Intelligent oncology: Synergy of Artificial Intelligence + Oncology

دکتر نسیبه رادی راز

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دانشگاه علوم پزشکی و خدمات بهداشتی، درمانی ایران

عنوان دوره آنلاین:

هوش مصنوعی در پزشکی با رویکرد بالینی

Online Course: Artificial Intelligence in Medicine with Clinical Approach

Course Topics	عناوین بیست و چهار جلسه	تاریخ جلسات
Artificial Intelligence (AI) in medicine	معرفی هوش مصنوعی در پزشکی	۲۸ بهمن ۱۴۰۲
AI and Fuzzy systems and its applications in medicine	هوش مصنوعی و سیستم های فازی در پزشکی	۵ اسفند ۱۴۰۲
Machine Learning and its applications in medicine	یادگیری ماشین و کاربردهای آن در پزشکی	۱۲اسفند۱۴۰۲
Evolutionary systems and its applications in medicine	الگوریتم های بهینه سازی تکاملی و کاربردهای آن در پزشکی	۱۹اسفند ۱۴۰۲
Neural networks and deep neural networks in medicine	شبکه های عصبی و شبکه های عصبی عمیق در پزشکی	۲۵فروردین ۱۴۰۳
Application of AI in Early Detection of Disease	کاربرد هوش مصنوعی در تشخیص زودهنگام بیماری ها	۱ اردیبهشت ۱۴۰۳
Swarm Intelligence and multi-agent/swarm in medicine	هوش ازدحامی، سیستم های چند عامله/ازدحامی در پزشکی	۸اردیبهشت ۱۴۰۳
Application of AI in Cancer	کاربردهای هوش مصنوعی در سرطان	۲۲اردیبهشت ۱۴۰۳
Application of AI in surgery	کاربردهای هوش مصنوعی در جراحی	۲۹ اردیبهشت ۱۴۰۳
Applications of AI in Neurology	کاربردهای هوش مصنوعی در مغز و اعصاب	۵ خرداد ۱۴۰۳
Application of AI in Internal Medicine	کاربردهای هوش مصنوعی در پزشکی داخلی	۱۲ خرداد ۱۴۰۳
Applications of AI in cardiovascular	کاربردهای هوش مصنوعی در قلب و عروق	۱۹ خرداد ۱۴۰۳
Applications of AI in Breast Disease	کاربردهای هوش مصنوعی در بیماری های پستان	۲۶ خرداد ۱۴۰۳
Application of AI in Ophthalmology	کاربردهای هوش مصنوعی در چشم پزشکی	۲ تیر ۱۴۰۳
Application of AI in Nephrology	کاربردهای هوش مصنوعی در نفرولوژی	۹ تیر ۱۴۰۳
Application of AI in Otorhinolaryngology	کاربردهای هوش مصنوعی در گوش و حلق و بینی	۱۶ تیر ۱۴۰۳
Application of AI in Gynecology and obstetrics	کاربردهای هوش مصنوعی در زنان و مامایی	۲۳ تیر ۱۴۰۳
Application of AI in pediatric medicine	کاربردهای هوش مصنوعی در پزشکی اطفال	۳۰ تیر ۱۴۰۳
Application of AI in anesthesia	کاربردهای هوش مصنوعی در بیهوشی	۶ مرداد ۱۴۰۳
Application of AI in emergency medicine	کاربردهای هوش مصنوعی در پزشکی اورژانس	۱۳ مرداد ۱۴۰۳
Applications of artificial intelligence in orthopedics	کاربردهای هوش مصنوعی در ارتوپدی	۲۰ مرداد ۱۴۰۳
Application of AI in pain management	کاربردهای هوش مصنوعی در مدیریت درد	۲۷ مرداد ۱۴۰۳
Application of AI in pharmacology	کاربردهای هوش مصنوعی در داروسازی	۳ شهریور ۱۴۰۳
Application of AI in dentistry	کاربردهای هوش مصنوعی در دندان پزشکی	۱۰ شهریور ۱۴۰۳

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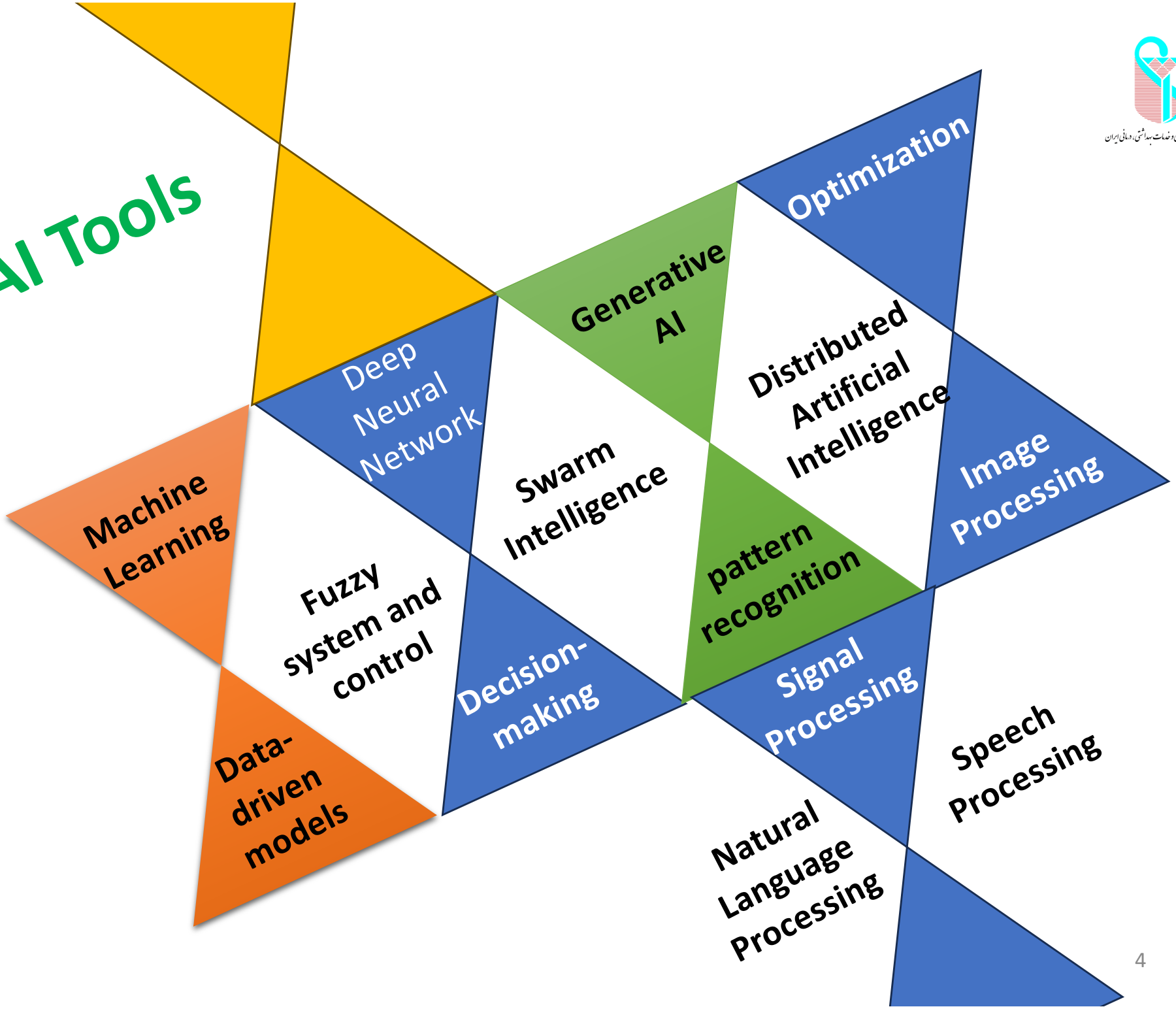
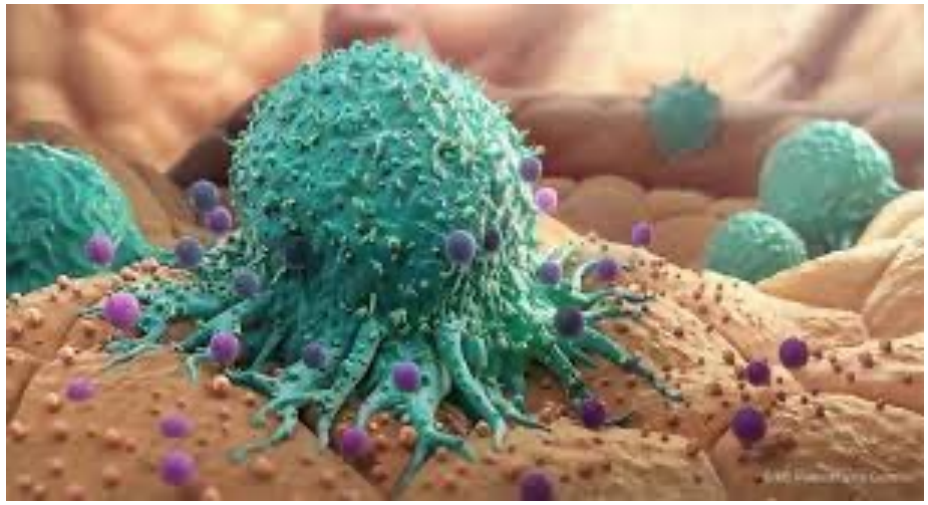
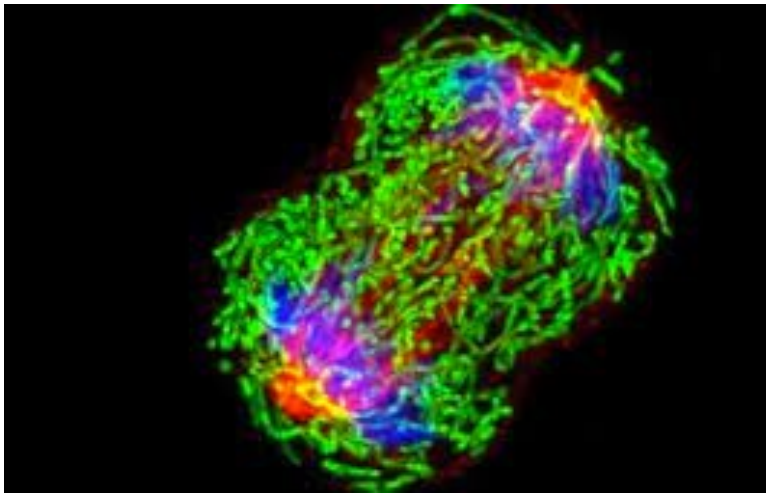
بسم الله الرحمن الرحیم

