AI Attention Language Model for Medical Diagnosis

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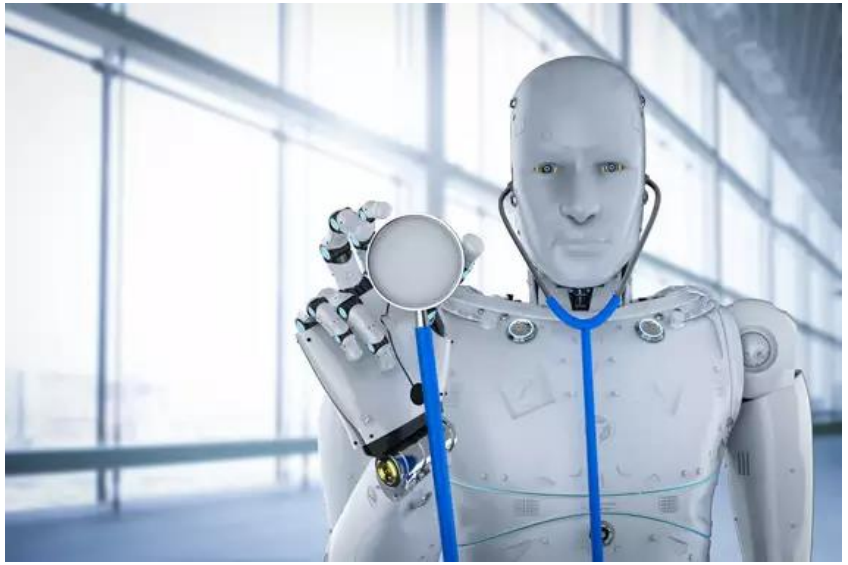
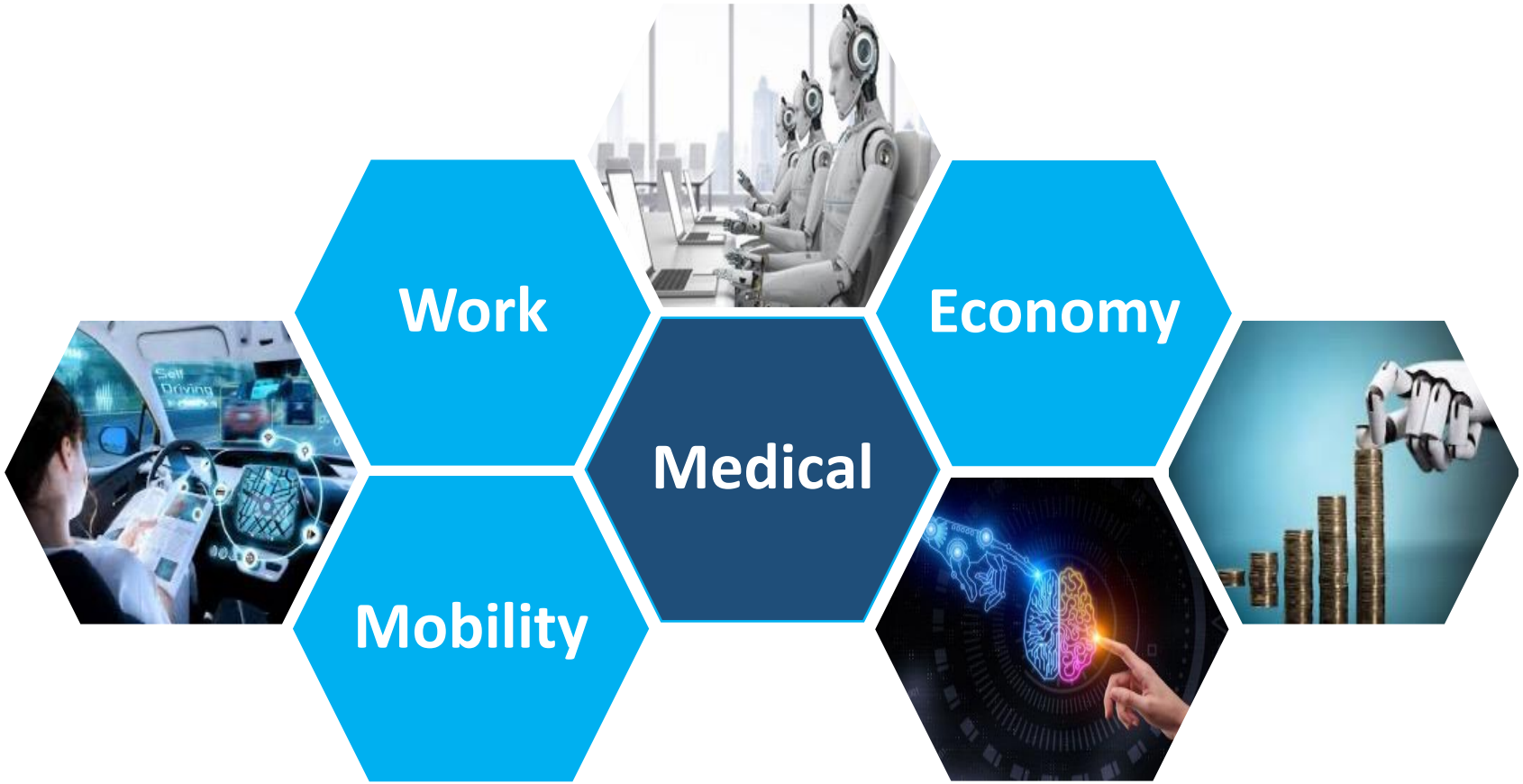
Machine Learning, AI-Enabled Healthcare

DiTech (**Di**agnosis **Tech**nology), **GPT Jordan**



On the Verge of Major Breakthroughs

Artificial Intelligence (AI) has been moving extremely quickly in the last few years, demonstrating a potential to revolutionize every aspect of our lives – **Artificial General Intelligence (AGI) is a game changer**



Meet Alex

Sept. 11, 2023:

“A little boy named Alex saw 17 different doctors over the course of three years, unable to find a root cause of his chronic pain.

At her wit's end, his mom, Courtney, fed his radiology report into **ChatGPT** and produced immediate answers

She shared everything she knew about her son's symptoms and all the information she could gather from his MRIs.

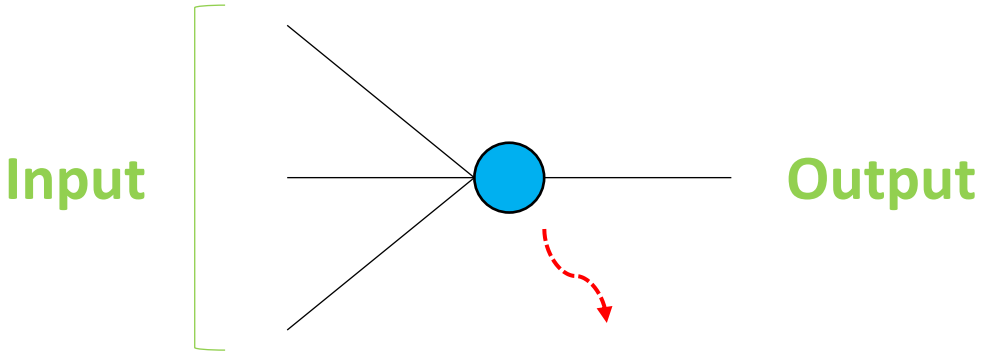
“We saw so many doctors. We ended up in the ER at one point. I kept pushing,” she says. “I really spent the night on the (computer) … going through all these things.“ So, when ChatGPT suggested a diagnosis of tethered cord syndrome, "it made a lot of sense," she recalls.

” Meghan Holohan

https://www.today.com/health/mom-chatgpt-diagnosis-pain-rcna101843

But, What is AI?

