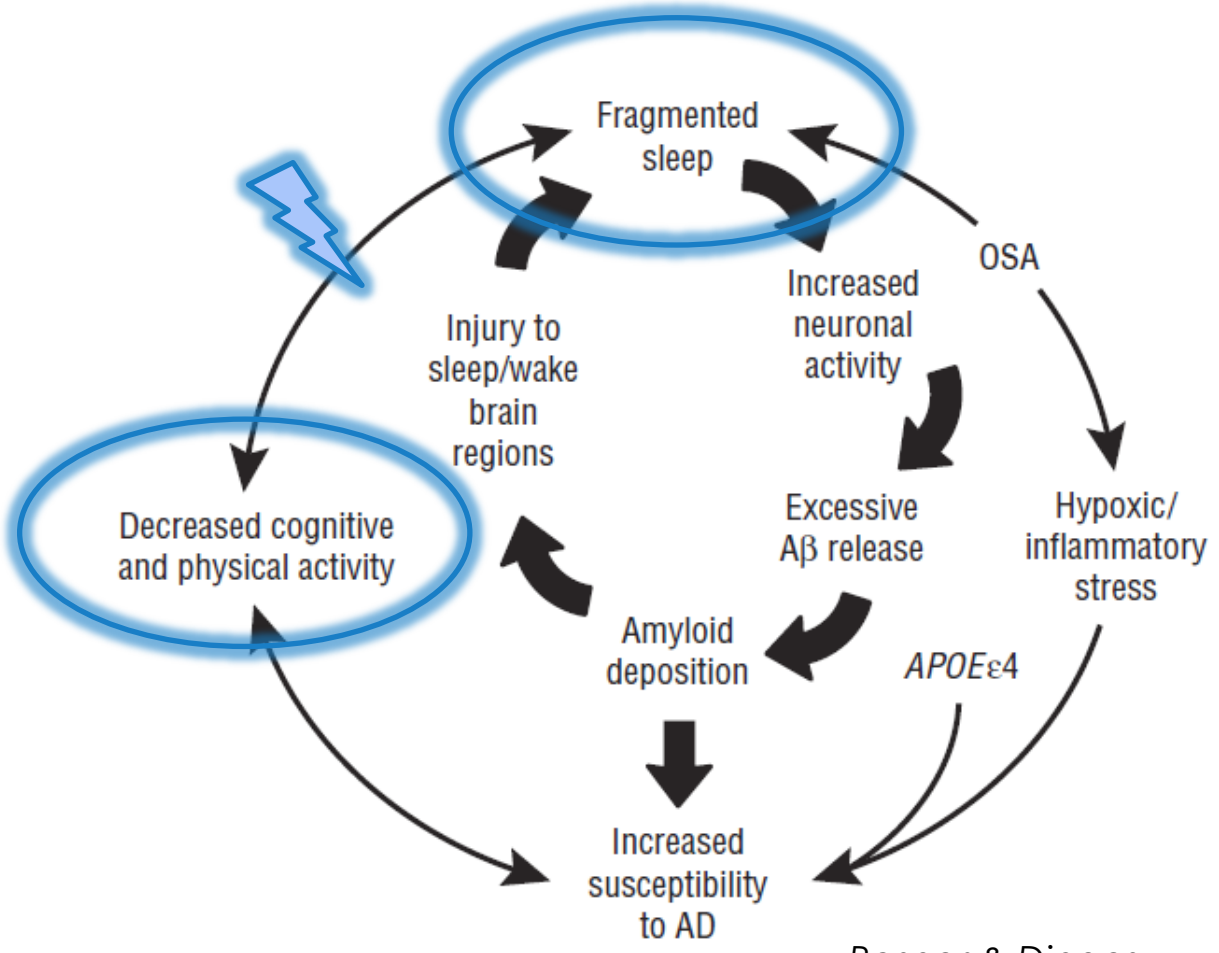
- Livingston et al., Lancet, 2020

Sleep changes in Neurological Conditions

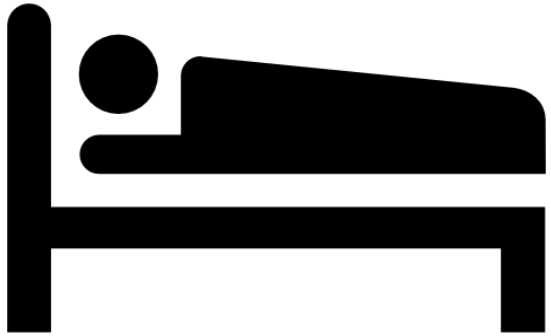
Fragmented sleep
Wake during sleep
Inconsistent sleep
Movement during sleep
Higher slow wave activity
Higher theta activity
REM latency

REM % (Inconsistent findings)
Overall sleep duration
REM latency
Cerebral glucose metabolic rate in the prefrontal cortex

Pediatric ADHD + Autism |
Observed in both |
Mild Cognitive Impairment

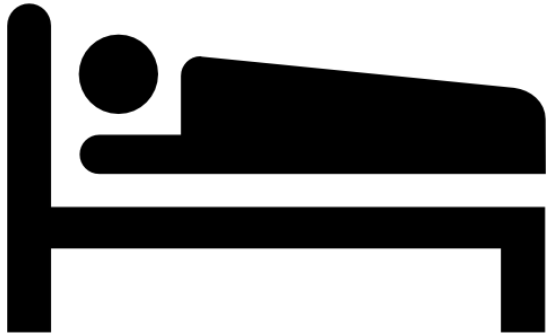


Basner & Dinges, Sleep, 2018



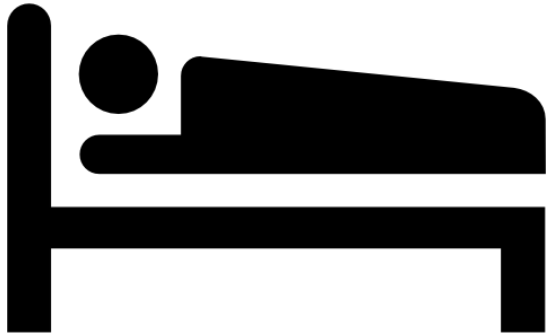
"our findings show adverse effects of **one-night sleep deprivation** on brain Aβ and expand on prior findings of higher Aβ accumulation with chronic less sleep"

Shokri-Kojori et al., PNAS 2018



"our findings
implicate **REM sleep**
mechanisms as predictors
of clinical dementia"