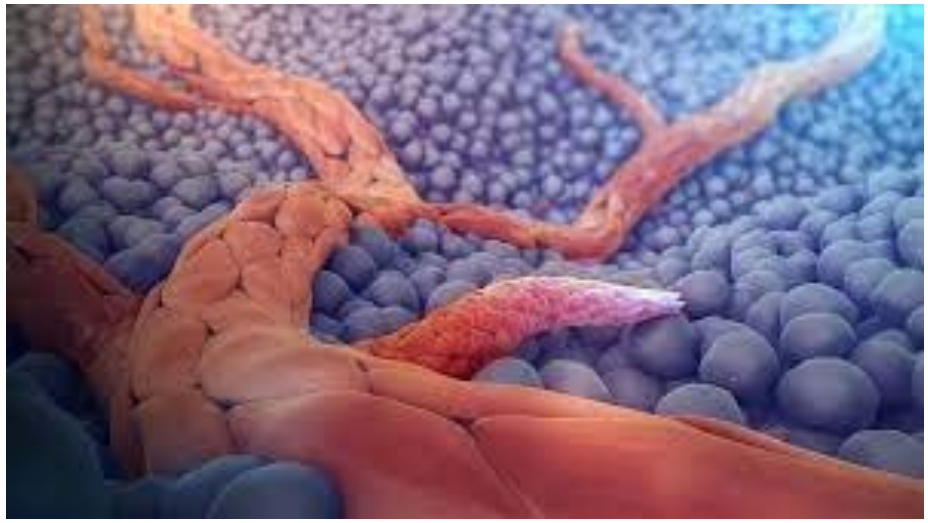
AI Tools


Machine Learning
Deep Neural Network
Generative AI
Optimization
Fuzzy system and control
Swarm Intelligence
Distributed Artificial Intelligence
Image Processing
Data-driven models
Decision-making
pattern recognition
Signal Processing
Speech Processing
Natural Language Processing