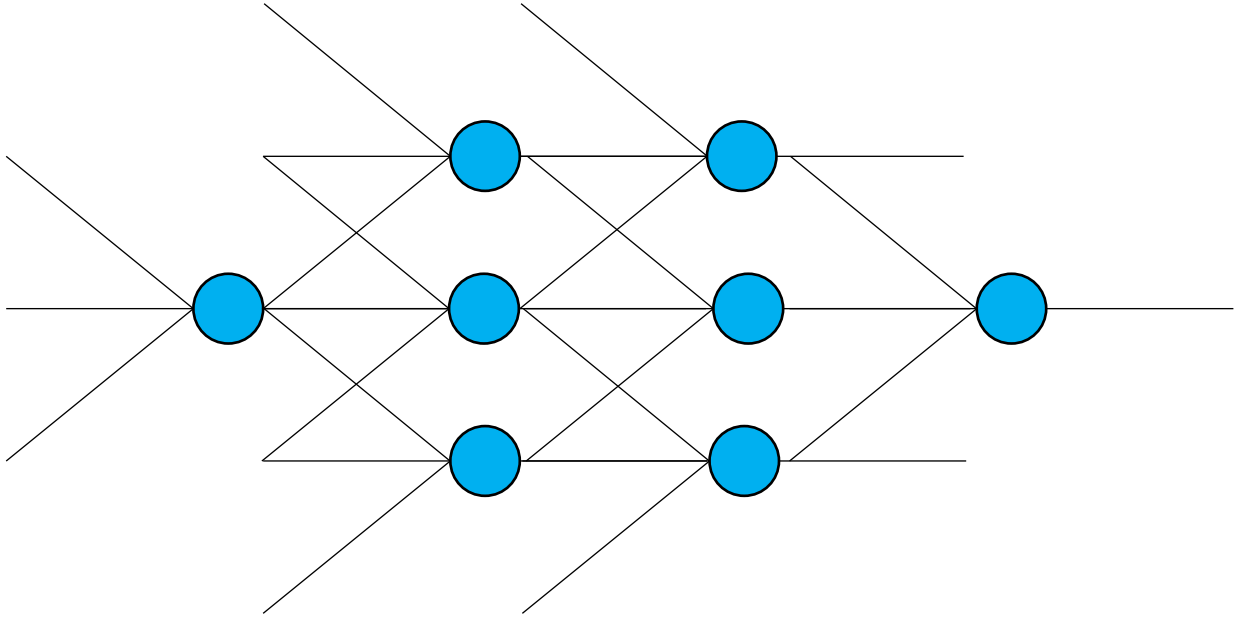
Think of this as incoming impulses (input) passed from one *neuron* (AI process) to the next, if any, and finally generating an output



AI process, which is essentially a *mathematical function*

But, What is AI?

- You can connect as many of these neurons as needed, resulting in what is called a *neural network* (a branch of AI)



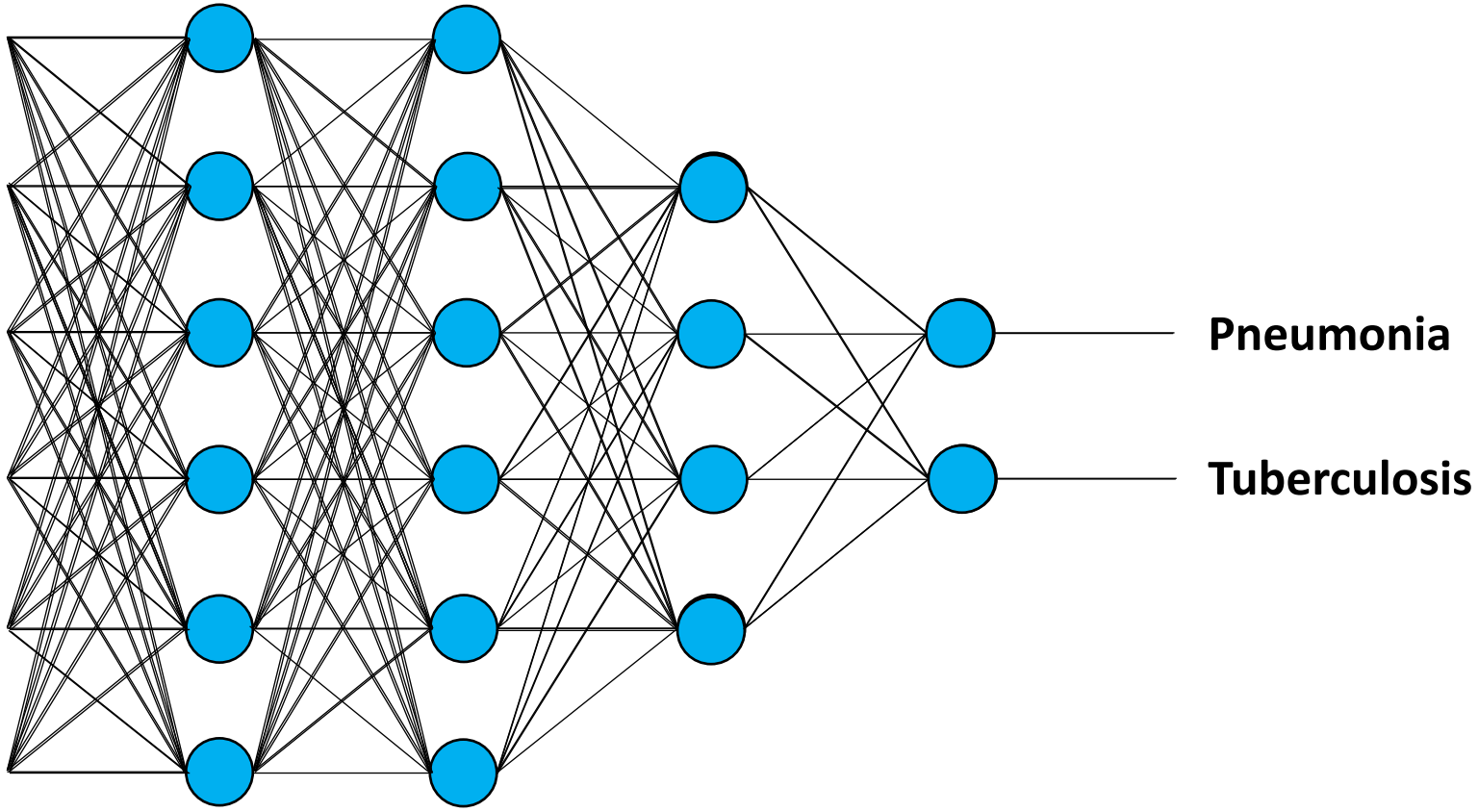
The more layers you add, the deeper it becomes. Deep ones are referred to as ***deep neural networks*** or ***deep learning (DL) models***

But, What is AI?

Subsequently, you can *train* your DL model

Tuberculosis

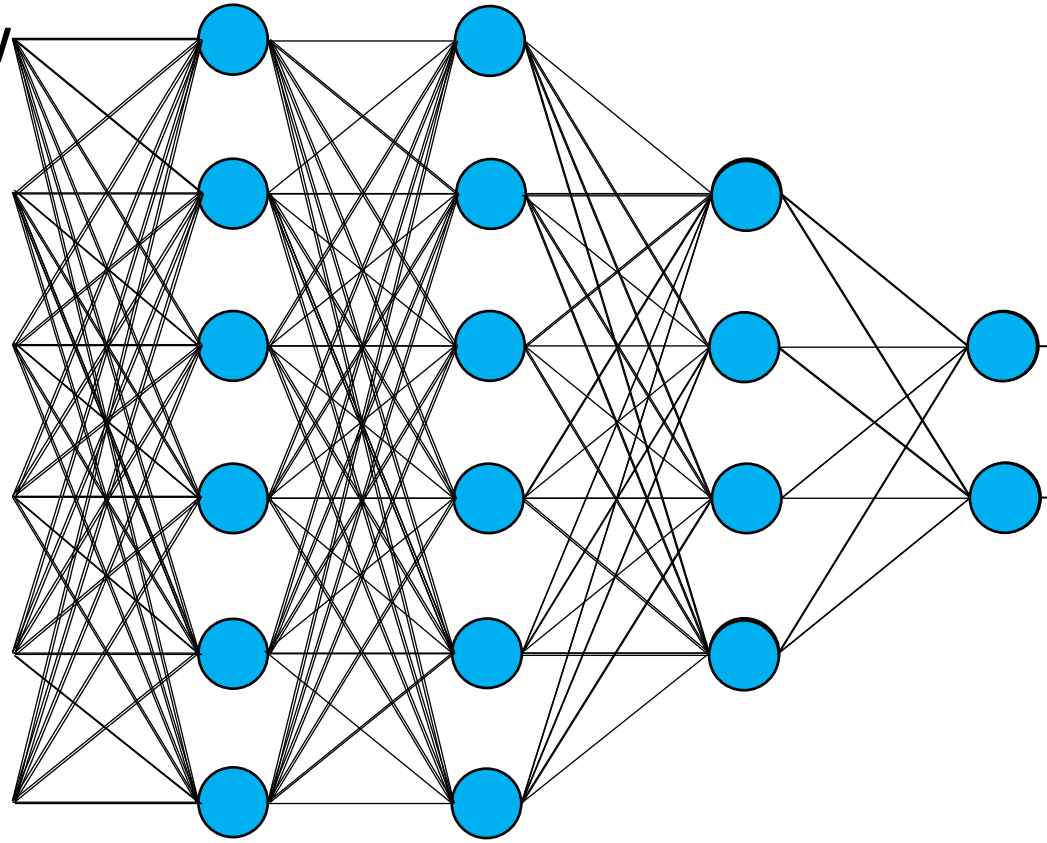
Example 1



But, What is AI?