Pase et al., Neurology 2017

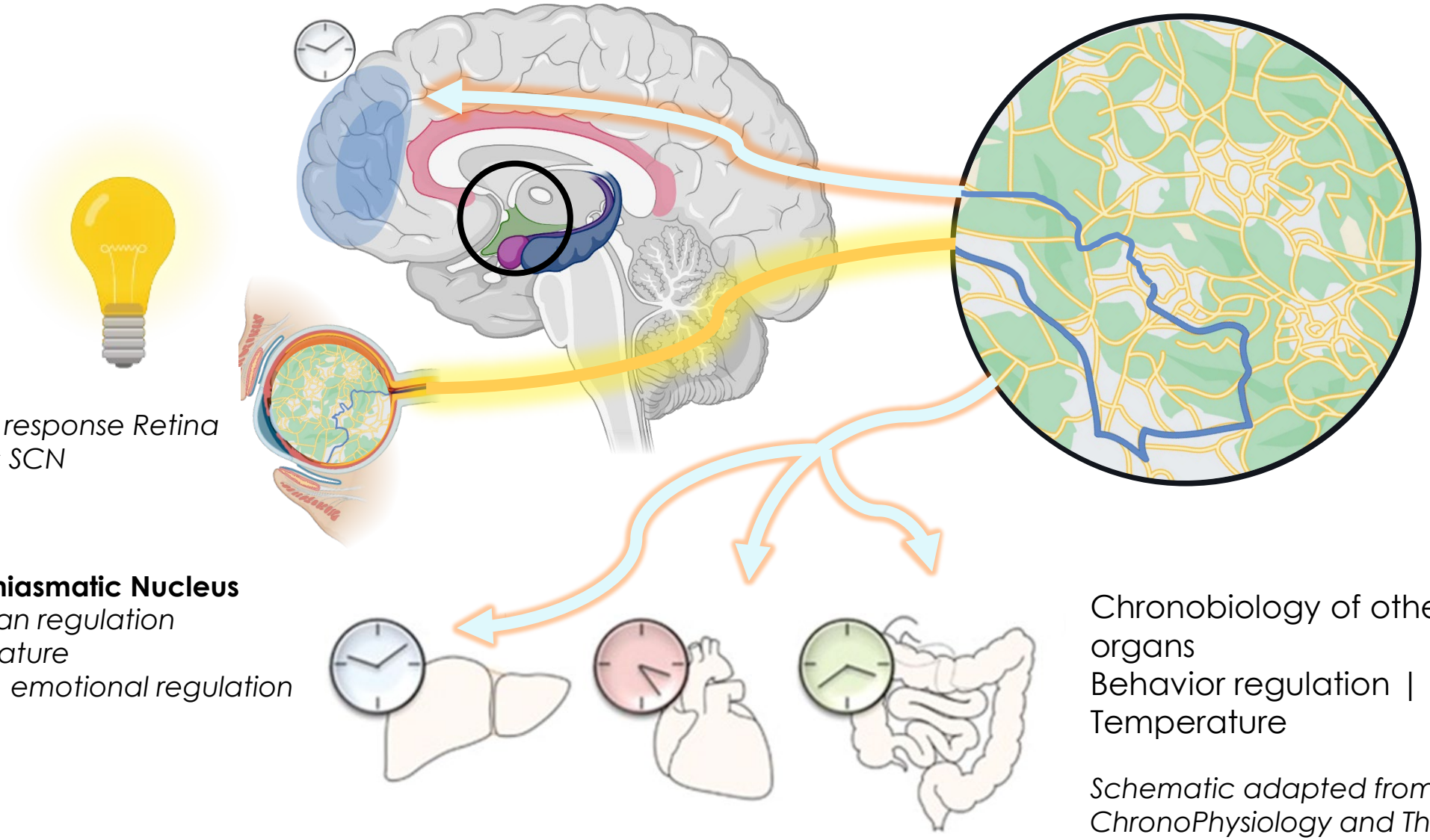


"…**sleep reduces** accumulating **DNA damage** in single neurons"

(shown in zebrafish model)

Zada et al., Nature Communications 2019

Brain Regions Regulating Sensory Response & Sleep/Wake Cycle

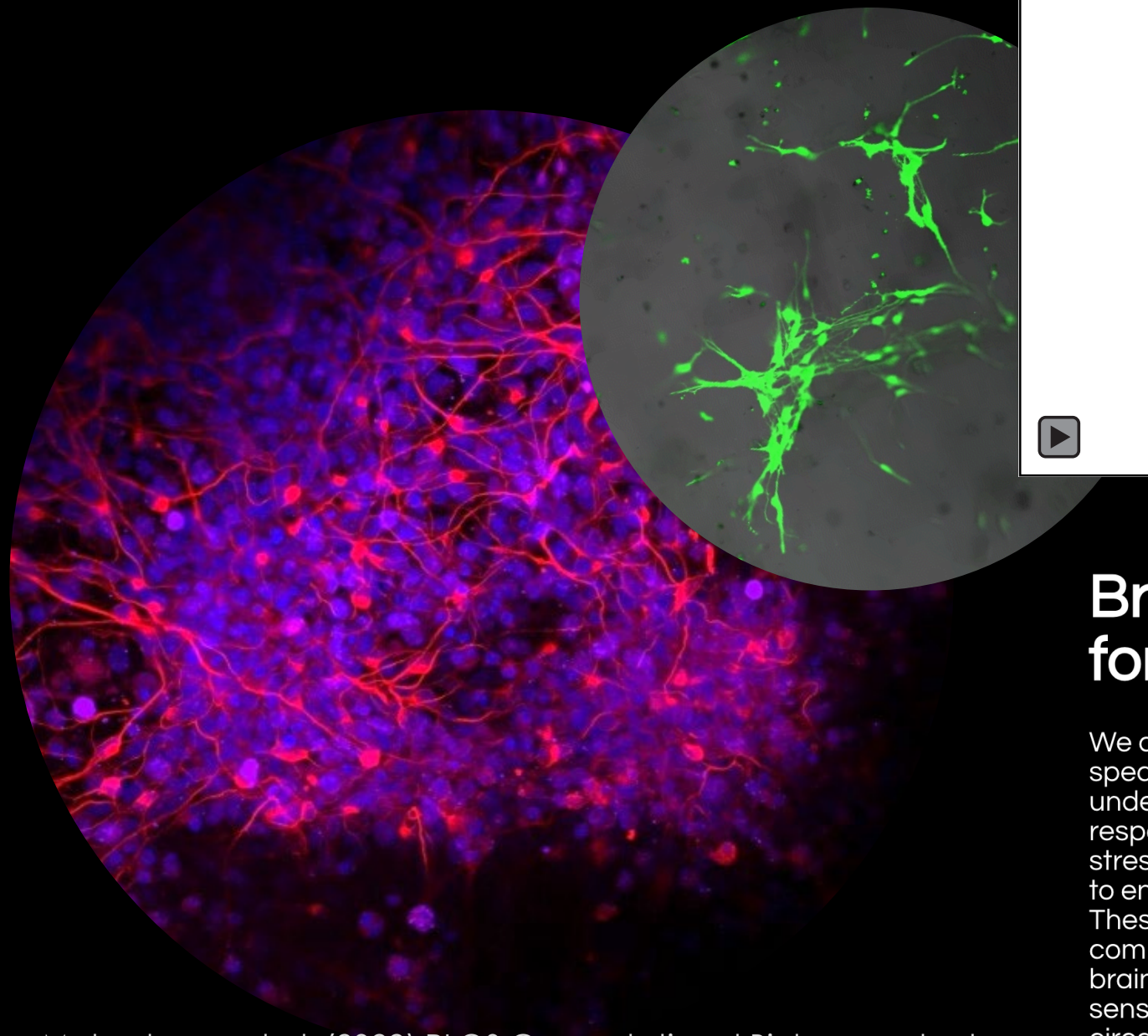


Eye
Sensory response Retina entrains SCN

Suprachiasmatic Nucleus
Circadian regulation
Temperature
Mood | emotional regulation