Cancer







Medical oncology

Surgical oncology

Radiation oncology

Clinical oncology

Neuro-oncology

Ocular oncology

Head & Neck oncology

Thoracic oncology

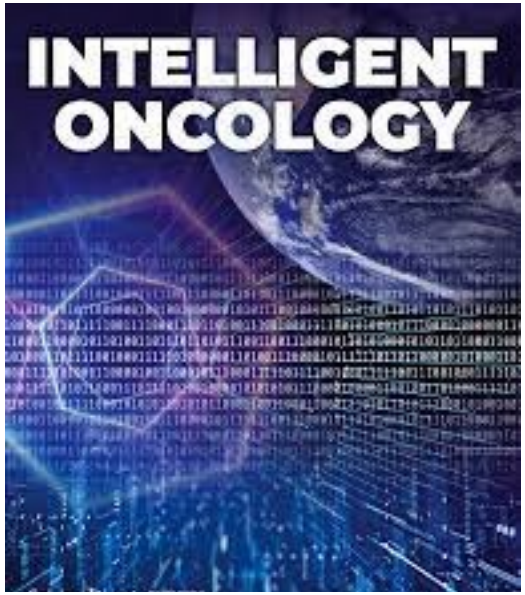
Breast oncology

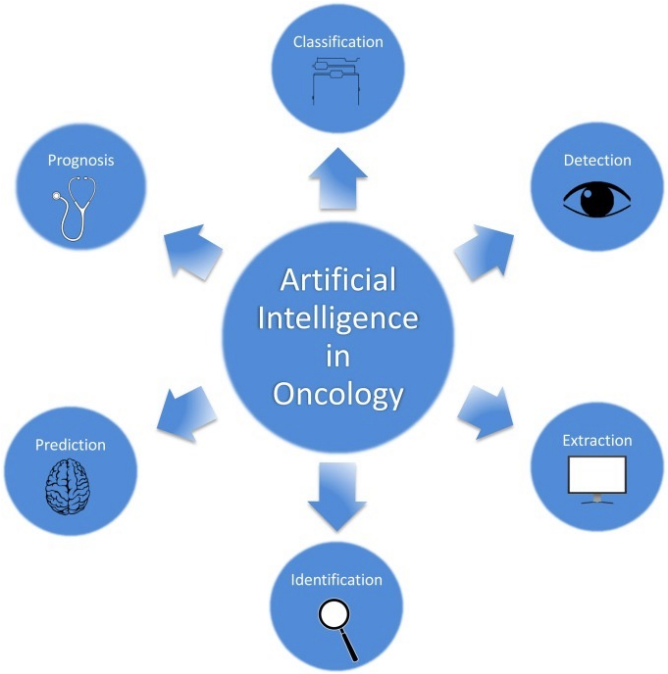
Gastrointestinal oncology

Bone & Musculoskeletal oncology

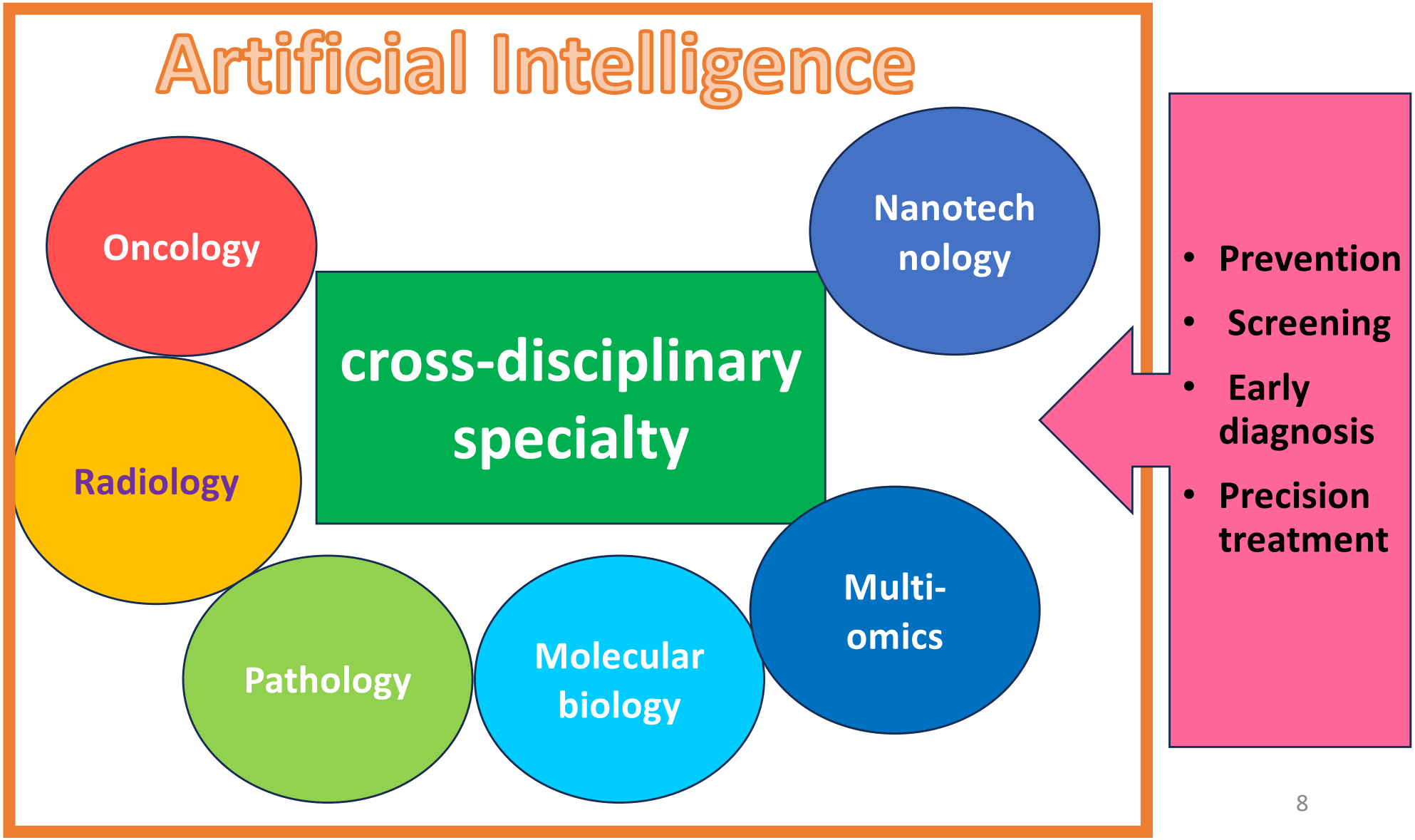
What is Intelligent oncology?

Harness the power Of modern artificial intelligence techniques for the fight against cancer.