- After training your DL model, you can use it to *infer* what an <u>*unknown*</u> image may show

?



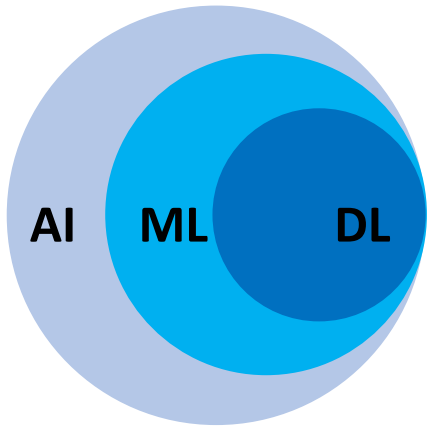
Pneumonia

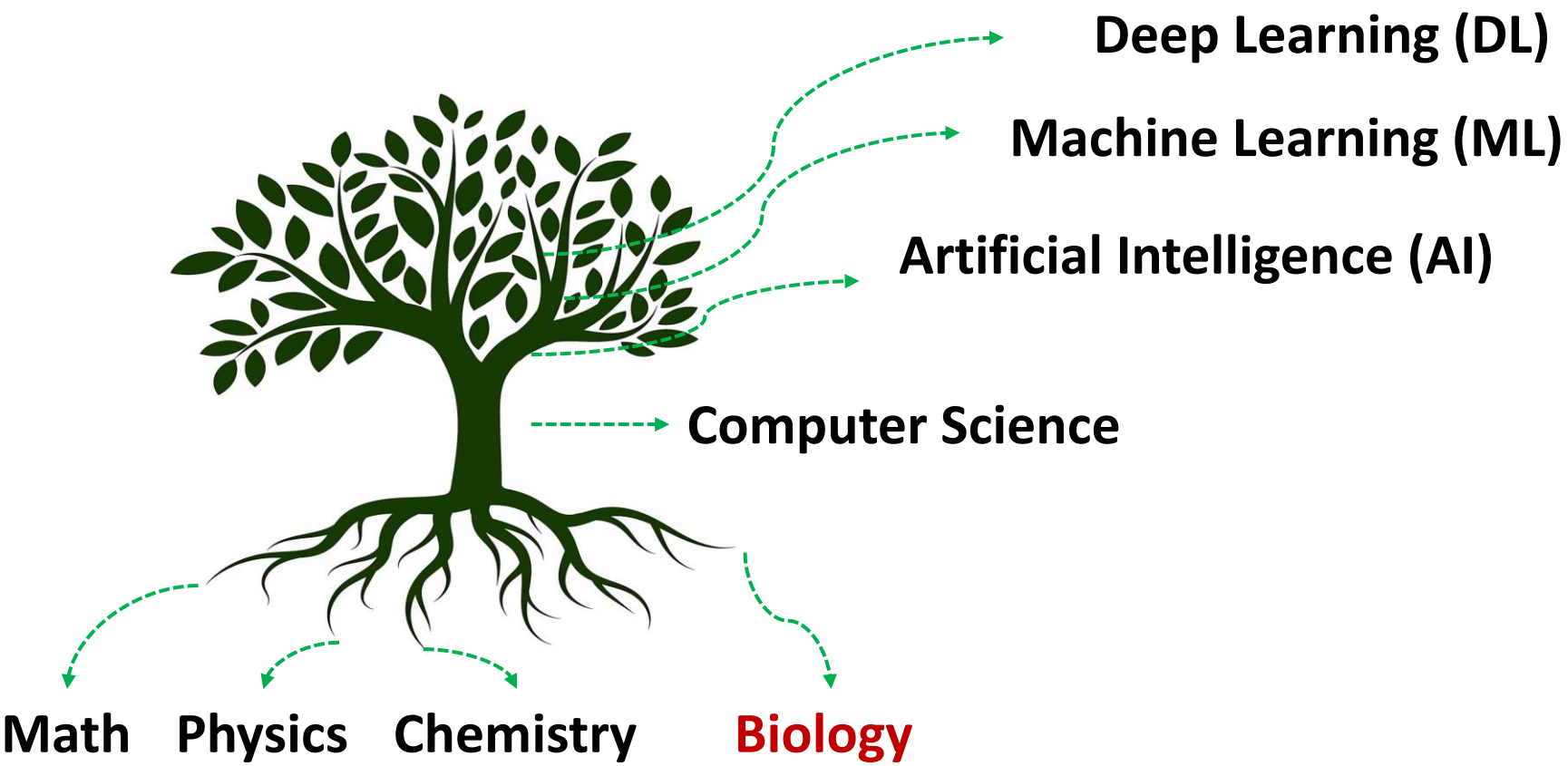
Tuberculosis

✓

But, How AI relates to Medical Diagnosis?

- DL is just a branch of machine learning, which is a branch of AI





Extracting Symptoms and their Status from Clinical Conversations

- Adopting Electronic Health Records (EHR) places a disproportinate burden of documentation on physicans, causing burnout among them
  - A study found that full-time primary care physicians spent about 4.5 hours of an 11-hour workday interacting with documentation systems
  - Yet, they were still unable to finish their documentations and had to spend an additional 1.4 hours after normal clinical hours
- Use Natural Language Processing (NLP) to simplify the task of documentation and allow physicians to dedicate more time to patients?!
- Google managed to develop a corpus of 90k de-identified and manually transcribed audio recordings of clinical conversations between physicians and patients
  - The corpus was annotated by professional medical scribes
  - It resulted in 5M tokens, 615K sentences, 92K labels, 186 symptoms, and 14 body systems
  - It demonstrated a great deal of challenges!

Extracting Symptoms and their Status from Clinical Conversations

- Some of these challenges:
  - The human scribes often disagreed on which labels to pick for which text, let alone the span of text to label
  - Symptoms were sometimes not stated explicitly, but rather explained or described in informal language over several conversation turns

Transcript	Symptoms + Status
DR: Any issues with your eyes? **PT**: Well sort of **DR**: Is your vision ok? **PT**: Yeah, but the right one hurts	**Eye pain**: Experienced **Vision loss**: Not experienced