Chronobiology of other organs
Behavior regulation | mood
Temperature

Schematic adapted from Tissara et al., ChronoPhysiology and Therapy, 2015



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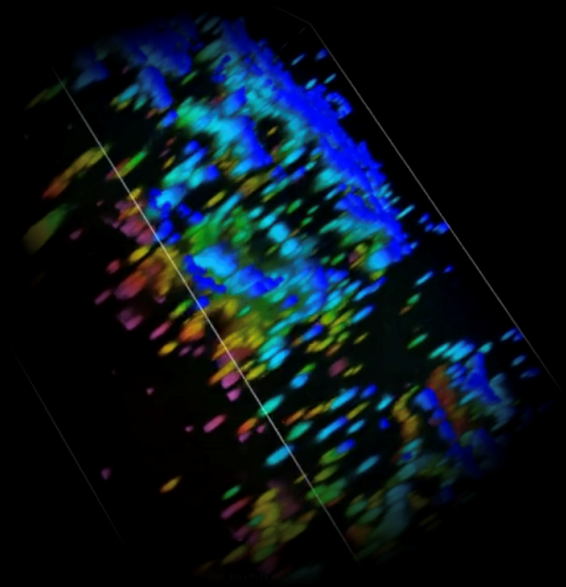
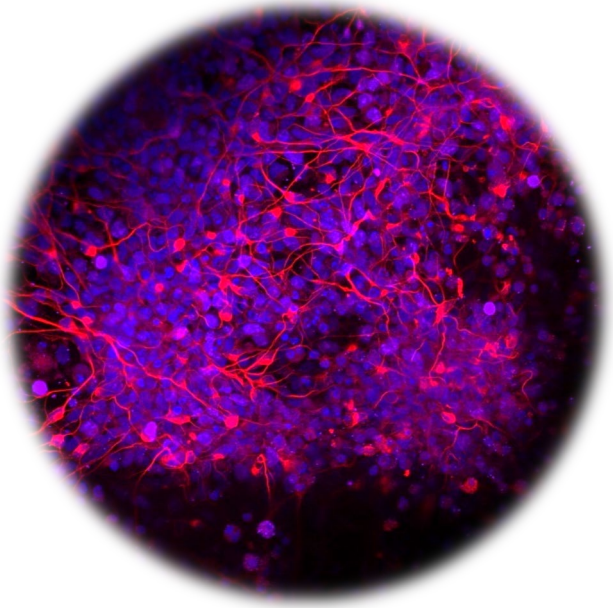
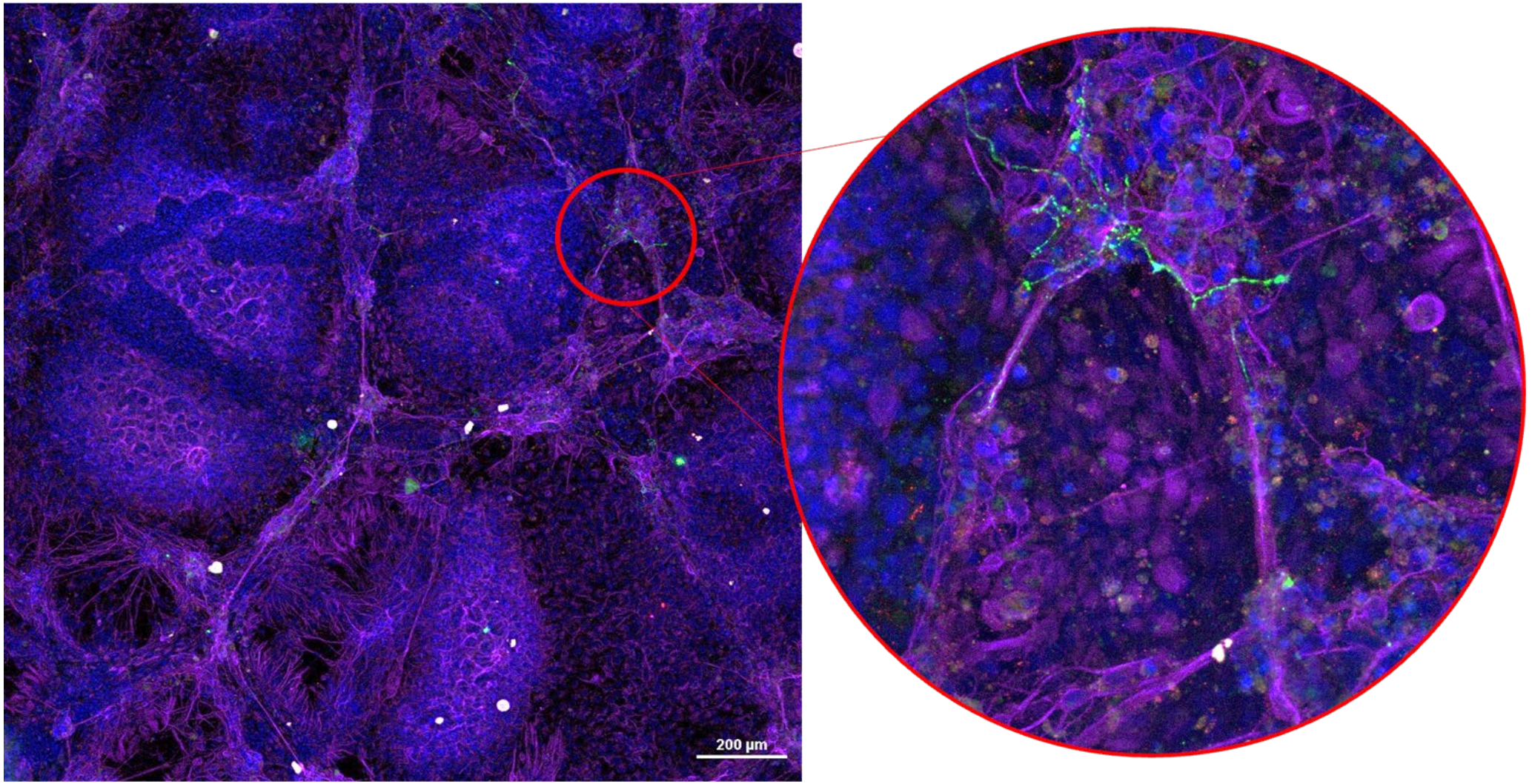


Mahadevan et al. (2022) PLOS Computational Biology; patent pending; Mahadevan et al. bioRxiv 055533