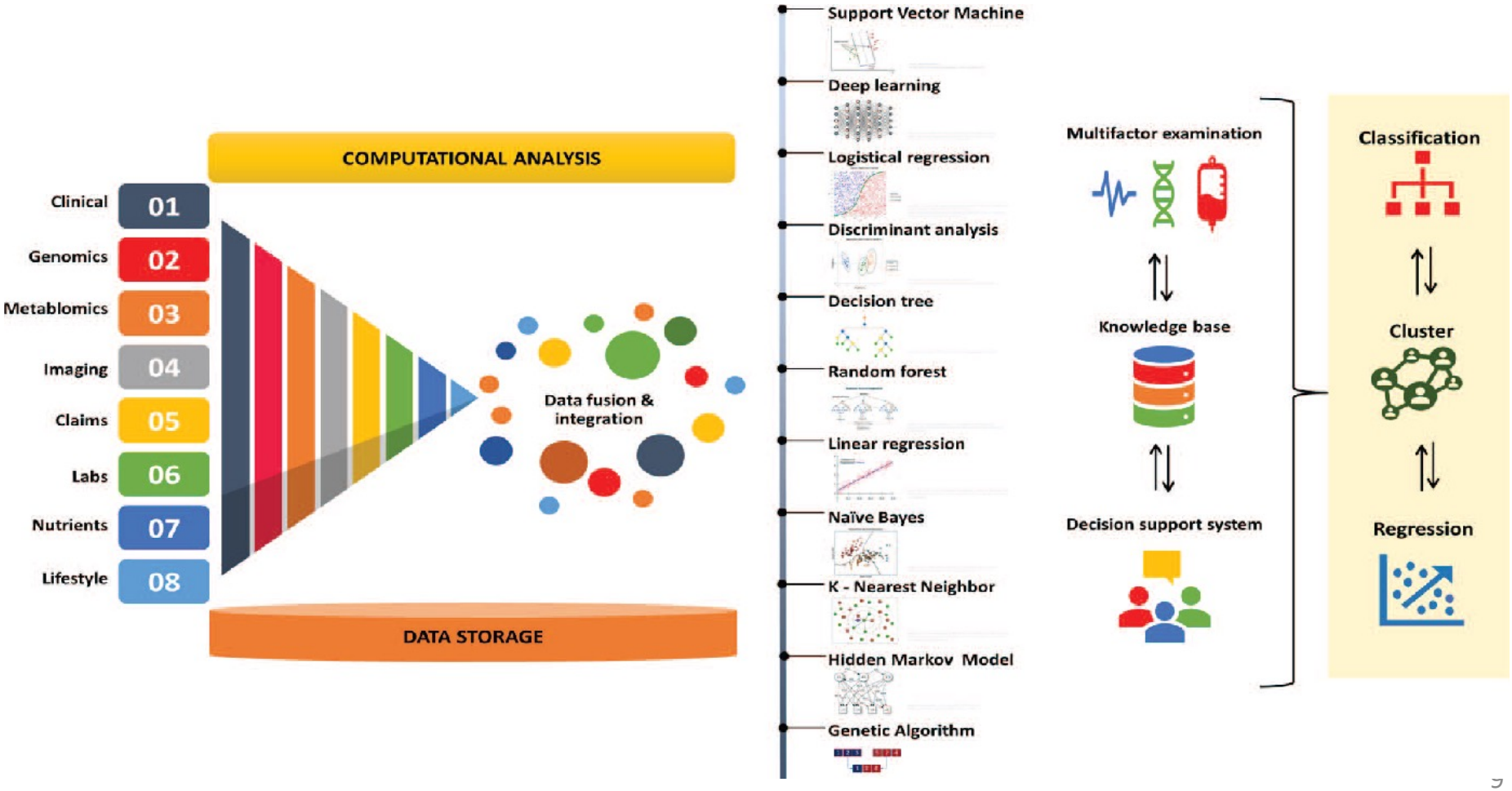


Intelligent Oncology

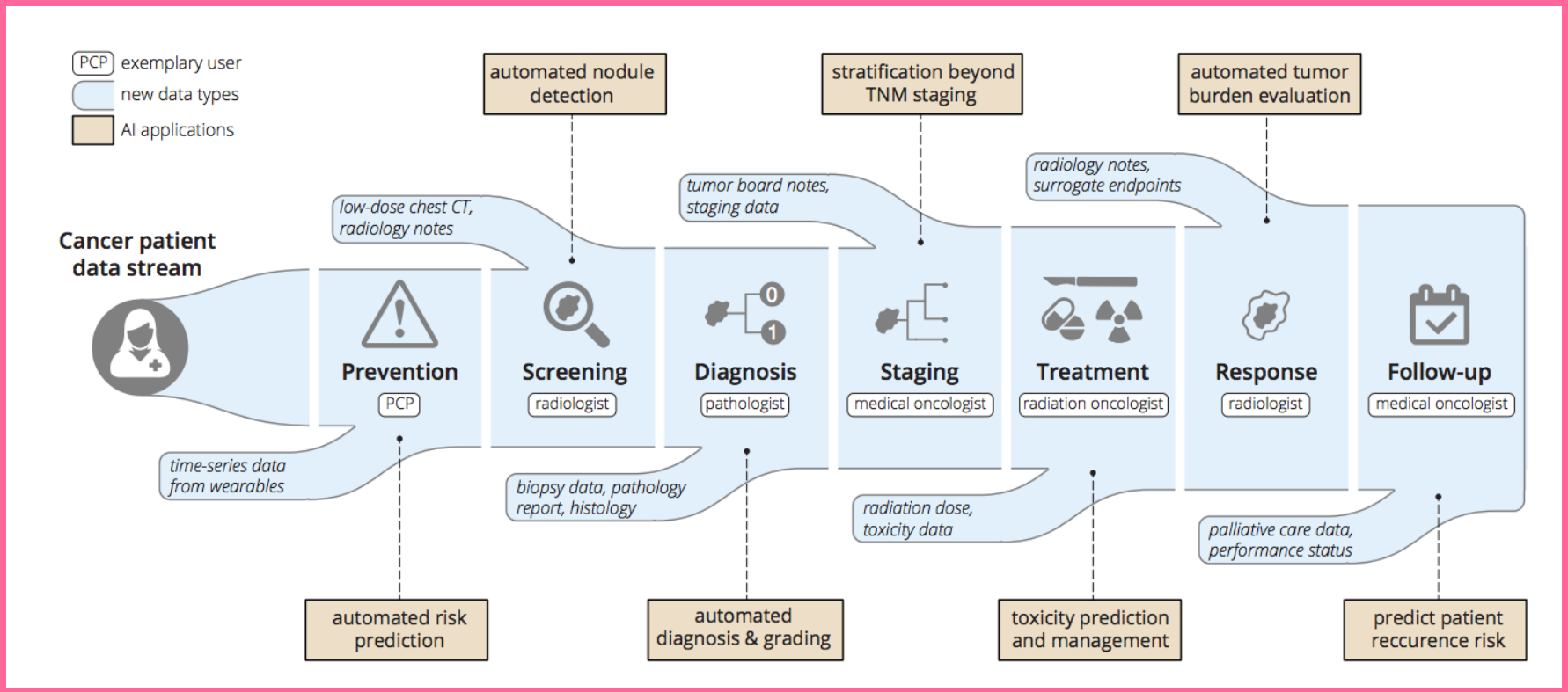


Artificial Intelligence in Medicine

Artificial Intelligence = **Augmented Intelligence**

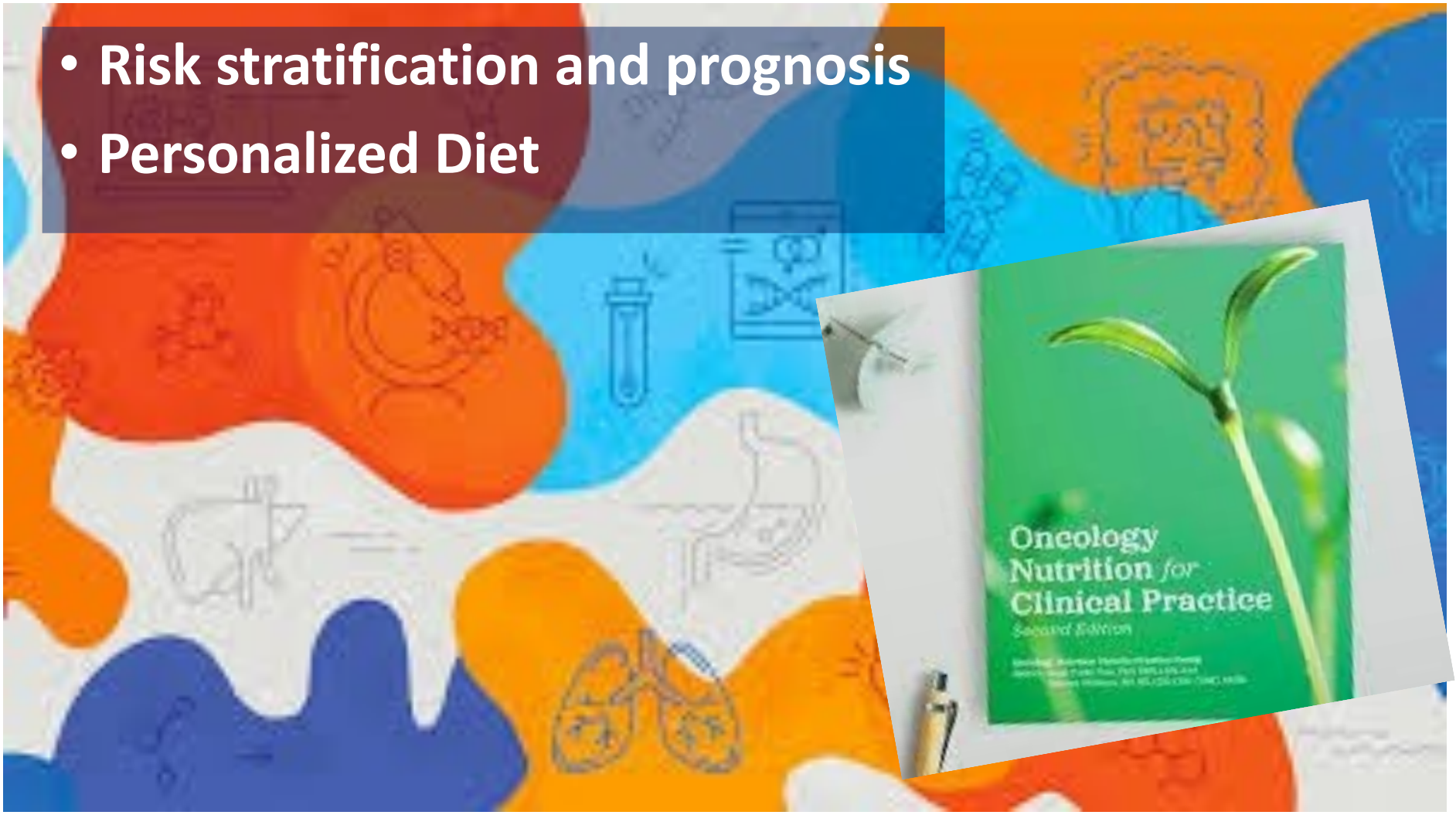


Intelligent Oncology



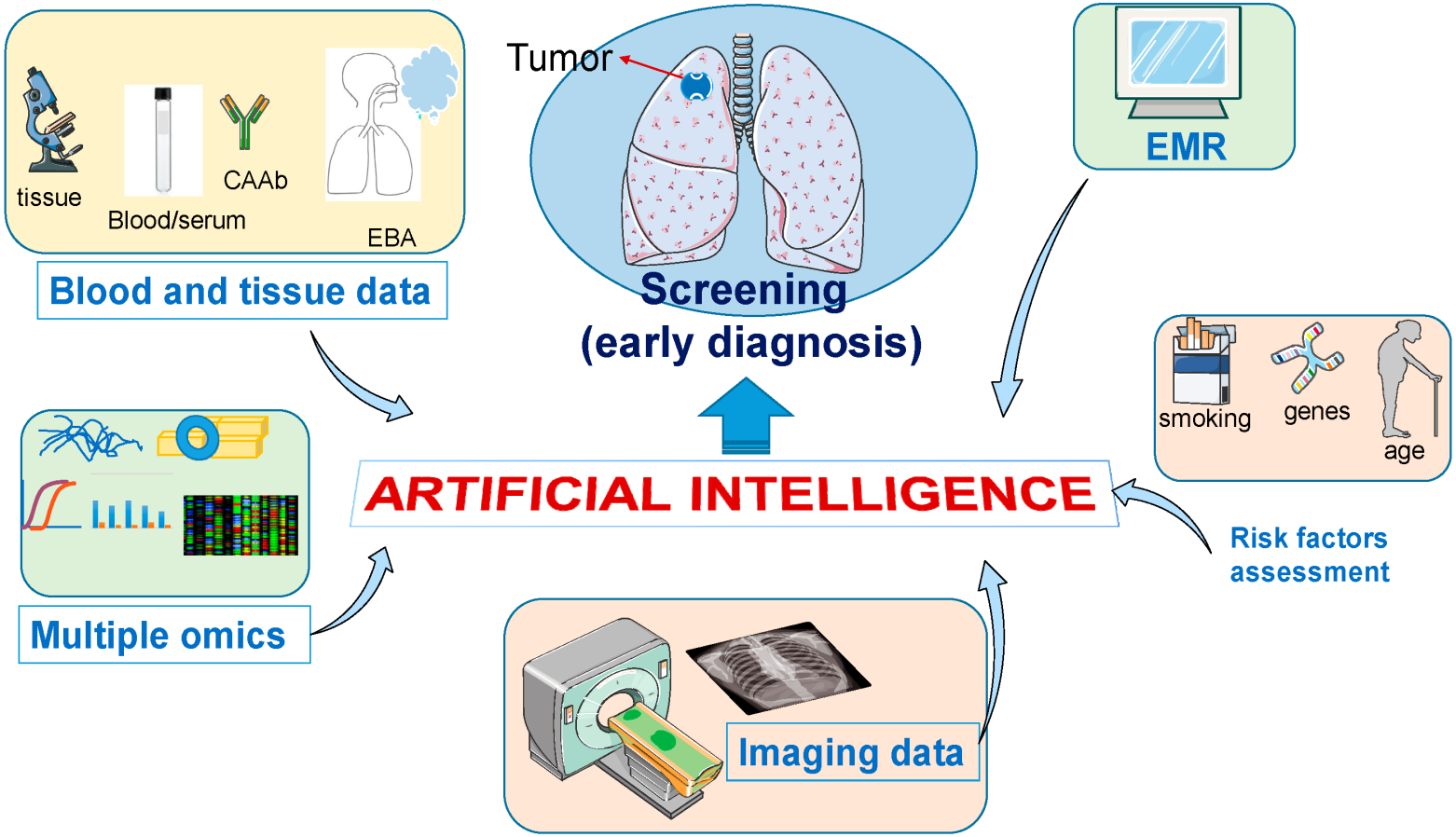