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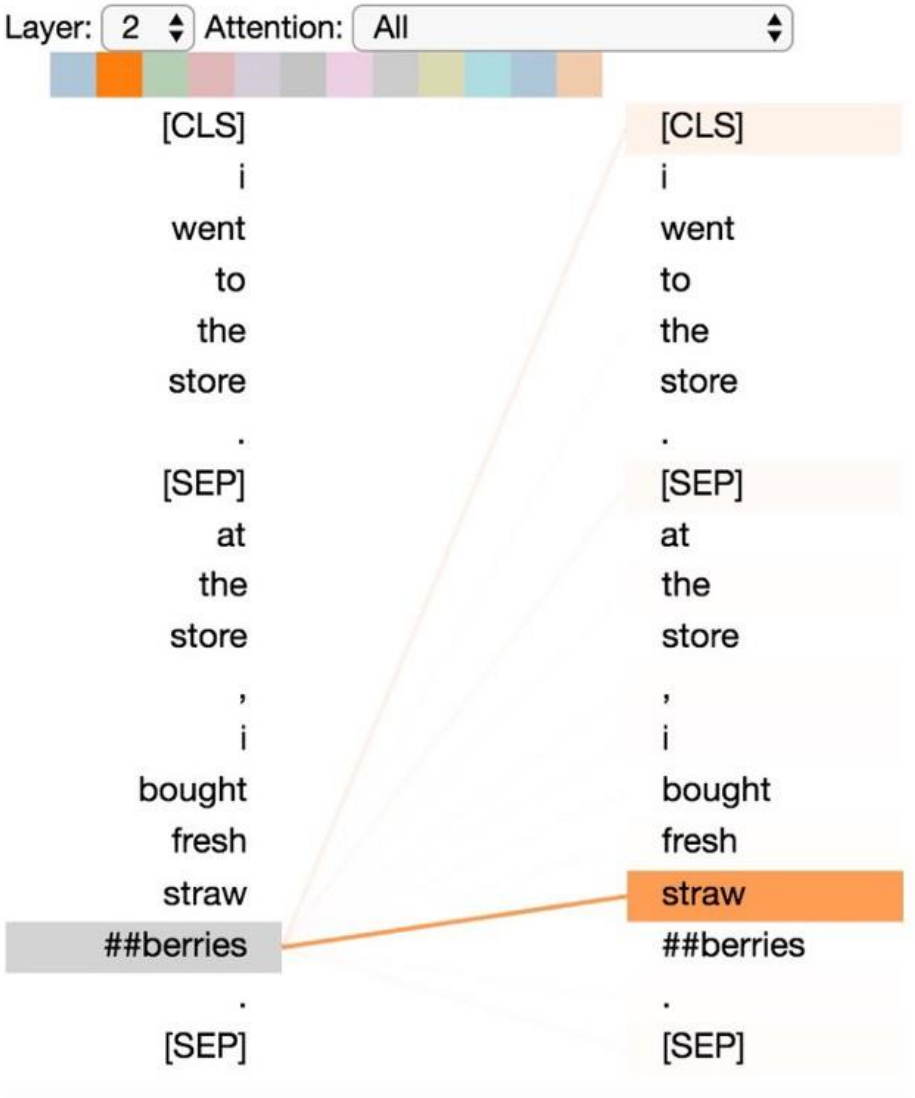
DR: Any issues with your eyes? **PT**: Well sort of **DR**: Is your vision ok? **PT**: Yeah, but the right one hurts	**Eye pain**: Experienced **Vision loss**: Not experienced
DR: How is your bladder? **PT**: I have to go, all the time **DR**: At night? **PT**: No, just during the day	**Frequent urination**: Experienced **Nocturia**: Not experienced

GPT-4 Transformer Architecture

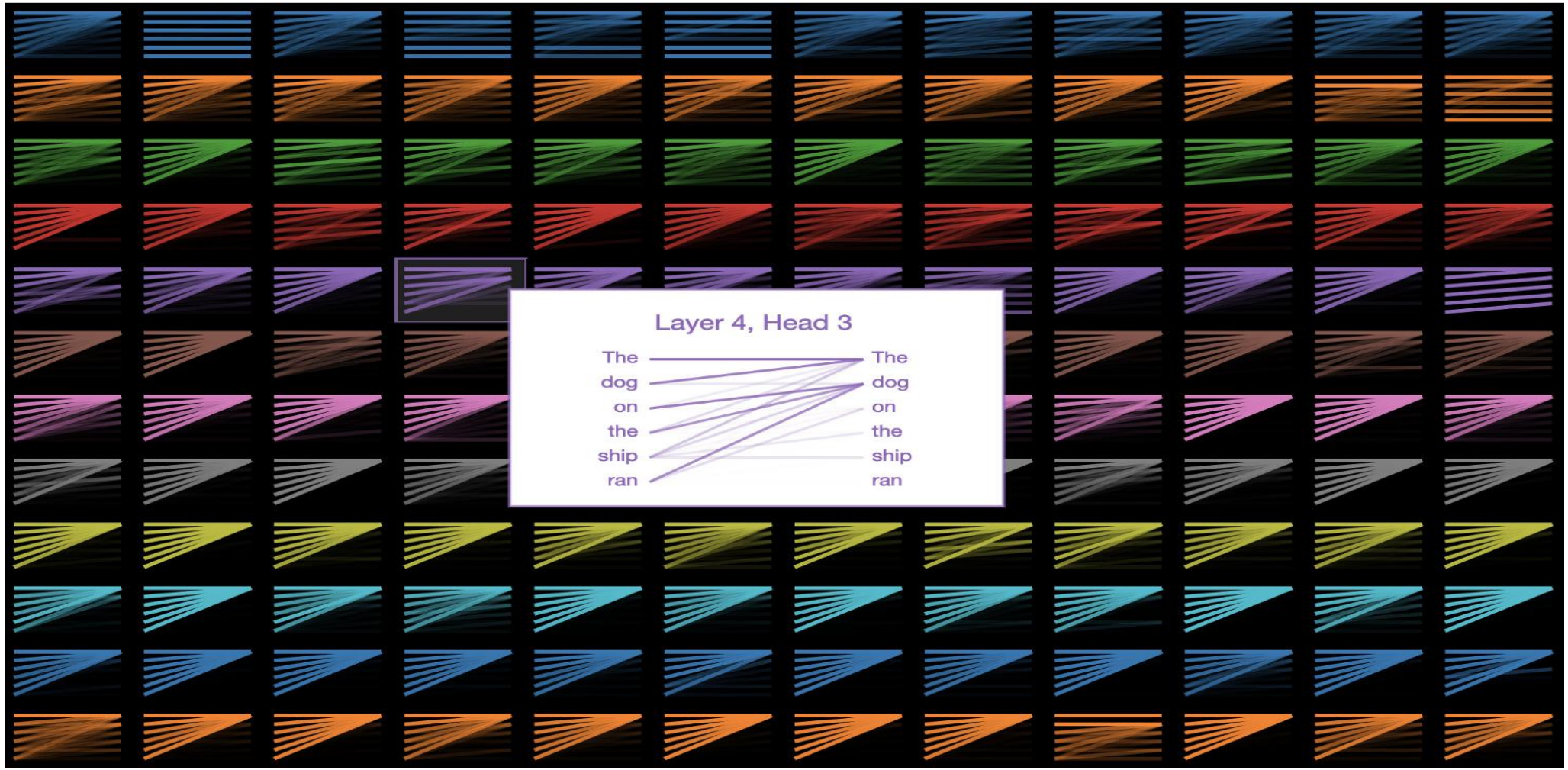
- GPT-4 is a significant departure from traditional Recurrent Neural Networks (RNNs) and Convolutional Neural Networks (CNNs). Unlike RNNs and CNNs, which process input sequentially, **Transformers process input in parallel, making them more efficient at handling long-range dependencies and complex language patterns**.
- **1.8 trillion parameters (**16 experts, each possessing about 111 billion parameters) spread across **120 layers**
- The model is trained on an enormous dataset comprising approximately **13 trillion tokens using 25,000 A100 GPUs over a period of 90 to 100 days**
- The model generates a single token or piece of output utilizing only about 280 billion parameters, requiring approximately 560 teraflops (TFLOPs) of computational power

Falcon 180B : 180 billion parameters, trained on 3.5 trillion tokens. It's currently at the top of the Hugging Face Leaderboard for pre-trained Open Large Language Models (https://huggingface.co/spaces/tiiuae/falcon-180b-demo)