Develop brain models to enable testing hypotheses of the role of environmental effects on the suprachiasmatic nucleus, and develop a therapeutic screening tool

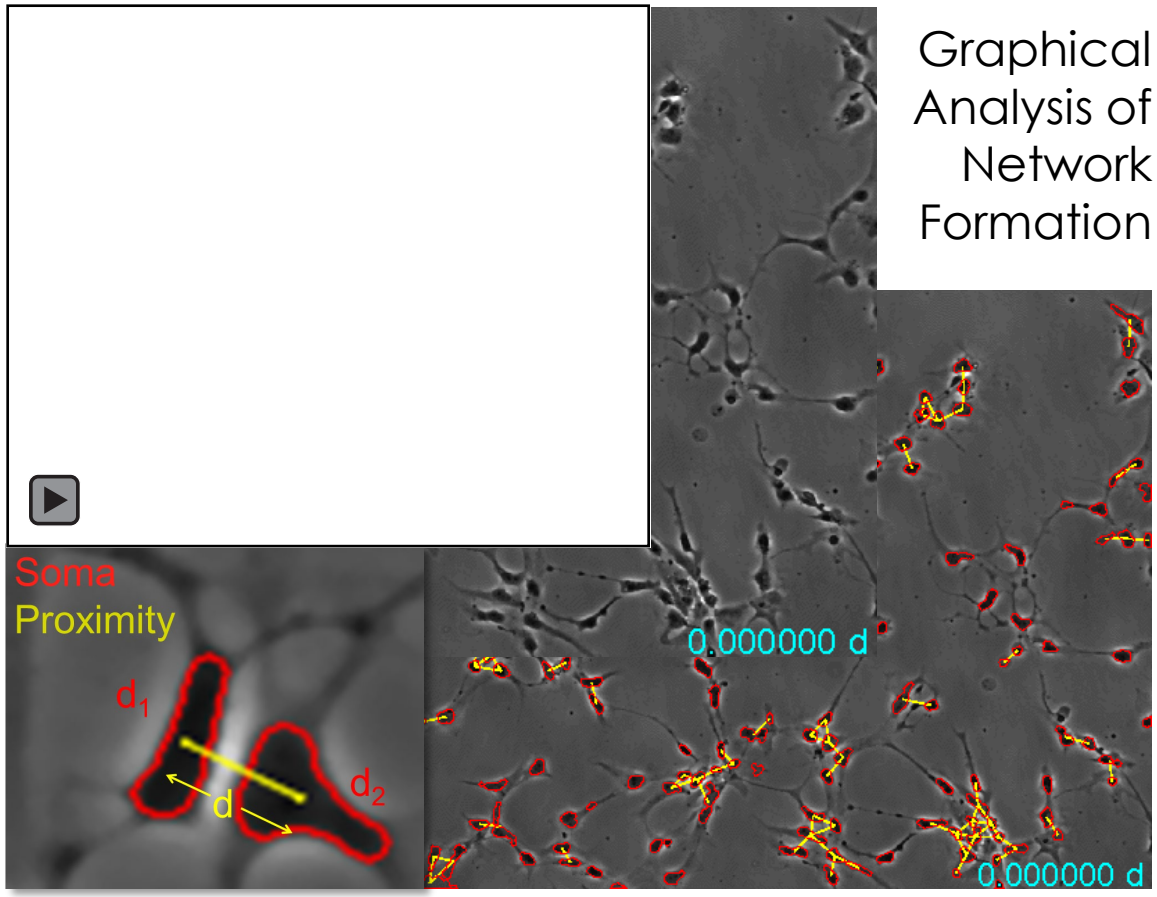


Human induced Pluripotent Stem Cell-Derived Suprachiasmatic Nucleus – *Master Clock of the Brain*

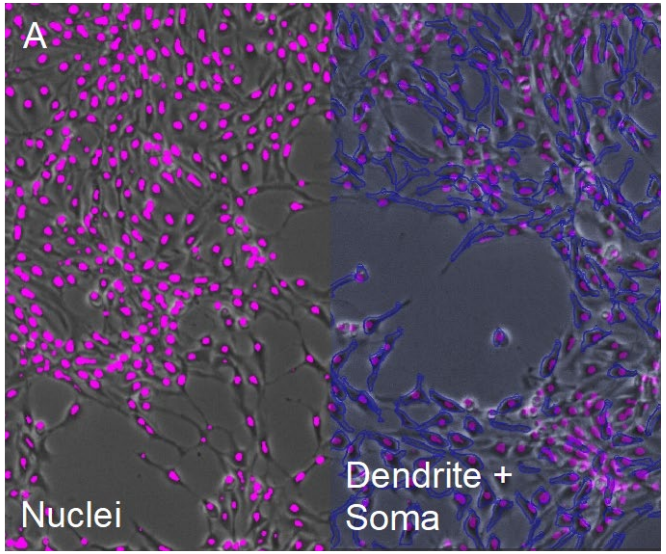


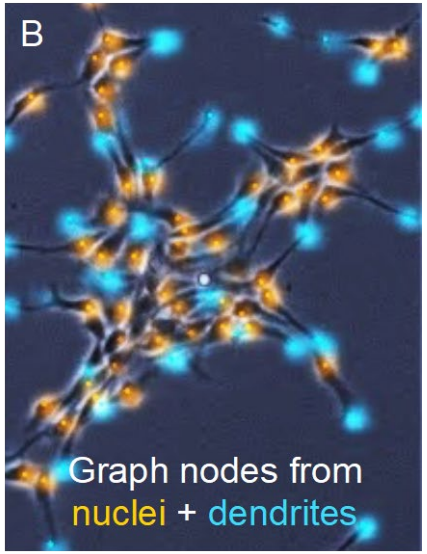
Credits: Sean Tritley, Qutub Lab

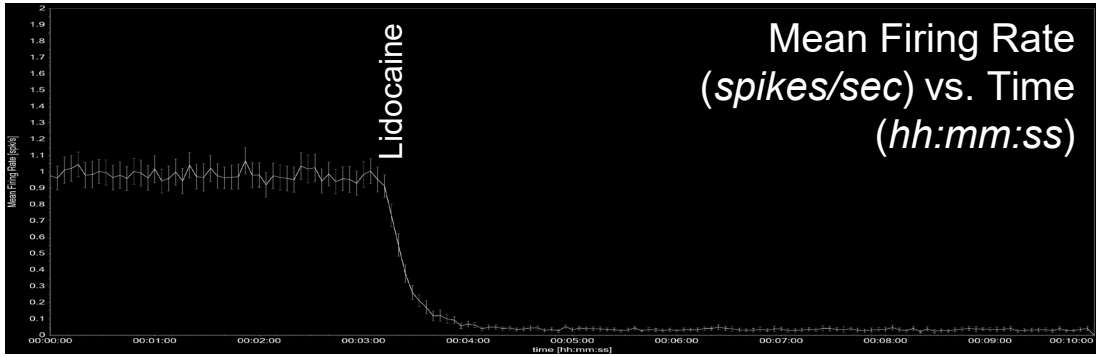
MorphoChemo & ***Electrical*** Maturation into Neurons