Intelligent Oncology: Prevention

- Risk stratification and prognosis
- Personalized Diet

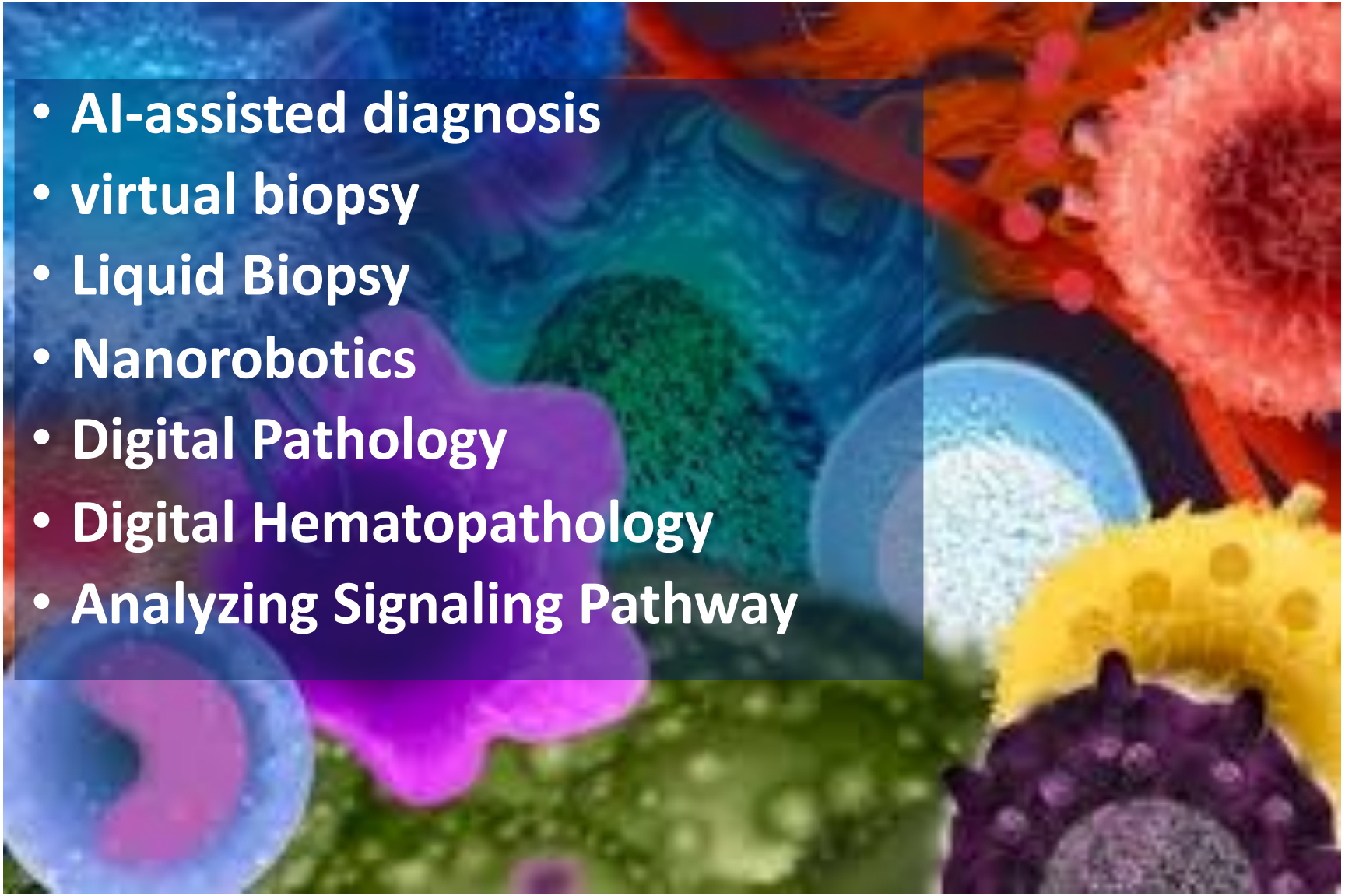


Intelligent Oncology: Screening

- **AI-Enhanced Lab-on-a-Chip**

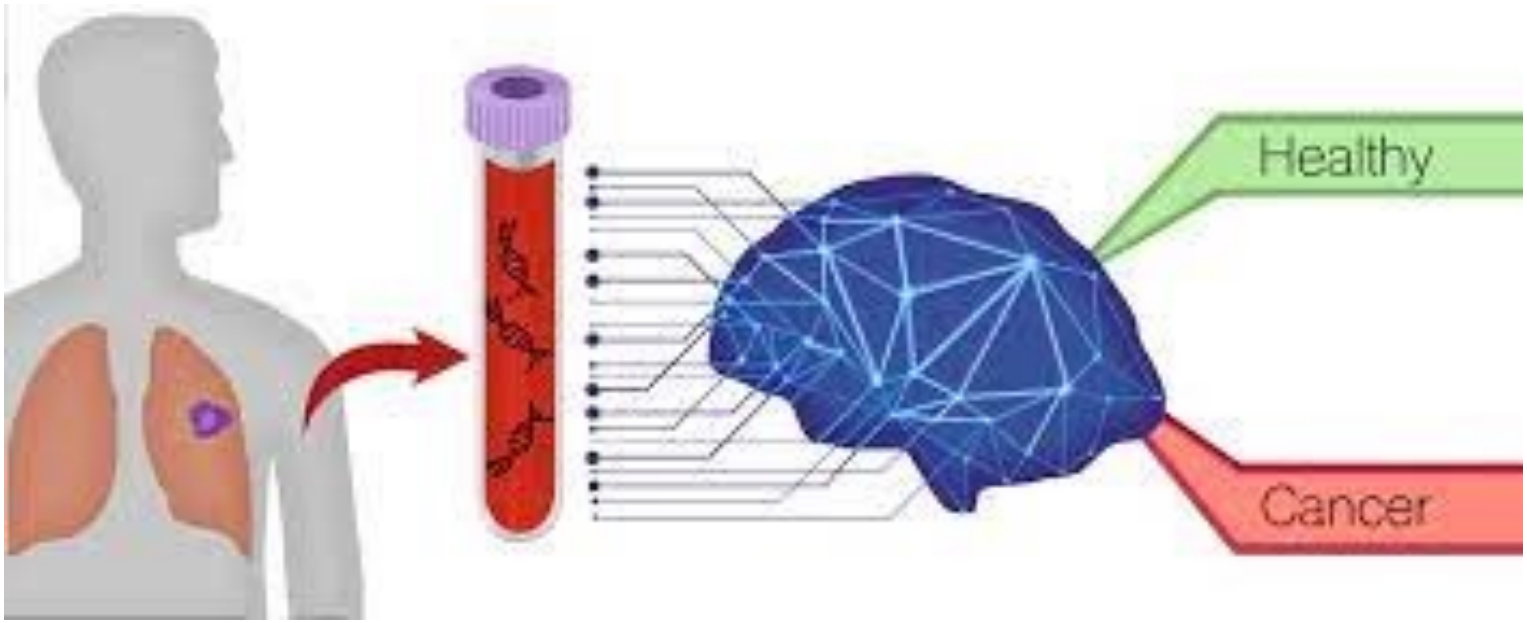


Intelligent Oncology: Diagnosis

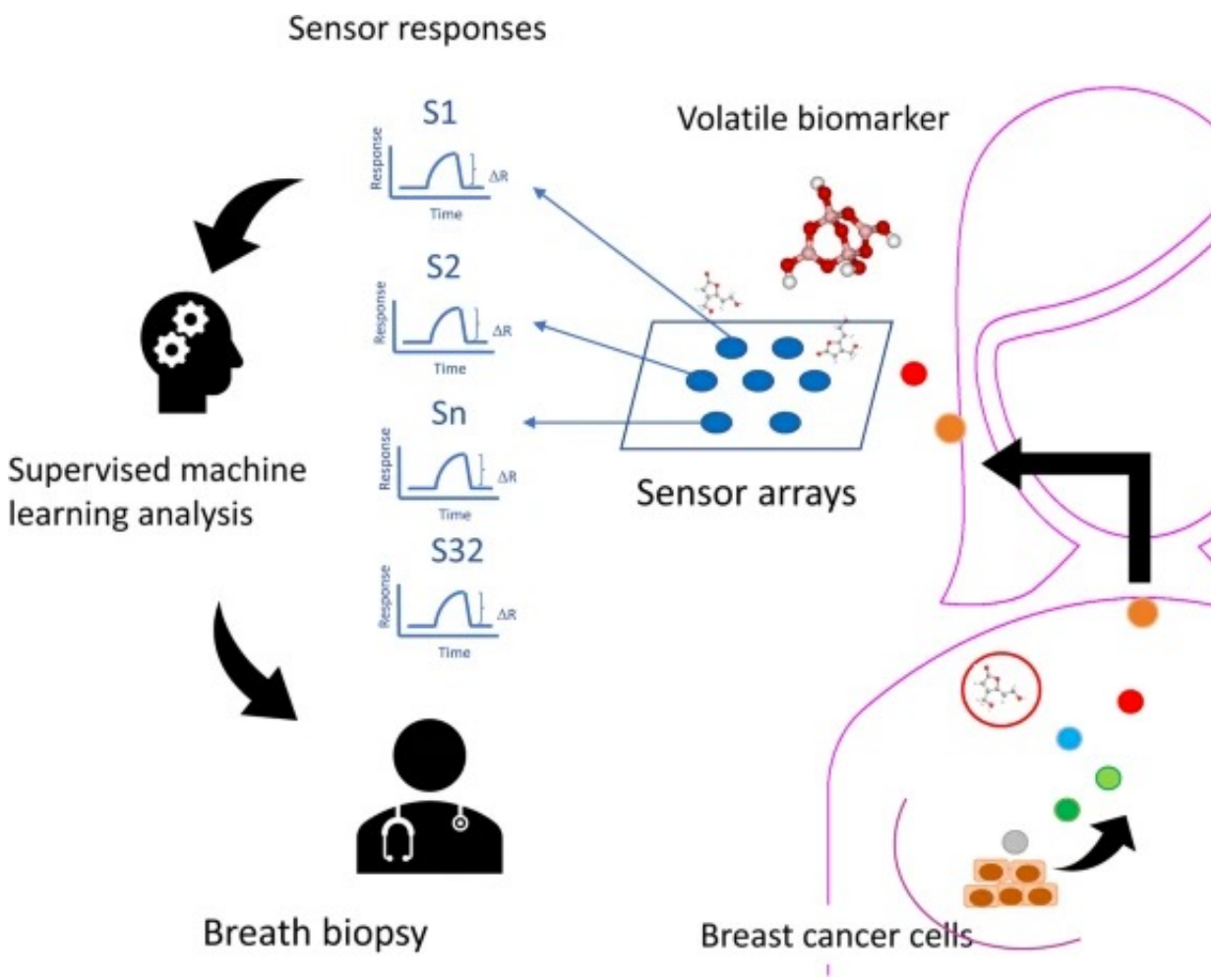