Visualizing Attention



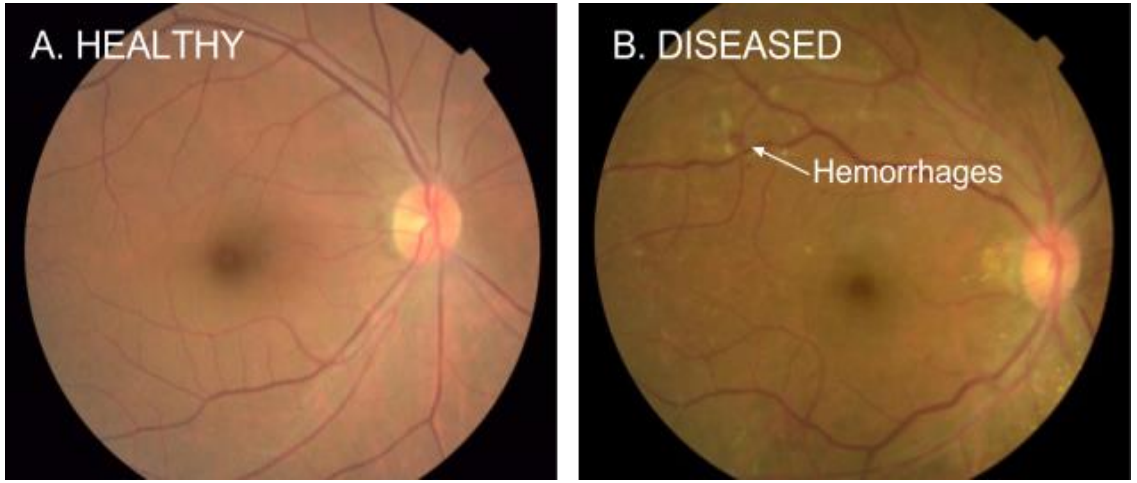
Visualizing Multi-head attention



Some Applications of AI in Medical Diagnosis

Poalelungi, et. al. "Advancing Patient Care: How Artificial Intelligence Is Transforming Healthcare" lists a comprehensive list of scientific articles that analyze the use of artificial intelligence in medical specialties https://www.mdpi.com/2075-4426/13/8/1214, Special Issue **Patient-Centered Care for Chronic Diseases, Journal of Personalized Medicine,** *13*(8), 1214; **https://doi.org/10.3390/jpm13081214**

Diagnosing Diabetic Eye Disease



- The number of people with diabetes mellitus (DM) is rapidly increasing, with up to 642 million cases expected by 2040.
- More than 40% of these diagnosed persons will develop retinopathy. Diabetic retinopathy (DR) and diabetic macular edema (DME) are the main ophthalmological complications of DM, with Diabetic retinopathy (DR) is the fastest growing, leading cause of blindness, with nearly 451 million diabetic patients at risk worldwide being of blindness and visual disability in the working-age population
- One of the most common ways to detect DR is to have a specialist examine eye pictures and rate them for disease presence and severity

Diagnosing Diabetic Eye Disease

- The risk of such vision loss can be reduced by annual retinal screening and early retinopathy detection to refer cases for follow-up and treatment.
- The necessary fundus photographs for such screening can be easily obtained non-invasively in an outpatient setting.
- **Implementing a nationwide screening program based on fundus photography resulted in DR no longer being the leading cause of blindness certification in the United Kingdom**
- If DR is caught early, the disease can be treated; if not, it can lead to irreversible blindness. As such, regular screening is essential for the early detection of DR
- Unfortunately, medical specialists capable of detecting DR are not available in many parts of the world where diabetes is prevalent
- Google has developed a deep learning algorithm capable of interpreting signs of DR in retinal photographs

Diagnosing Diabetic Eye Disease

- They created a dataset of 128,000 images, each labeled by 3-7 ophthalmologists from a panel of 54 ophthalmologists
  - DR severity (none, mild, moderate, severe, or proliferative) was graded according to the International Clinical Diabetic Retinopathy scale

- They then used this dataset to train a deep learning algorithm to detect referable diabetic retinopathy

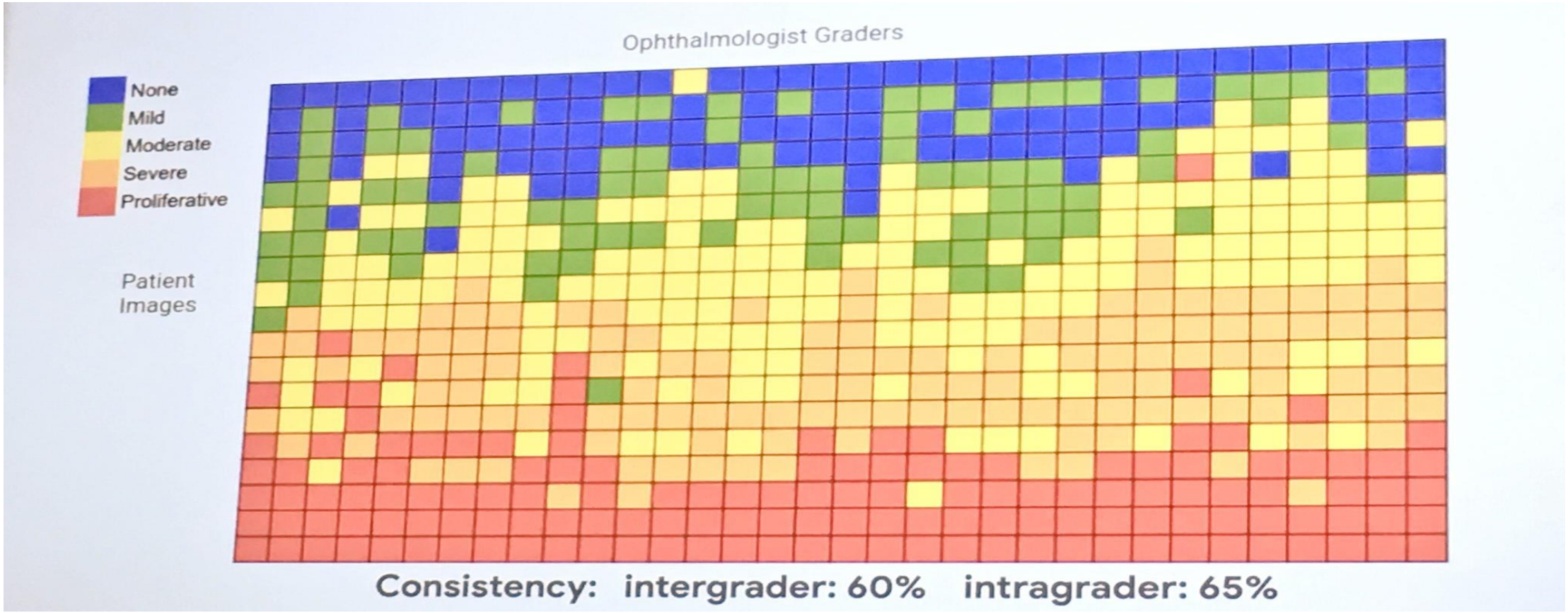
- Afterwards, they tested the algorithm on two clinical validation sets totaling ~12,000 images, with a panel of 7-8 U.S. board-certified ophthalmologists serving as the reference standard

Diagnosing Diabetic Eye Disease

- The ***F-score*** (combined *sensitivity* and *precision*) of the algorithm was 0.95, which is slightly better than the median F-score of the 8 board-certified ophthalmologists (measured at 0.91)

- What does this study entail?
  - **AI can now offer an automated system for DR detection with**
    - **A very high accuracy**
    - **Near instantaneous reporting of results!**
    - **Consistency of interpretation (the algorithm will make the *same* prediction on the *same* image every time)**