Graphical Analysis of Network Formation

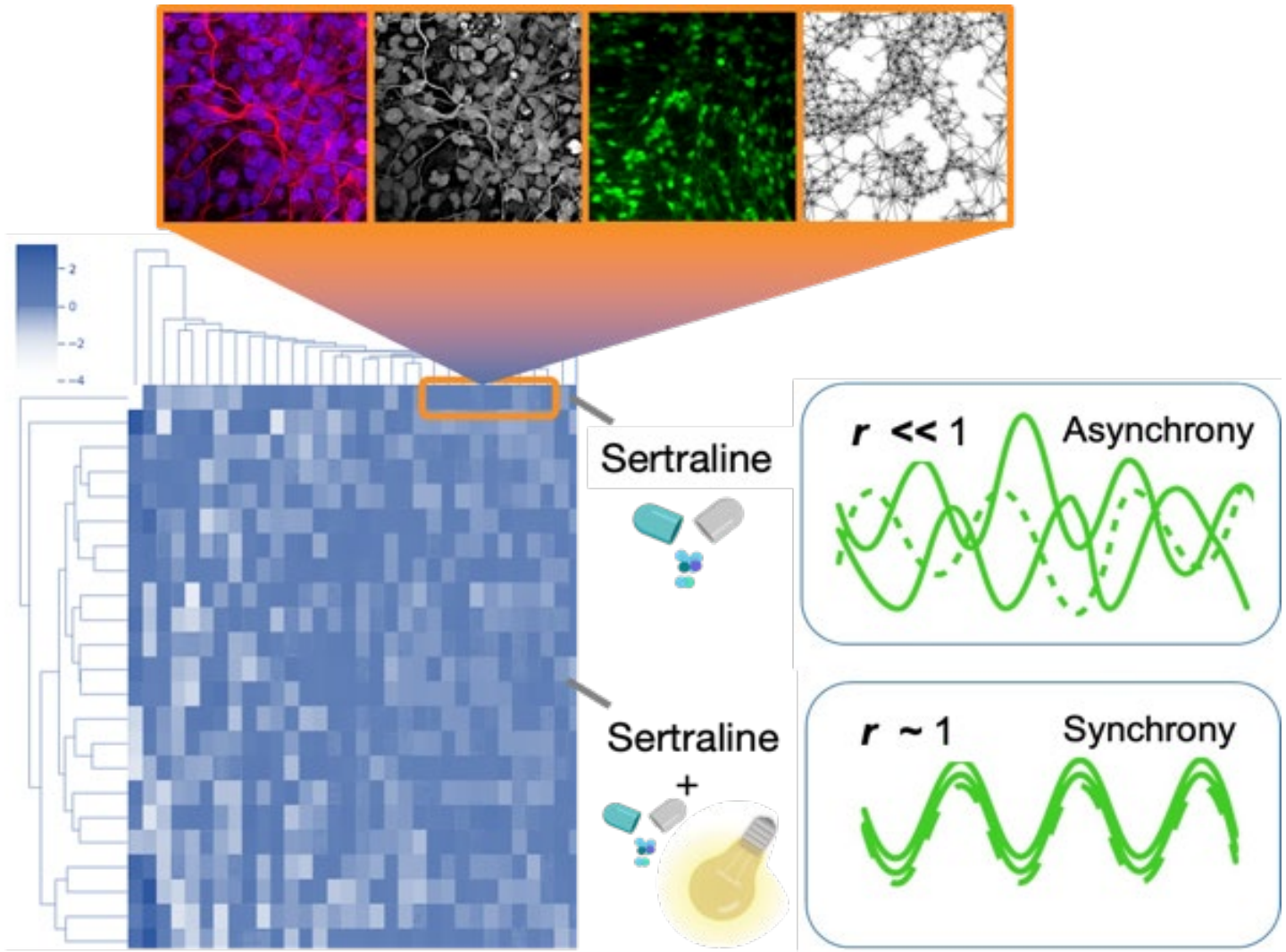




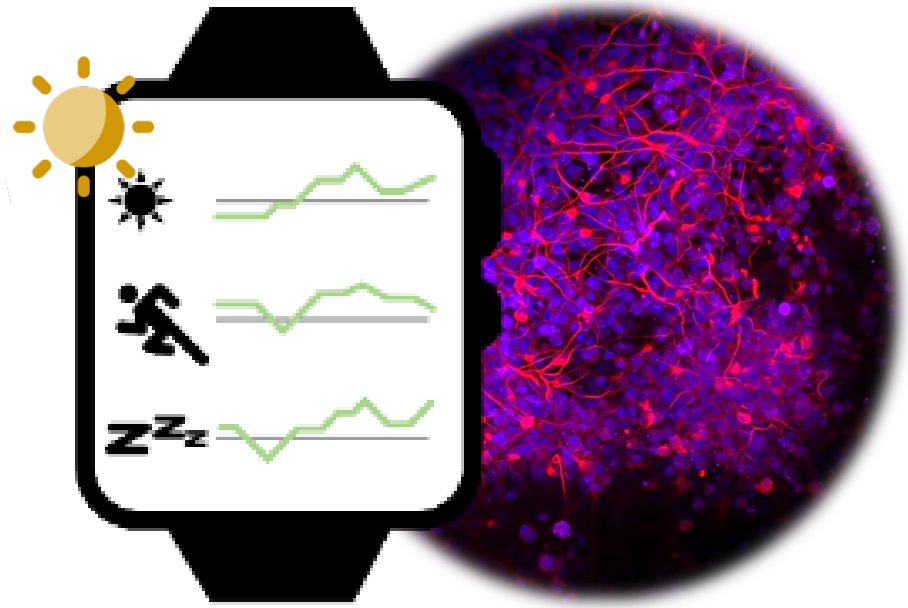


Credits: Sean Tritley; Courtney Rouse (SwRI); Arun Mahadevan

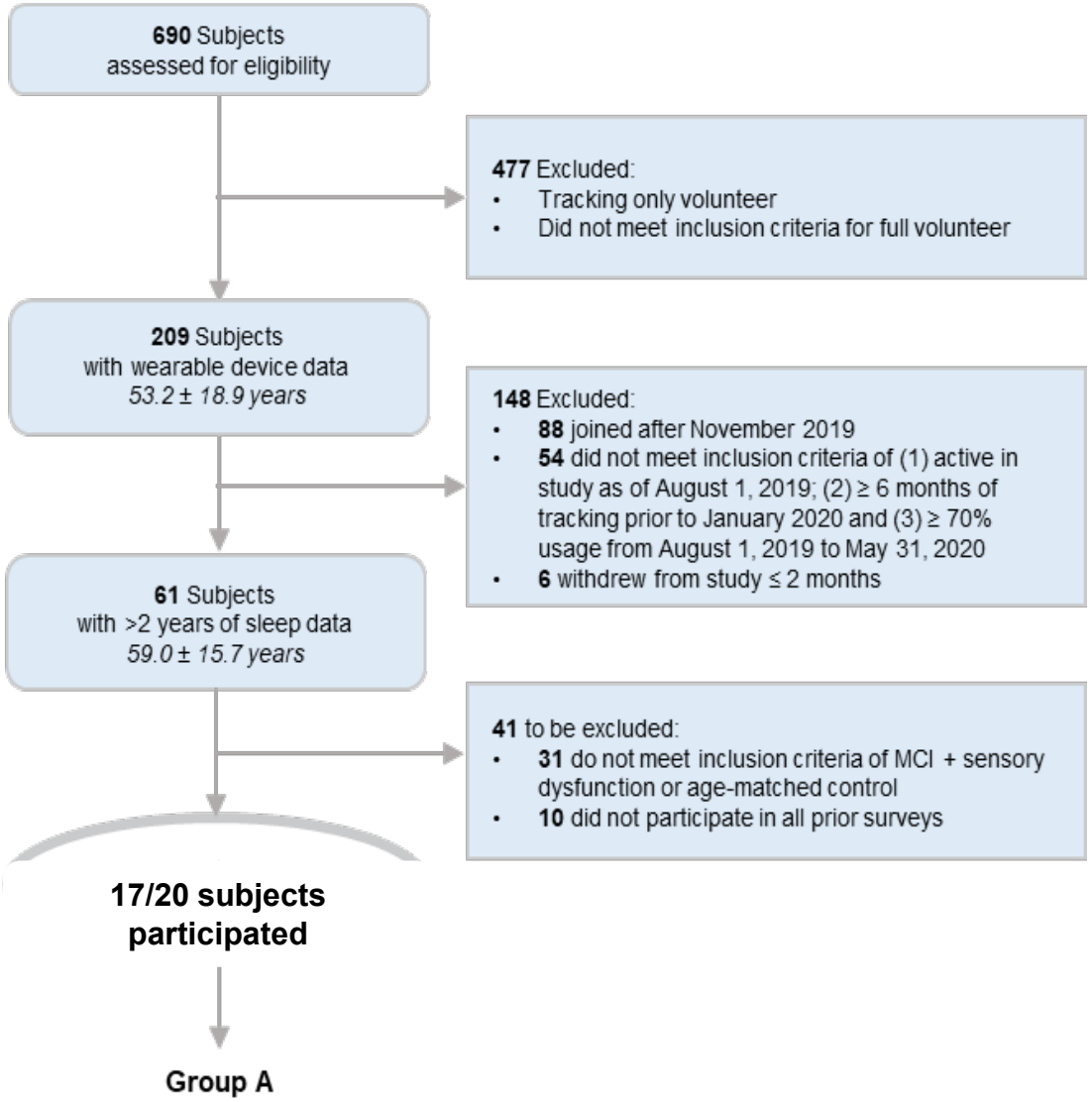
Human brain models as nutrient and therapeutic screening tools

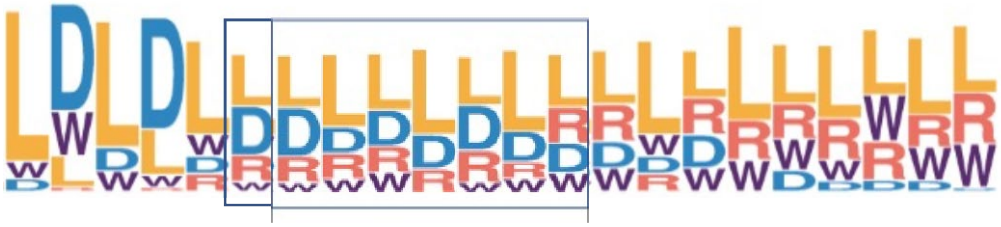


Computational analyses integrate + quantify environmental + neuronal features and behavior



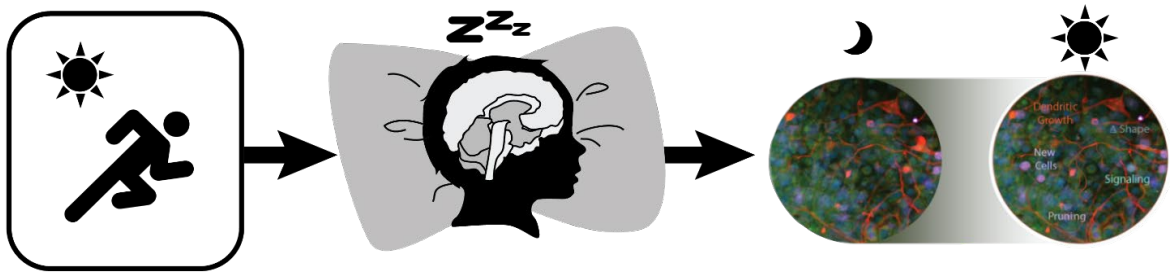
Characterize neurosignatures of behavioral response to sensory stimulation