- AI-assisted diagnosis
- virtual biopsy
- Liquid Biopsy
- Nanorobotics
- Digital Pathology
- Digital Hematopathology
- Analyzing Signaling Pathway

AI-assisted diagnosis

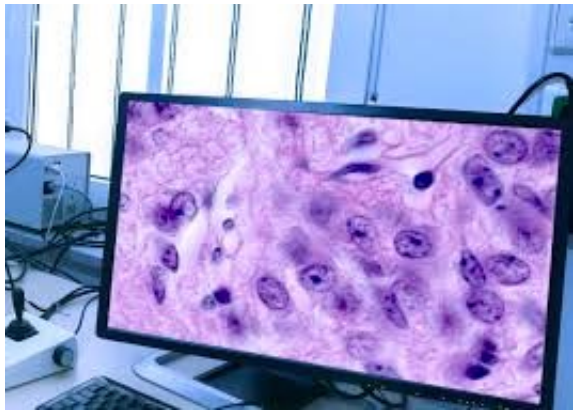


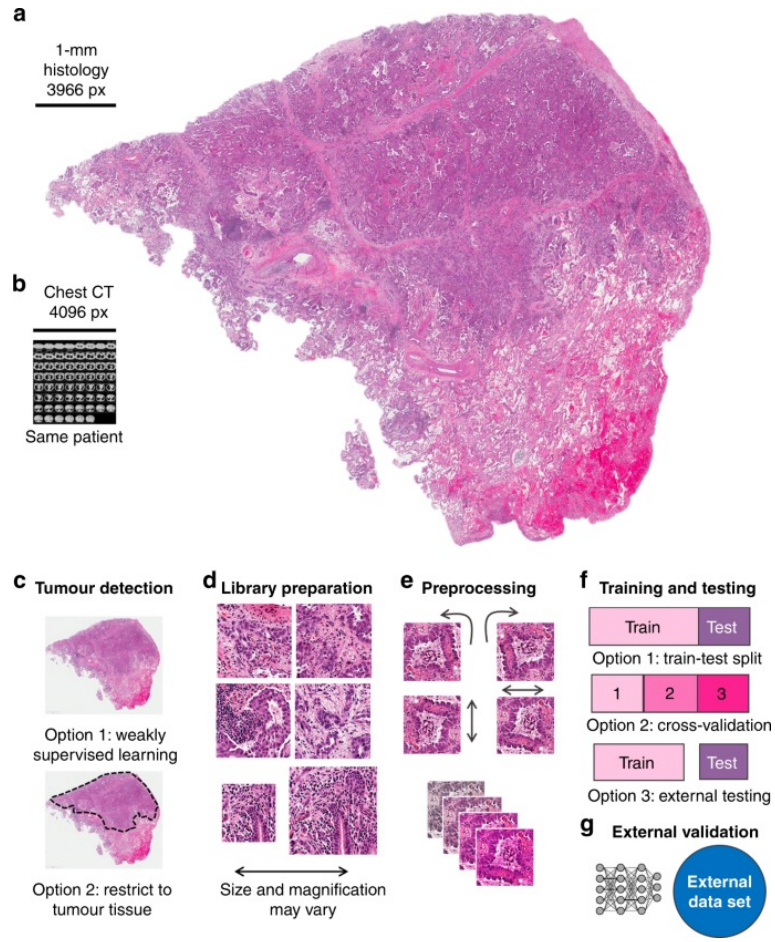
New types of Biopsy:
Breath biopsy for Breast Cancer