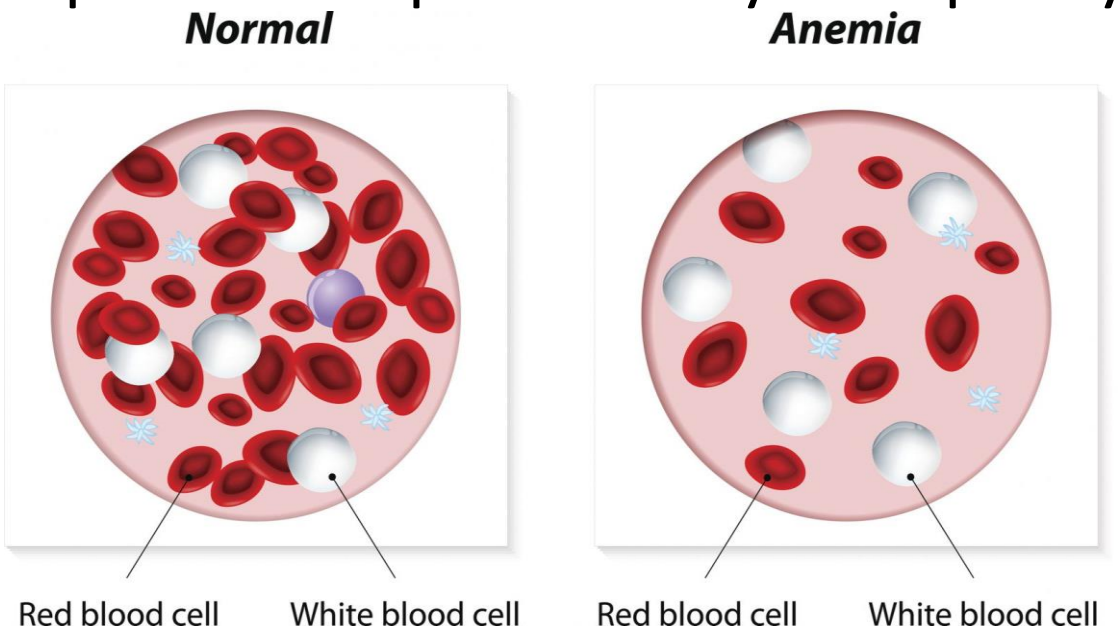
Diagnosing Diabetic Eye Disease



A slide from Jeff Dean's Keynote in 2019 at the "Big Data in Precision Health" conference at Stanford Medicine

Detecting Anemia from Retinal Fundus Images

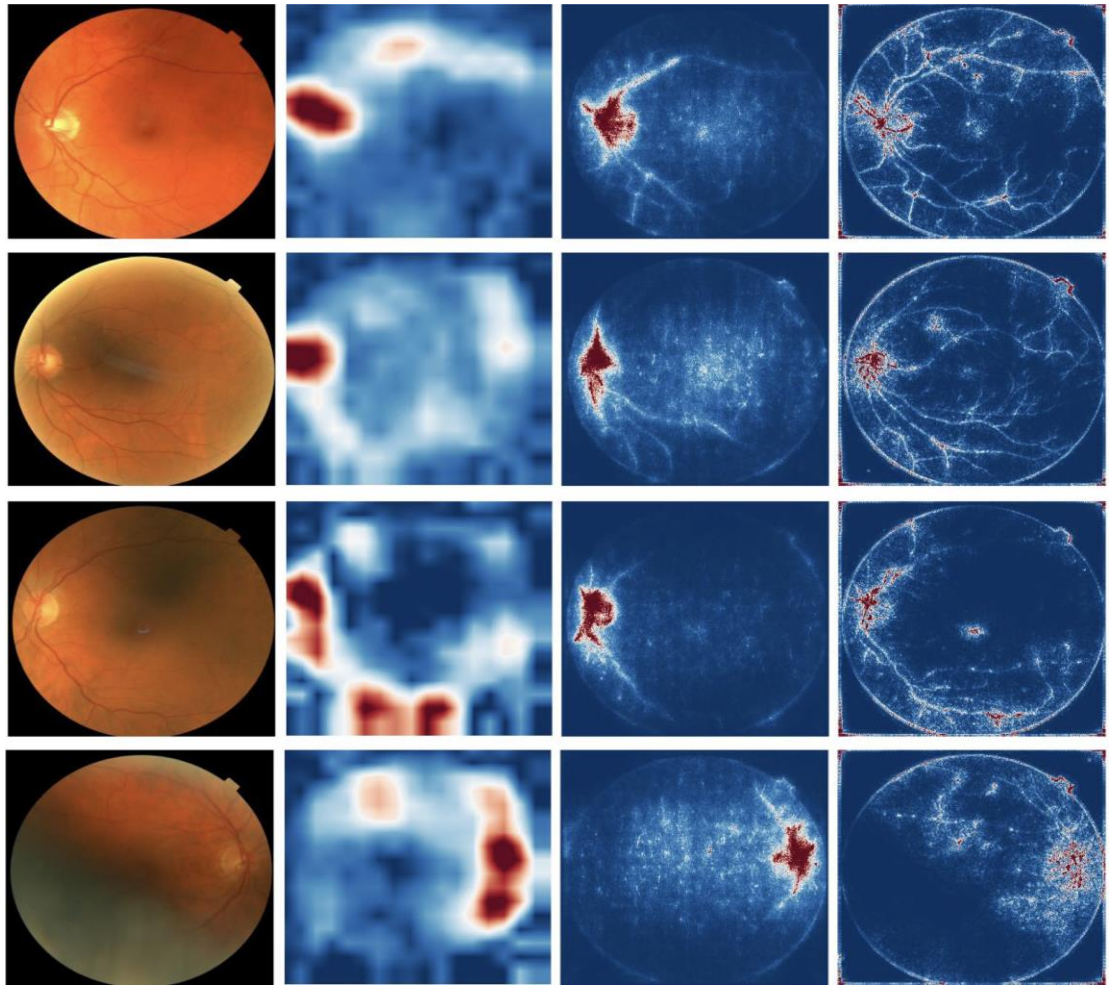
- Anemia is a public health problem impacting an estimated 1.62 billion people and inducing far-reaching consequences on productivity and quality-of-life
- Anemia is usually correctable; hence, timely detection and intervention are key!



- The most reliable indicator of anemia is hemoglobin concentration (Hb), which is measured using a venous or capillary blood sample
- This is invasive & painful and can cause infection in patients & healthcare workers, let alone that it generates biohazardous waste

Detecting Anemia from Retinal Fundus Images

- Results of the fundus-only model:
  - Red and white areas represent regions the model was positively influenced by
  - Red indicates a stronger contribution than white
  - Blue regions have little to no contribution towards the prediction
- The model correctly predicts moderate anemia in each case



And the Power of AI is Yet to Usher

- The first medical image ever taken was in 1895 by Wilhelm Röntgen
  - This allowed looking inside a human body without slicing someone open!

- Since then, **medical imaging** has represented the fastest growing source of medical data and **literally changed the face of medicine**

- Imaging can sometimes reveal a disease before we feel it
  - For several diseases (e.g., cancer), the earlier we diagnose them the more likely the patients will survive, let alone reducing pain, suffering, cost, etc.

Discovery and Visualization of Structural Biomarkers from MRI using Machine Learning

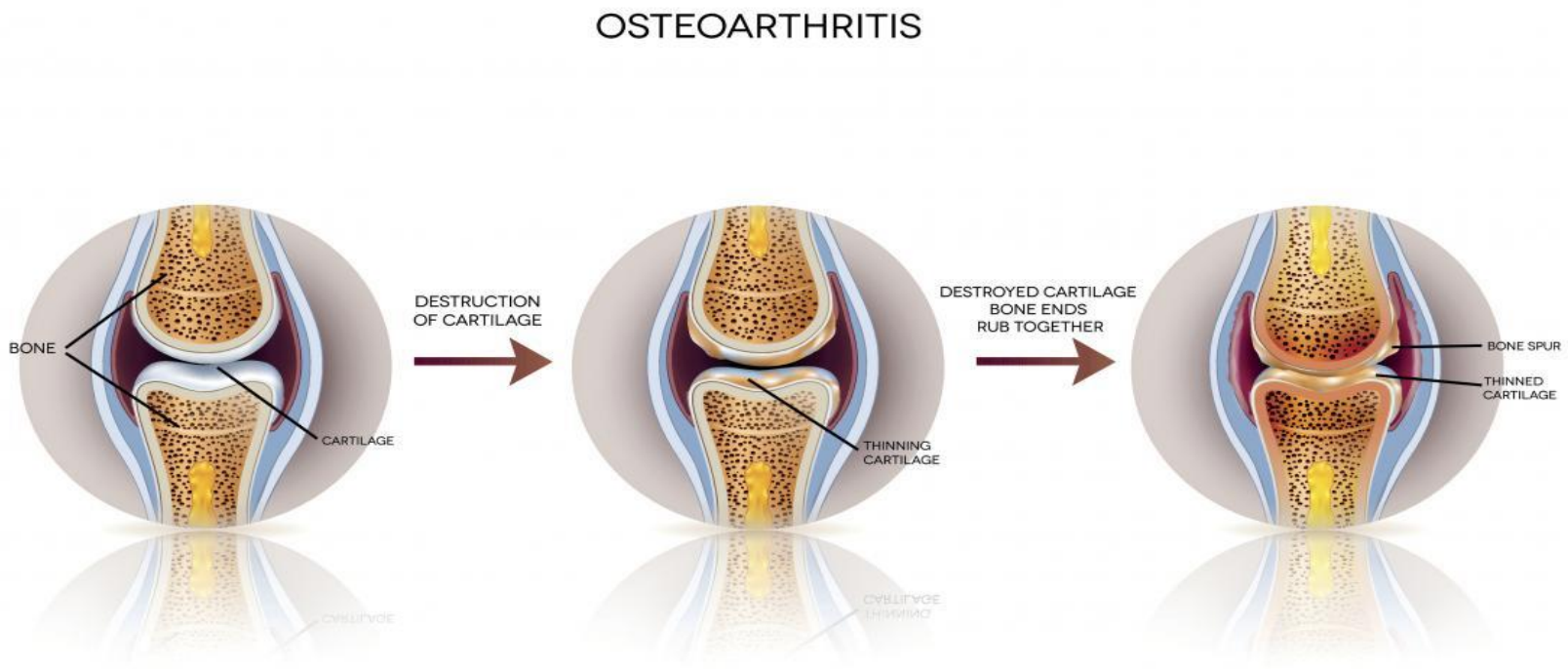
- That is why we screen people who exhibit no signs or symptoms yet