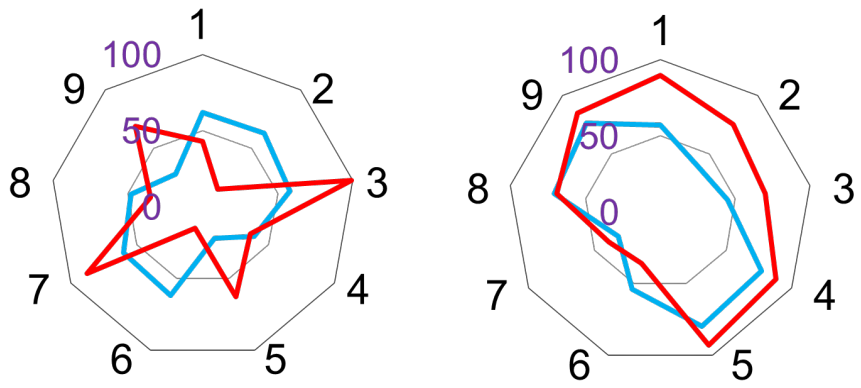


Participant A: < 25 yrs

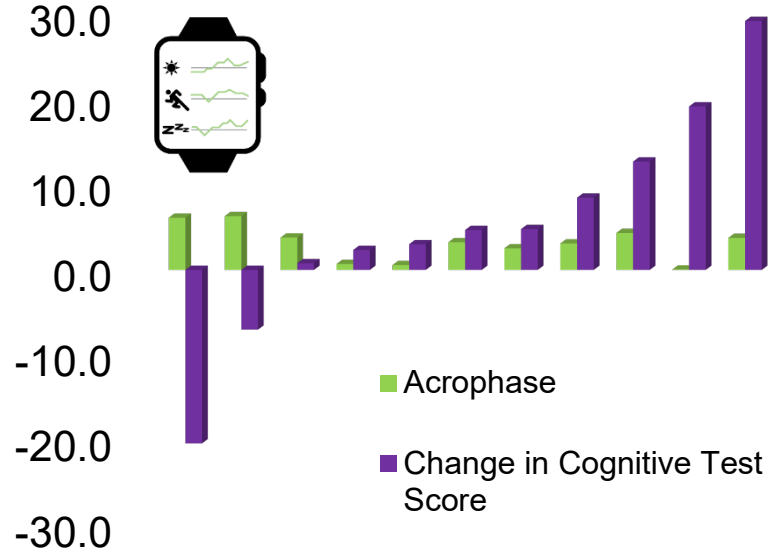
Participant B: > 51 yrs



Measuring An Individual's Neurosignature: Behavior-to-Molecular



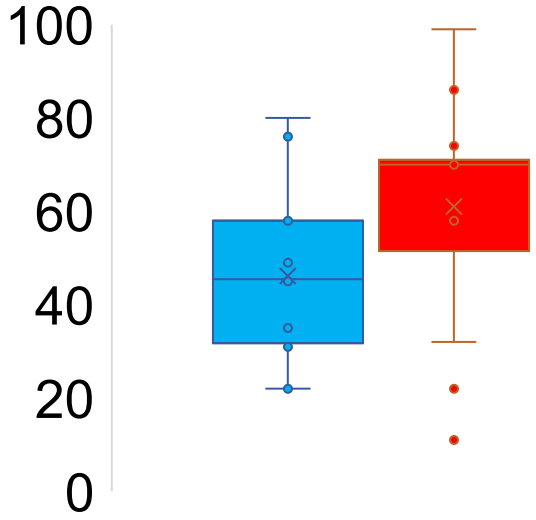
1. Instant Verbal Memory
2. Delayed Verbal Memory
3. Attention
4. Emotion Identification
5. Processing Speed
6. Flexible Thinking
7. Working Memory
8. Executive Function
9. Spatial Memory