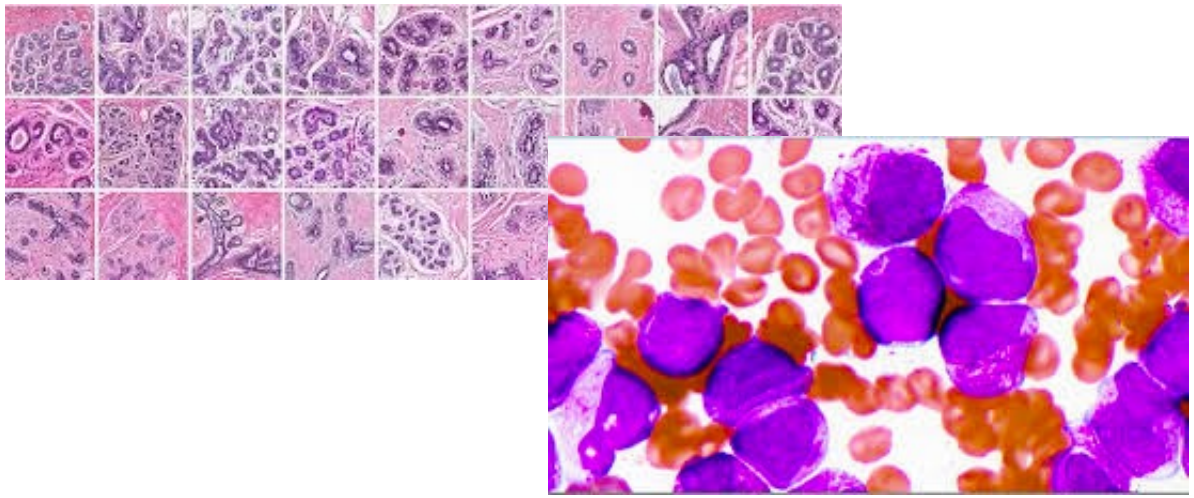


Breath biopsy of breast cancer using sensor array signals and machine learning analysis, Scientific Reports volume 11, Article number: 103 (2021)

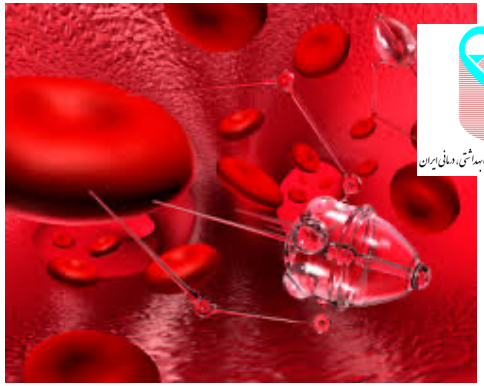
Digital Pathology
Digital Hematopathology

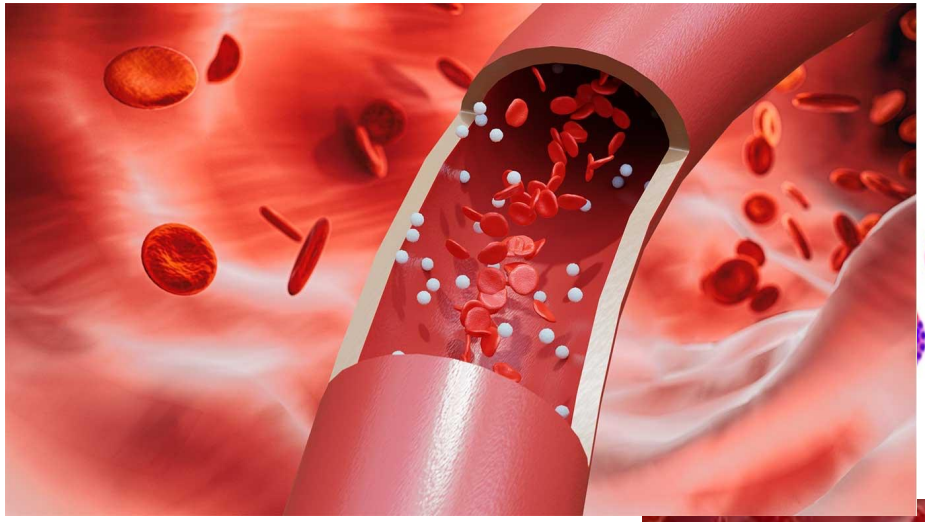


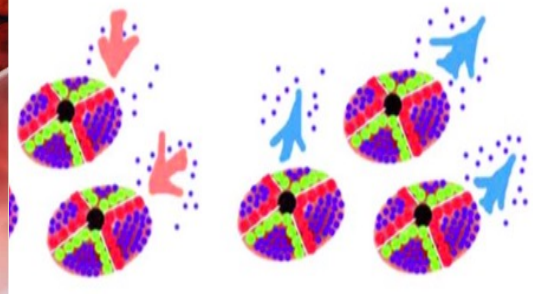


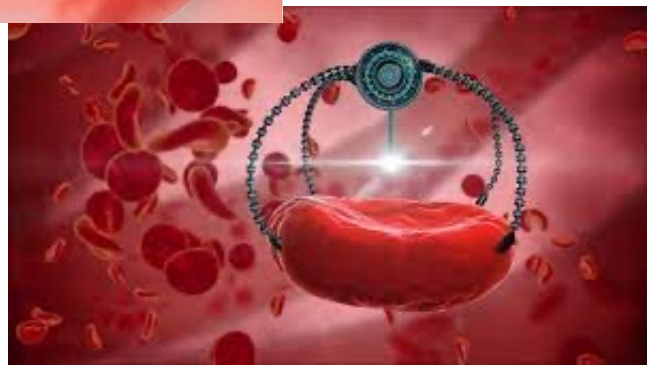


Nanomedicine







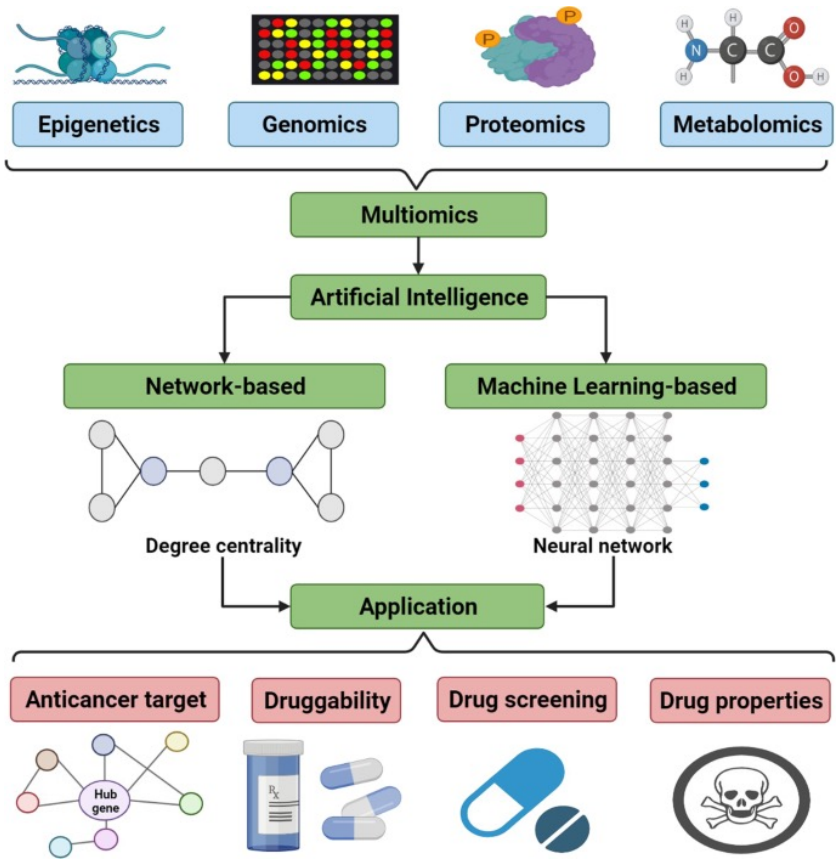


[1] N. Rady Raz, M. -R. Akbarzadeh-T and S. Setayeshi, "Influence-Based Nano Fuzzy Swarm Oxygen Deficiency Detection and Therapy," *in IEEE Transactions on Systems, Man, and Cybernetics: Systems*, vol. 53, no. 8, pp. 4994-5005, Aug. 2023, N. Rady Raz, M. R. Akbarzadeh T., "Target Convergence Analysis of Cancer Inspired Swarms for Early Disease Diagnosis and Targeted Collective Therapy,"*IEEE Transactions on Neural Networks and Learning Systems*, 2022.

[2] N. Rady Raz, M. R. Akbarzadeh T., "Swarm-Fuzzy Rule-Based Targeted Nano Delivery Using Bioinspired Nanomachines,"*IEEE Transactions on NanoBioscience*,Vol.18, No.3, pp. 404 - 414, July 2019.