- But, the earlier we capture images, the smaller & smaller the visible evidences of diseases become, until they vanish before our naked eyes
  - How early can we detect diseases?

- **There is a growing belief that there is an invisible side to imaging!**
  - These are small changes (or *hidden patterns*) that are imperceptible to humans
  - Yet, they can be detected by AI!

Discovery and Visualization of Structural Biomarkers from MRI using Machine Learning

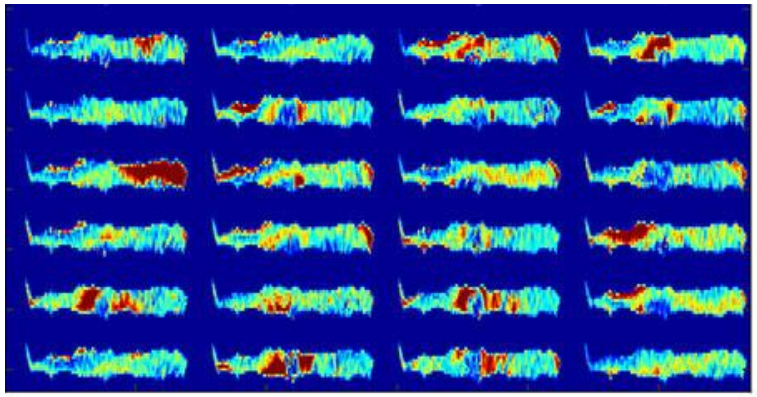
- One in 10 develop knee osteoarthritis, which cannot be detected until the damage has occurred



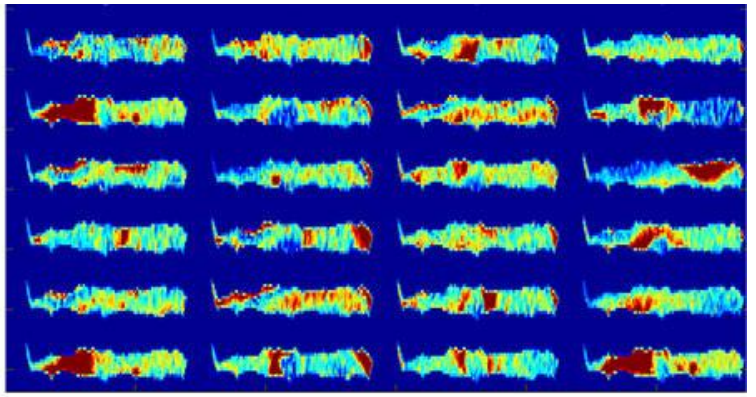
Discovery and Visualization of Structural Biomarkers from MRI using Machine Learning

- Here are scans that belong to different subjects, with different colors representing different ingredients that make up the cartilage

Group A



Group B



Which group has osteoartherits? Best experts cannot tell!

Discovery and Visualization of Structural Biomarkers from MRI using Machine Learning

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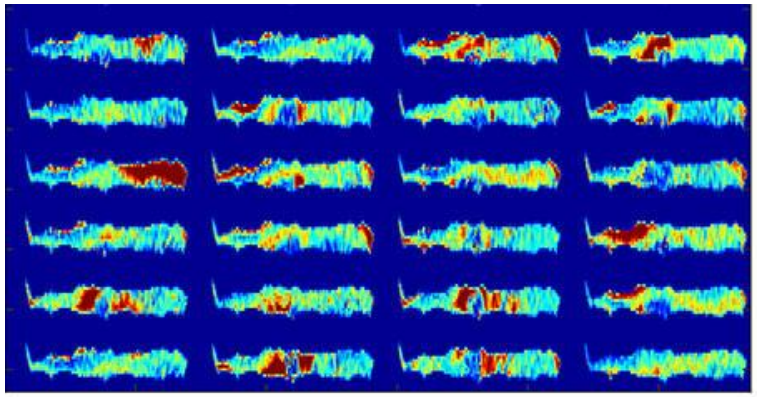
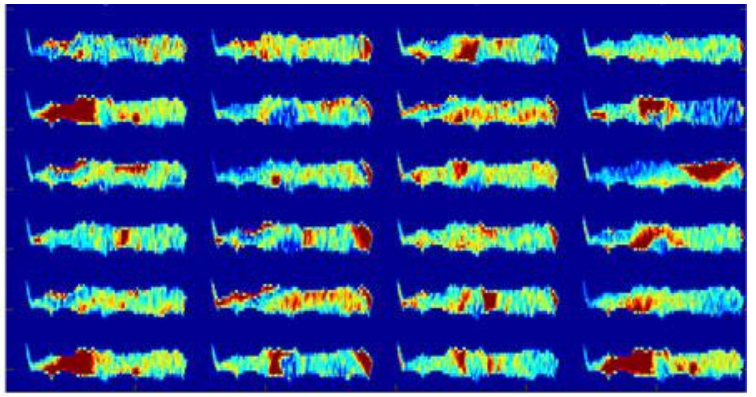


NO osteoarthritis in 3 years

Group B



Osteoarthritis in 3 years

Discovery and Visualization of Structural Biomarkers from MRI using Machine Learning

- This can be predicted using a machine learning algorithm that applies a technique known as “transport based morphometry”

- **The algorithm is able to predict whether a person will develop osteoarthritis 3 year down the line with an accuracy of 86.2%**

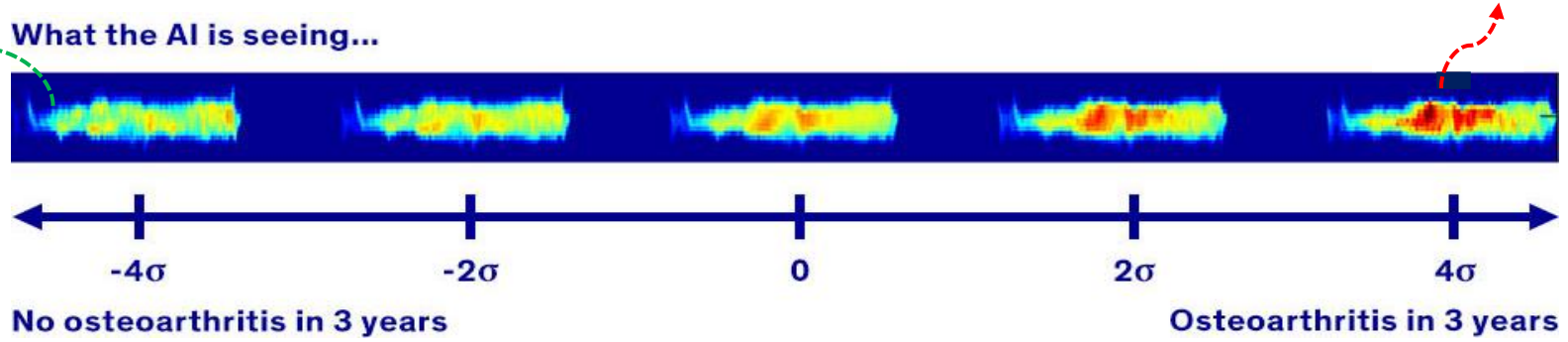
- The algorithm can learn more with experience, hence, it will only get better and better as we feed it with more scans

Discovery and Visualization of Structural Biomarkers from MRI using Machine Learning

- But what does this algorithm see that doctors cannot?
  - The diffusion of water

Water is evenly distributed throughout the cartilage

The pooling of water at the center of the cartilage suggests that there is a weakening of cartilage at that location



Discovery and Visualization of Structural Biomarkers from MRI using Machine Learning

- This can augment our capability and help us identify new targets for treatments

- Can we apply this technique to other diseases (e.g., Alzheimer, autism, schizophrenia)?
  - If so, can we halt them before they even begin?