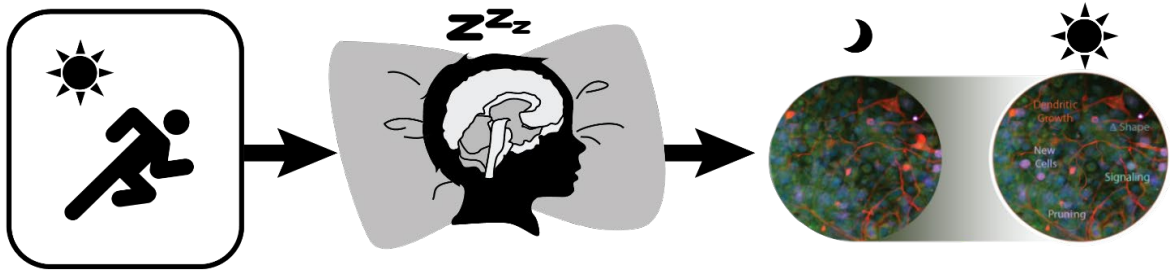


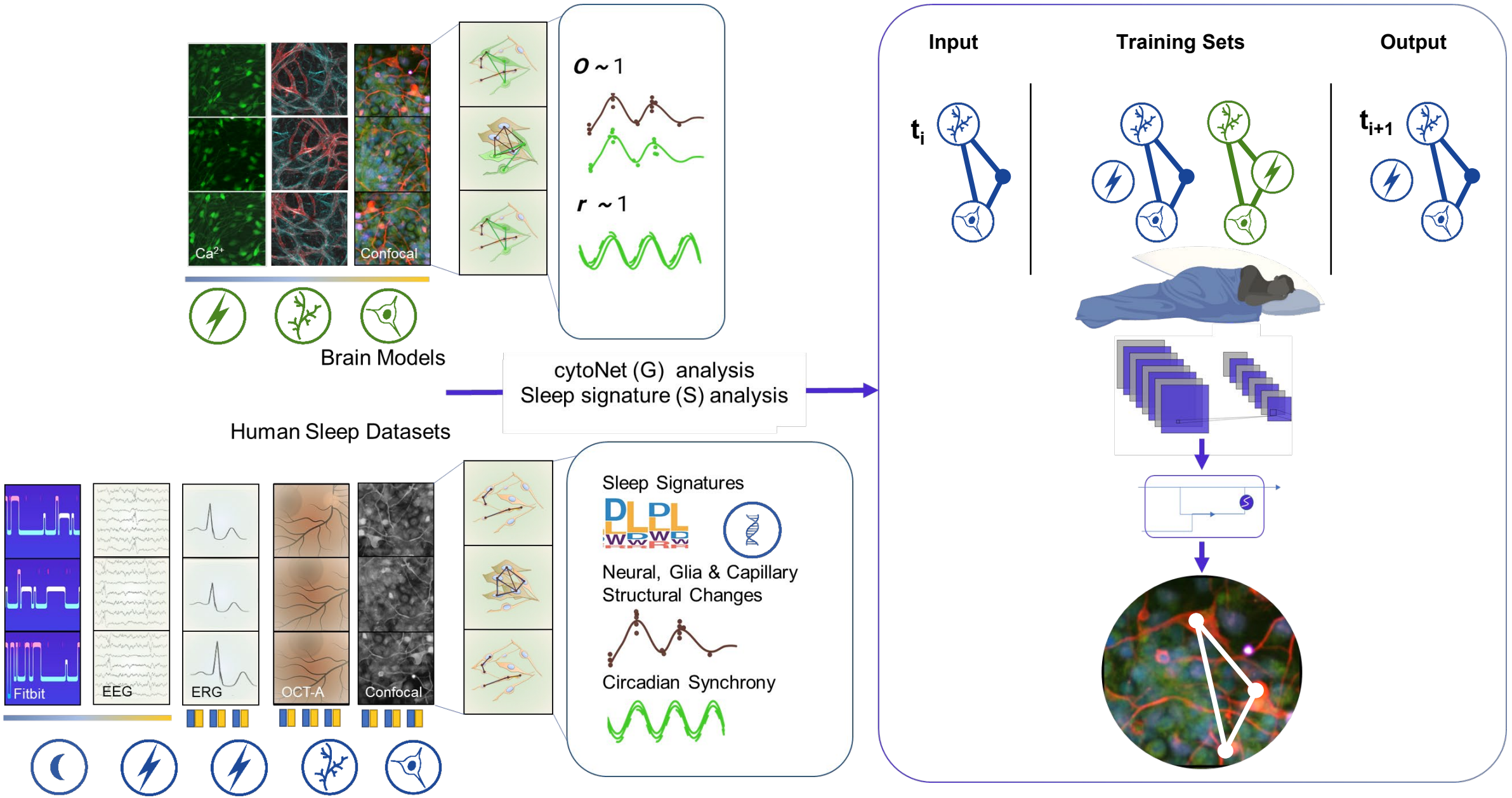
Attention Score

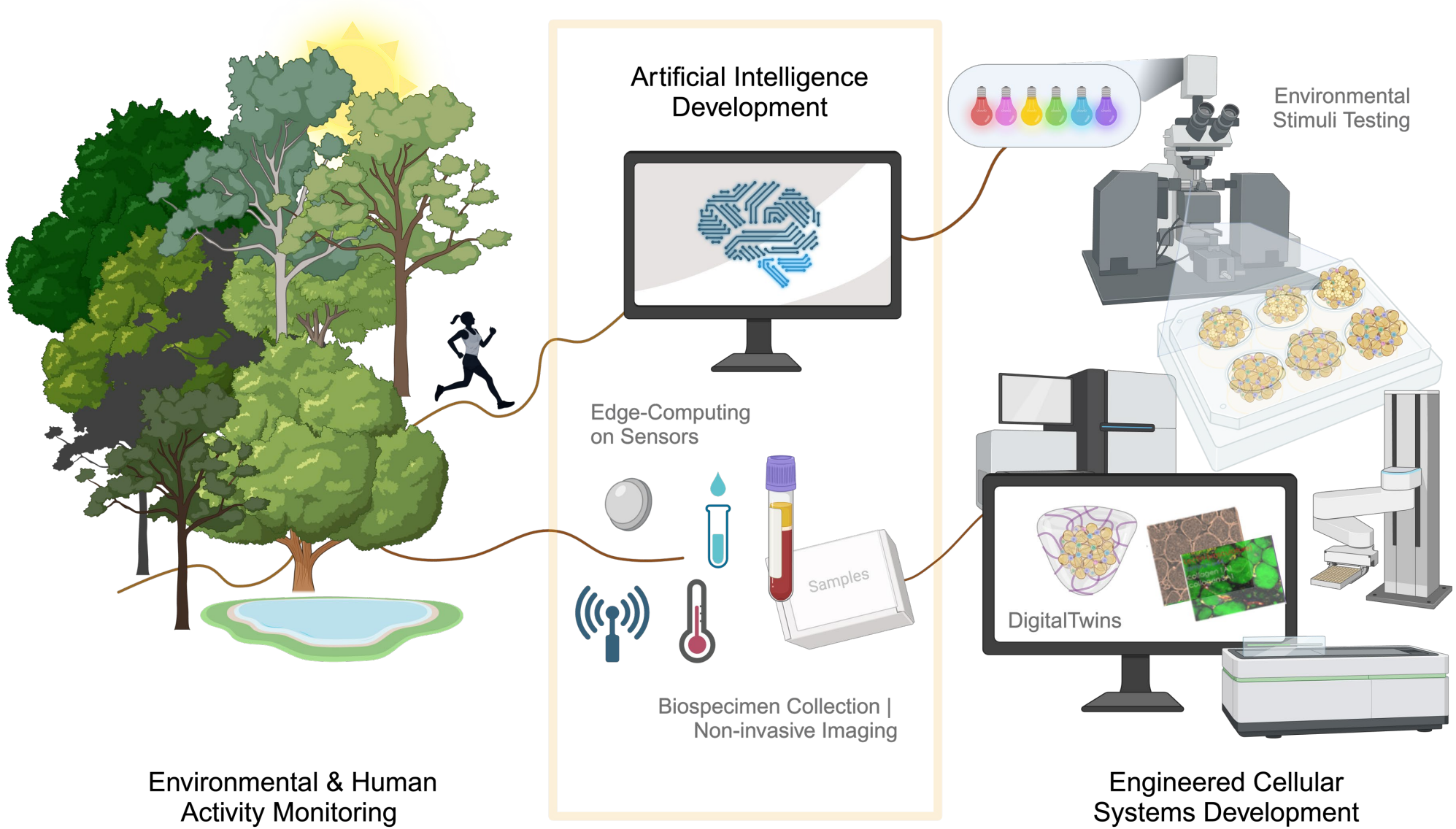
before (blue) | after (red)

60-day exercise intervention






Ca2+
Confocal
O ~ 1
r ~ 1
Brain Models
cytoNet (G) analysis
Sleep signature (S) analysis
Human Sleep Datasets
Fitbit
EEG
ERG
OCT-A
Confocal
Sleep Signatures
Neural, Glia & Capillary
Structural Changes
Circadian Synchrony
Input
Training Sets
Output
ti
ti+1



QutubLab.org

Predictive Biology for

Therapies

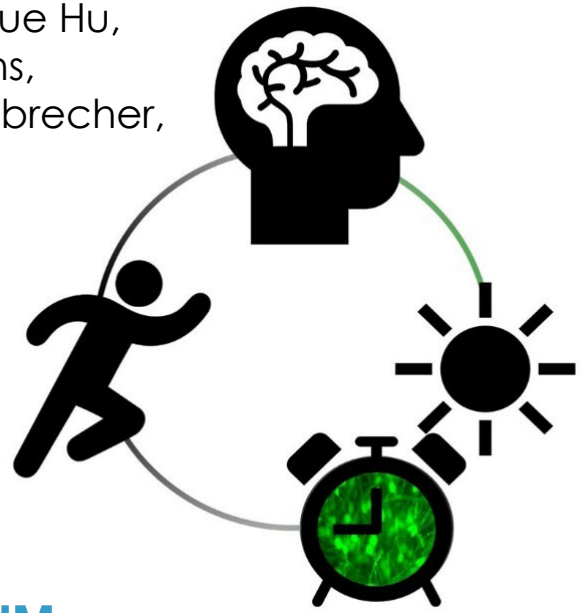
Discovery

AI for Real-Time Precision Health

Qutub Lab | UTSA | MATRIX AI

Miggy Frances Dumanjog (AI, computer vision)
Christian Cruz (Data analysis & AI for trauma care)
Sambit Panda (AI for trauma care)
Sean Tritley (SCN models)
David Hernandez Guzman (brain lymphatics)
Lorinda Aspiras
Mariam Dayeh

Alumni: Arun Mahadevan, Wendy Chenyue Hu, Byron Long, David Noren, Jennifer Dawkins, George Britton, Andre Schulz, Becky Zaunbrecher, Grace Ching



UT Southwestern
Ben Levi, Deb Carlson, Ryan Huebinger, Sneha Korlakunta, Alaa Hazime

University of Michigan
Omer Berenfeld

UT Health
Brian Eastridge, Mark Goldberg, Kumar Sharma, Jim Lechleiter

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Texas Children's Hospital | Baylor College of Medicine
Francois St-Pierre, Terzah Horton

Neurodevelopmental Stem Cell Biology | Sanford
Kevin Francis

Quantu Project Volunteers

Relevant Qutub Lab Publications
Mahadevan et al. (2022) PLOS Comp Bio
Sanders et al. (2023) Nature Machine Intelligence
Britton et al. (2019) Development
Hu et al. (2019) Nature Biomedical Engineering
Hu et al. (2018) BMC Bioinformatics
Noren et al. (2016) Science Signaling

Provisional Patent
"Method to Identify Patterns in Brain Activity," Qutub et al., 2024