- **Just like in 1985 when the first image was taken**, the face of medicine is about to change again
  - At that time we were able to see the visible
  - **Now, we can see the invisible through AI!**

What's Next? Mortality Challenges!

DA

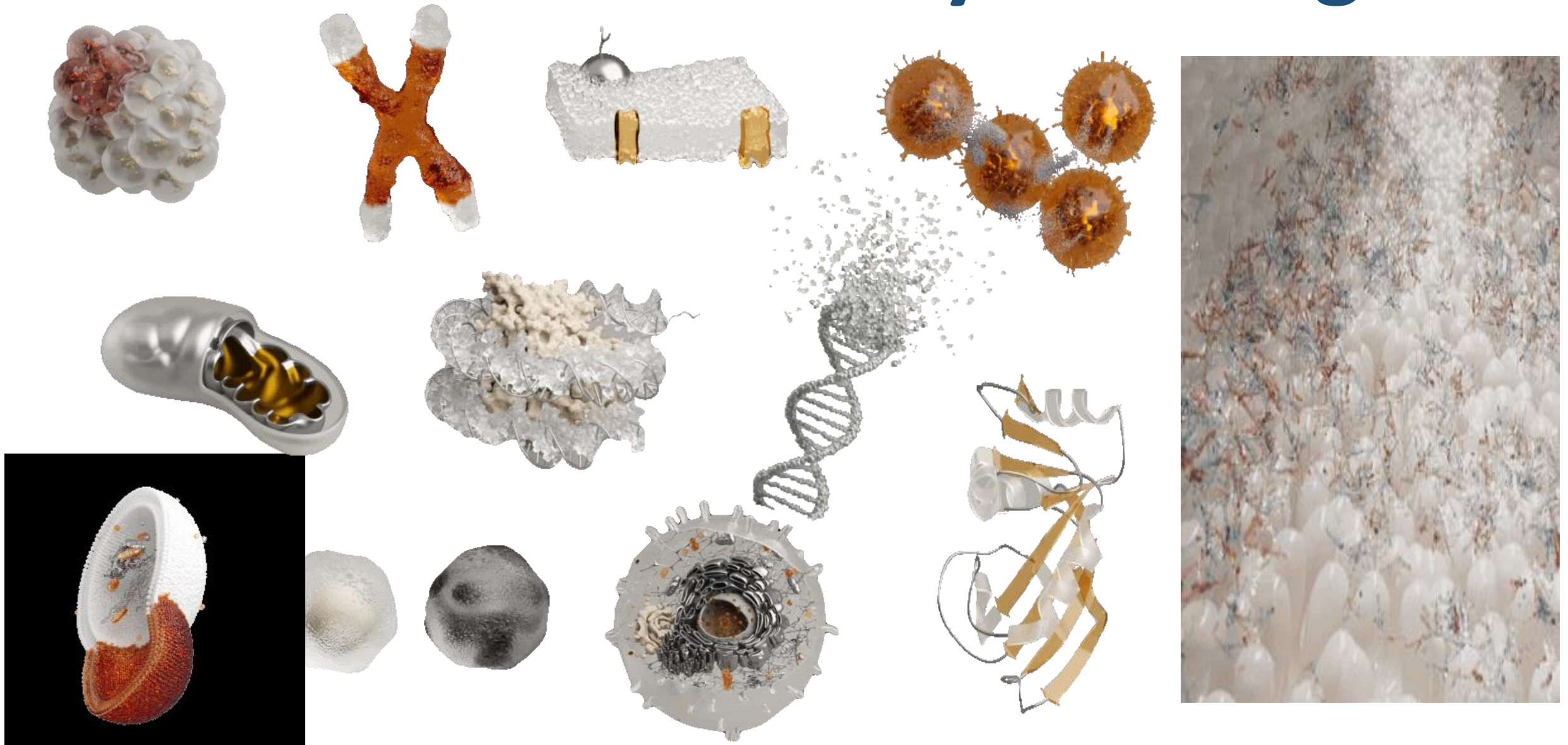
Summarize all the above and devise a plan to live longer younger

To live longer and age more slowly, it's important to adopt a comprehensive approach that addresses various aspects of aging. Here's a summary of key factors and a plan for healthy aging:

Factors Affecting Aging:

1. **Mitochondrial Dysfunction:** Mitochondria, the cell's powerhouses, can become less efficient with age. A healthy diet, regular exercise, and supplements like CoQ10 can support mitochondrial health.
2. **Cellular Senescence:** Senescent cells accumulate with age and contribute to tissue dysfunction. Consider senolytics, exercise, and a balanced diet to remove or rejuvenate these cells.
3. **Loss of Proteostasis:** Maintaining protein quality is vital. Promote proper protein folding, support autophagy, and avoid toxins to reduce protein damage.

What’s Next? Mortality Challenges!



Devise a plan to live longer younger!

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- **Loss of Proteostasis:** Maintaining protein quality is vital. Promote proper protein folding, support autophagy, and avoid toxins to reduce protein damage.
- **Altered Cellular Communication:** Dysregulated cell signaling can lead to age-related diseases. Focus on hormone balance, anti-inflammatory strategies, and lifestyle factors to restore healthier cellular communication.
- **Epigenetic Alterations:** Epigenetic changes influence gene expression. Explore interventions like dietary modifications, exercise, and potentially epigenetic therapies to restore youthful epigenetic patterns.
- **Telomere Shortening:** Shortened telomeres are associated with aging. While telomere extension is a complex field, maintaining a healthy lifestyle and managing stress can help preserve telomere length.
- **Disabled Macroautophagy:** Impaired autophagy can lead to cellular dysfunction. Promote autophagy through exercise, intermittent fasting, and potentially pharmacological interventions.
- **Inflammaging:** Chronic inflammation contributes to aging. Eat an anti-inflammatory diet, practice stress reduction, and consider anti-inflammatory drugs or supplements cautiously.
- **Microbiome Dysbiosis:** A balanced gut microbiome is crucial. Adopt a fiber-rich diet, probiotics, prebiotics, and consider personalized interventions based on microbiome testing.

Plan for Healthy Aging

- **Diet:**
  - Eat a balanced, anti-inflammatory diet
    - Apples, Strawberries for (Magnesium malate)
    - Blueberries, strawberries and grapes for (Pterostilbene)
    - Calcium Alpha-Ketoglutarate
    - Liver or Eggs for Vitamin B6
    - Omega-3 fatty acids
    - Flavonoids (Fisetin) are substances that give fruits and vegetables their bright colors (like yellow, orange and blue)
    - Ginger
    - Vitamin C
  - Consider intermittent fasting and reduce processed foods and sugar intake.
- **Exercise:** Incorporate regular physical activity, including both aerobic and strength training exercises.
- **Stress Management:** Practice stress-reduction techniques such as meditation, mindfulness, or yoga.
- **Sleep:** Prioritize quality sleep to support cellular repair and overall health.
- **Supplements:** Consider supplements like CoQ10, antioxidants, and specific vitamins based on individual needs and consultation with a healthcare professional.
- **Lifestyle:** Avoid toxins, maintain a healthy weight, and avoid smoking and excessive alcohol consumption.
- **Medical Check-ups:** Regularly visit healthcare professionals for check-ups, screenings, and discussions about anti-aging strategies.

Thank You!