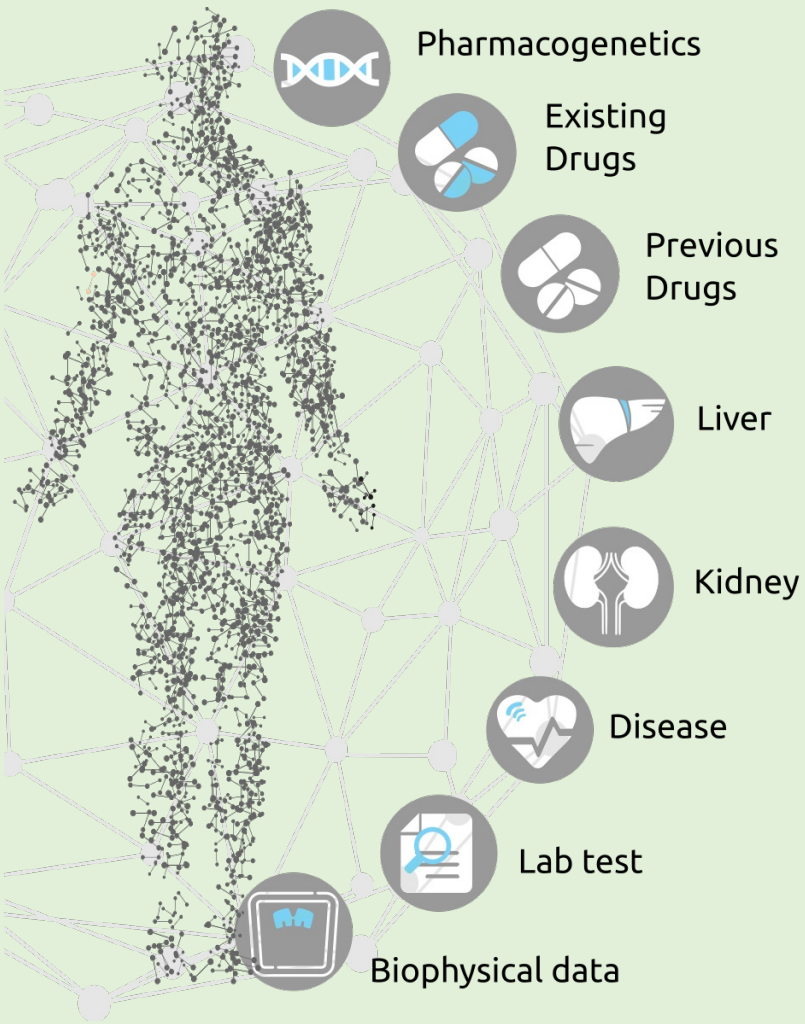
[3] N. Rady Raz, M. R. Akbarzadeh T., M. Tafaghodi, "Bio-Inspired Nanonetworks for Targeted Cancer Drug Delivery,"*IEEE Transactions on NanoBioscience*,Vol.14, No.8, pp. 894-906, Dec. 2015.

Analyzing Signaling Pathway for therapeutic targets

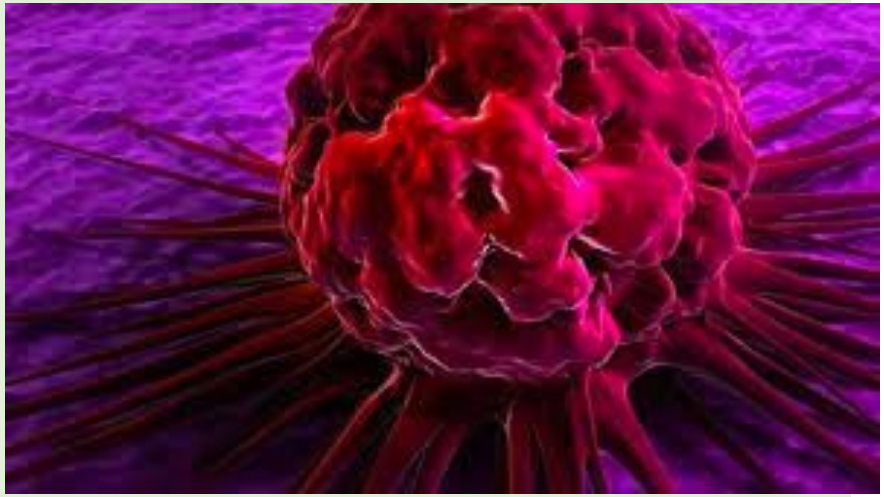


Artificial intelligence in cancer target identification and drug discovery, Signal Transduction and Targeted Therapy volume 7, Article number: 156 (2022)

Intelligent Oncology: Staging



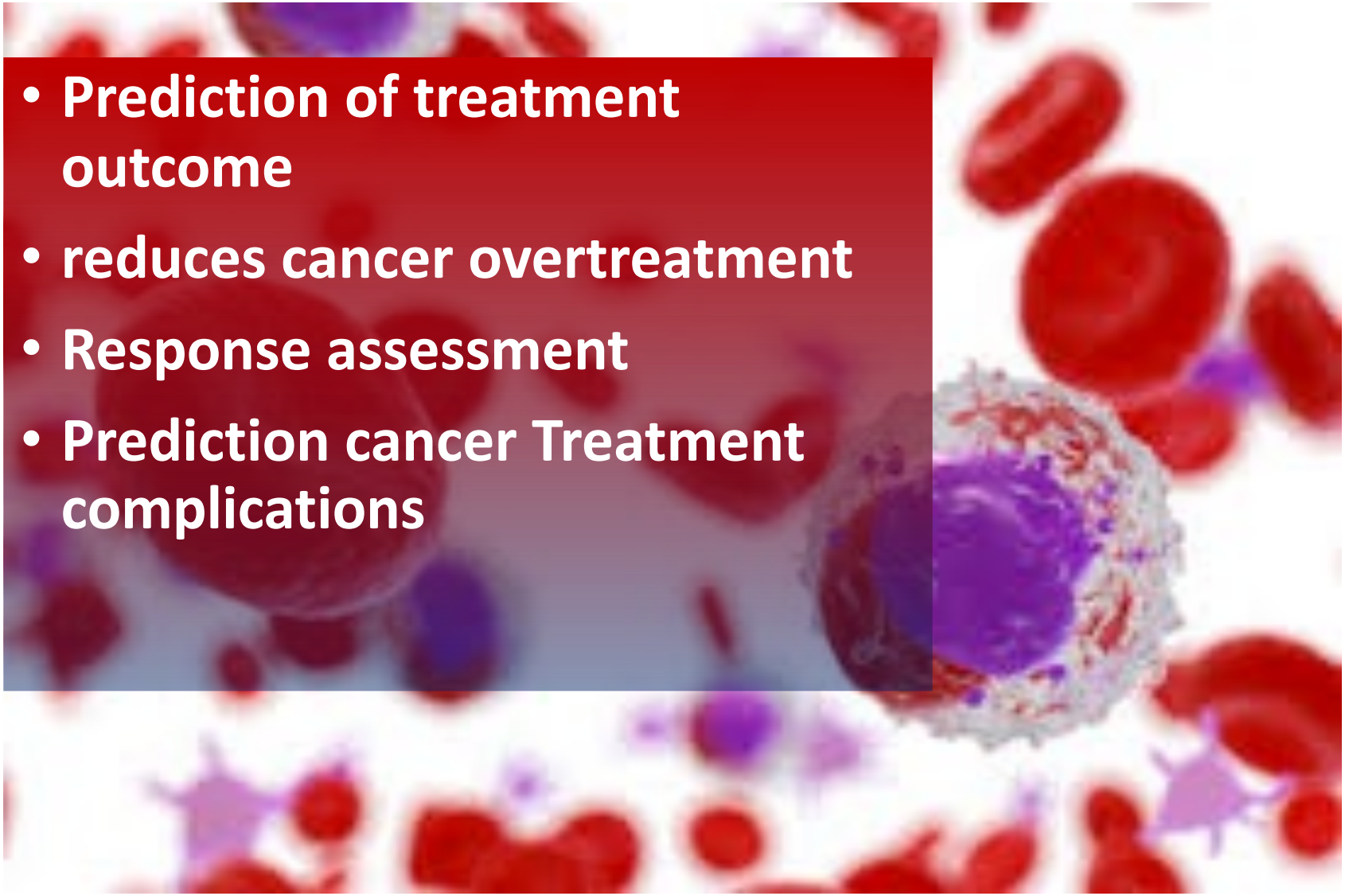
Clinical decision support systems



Intelligent Oncology: Treatment

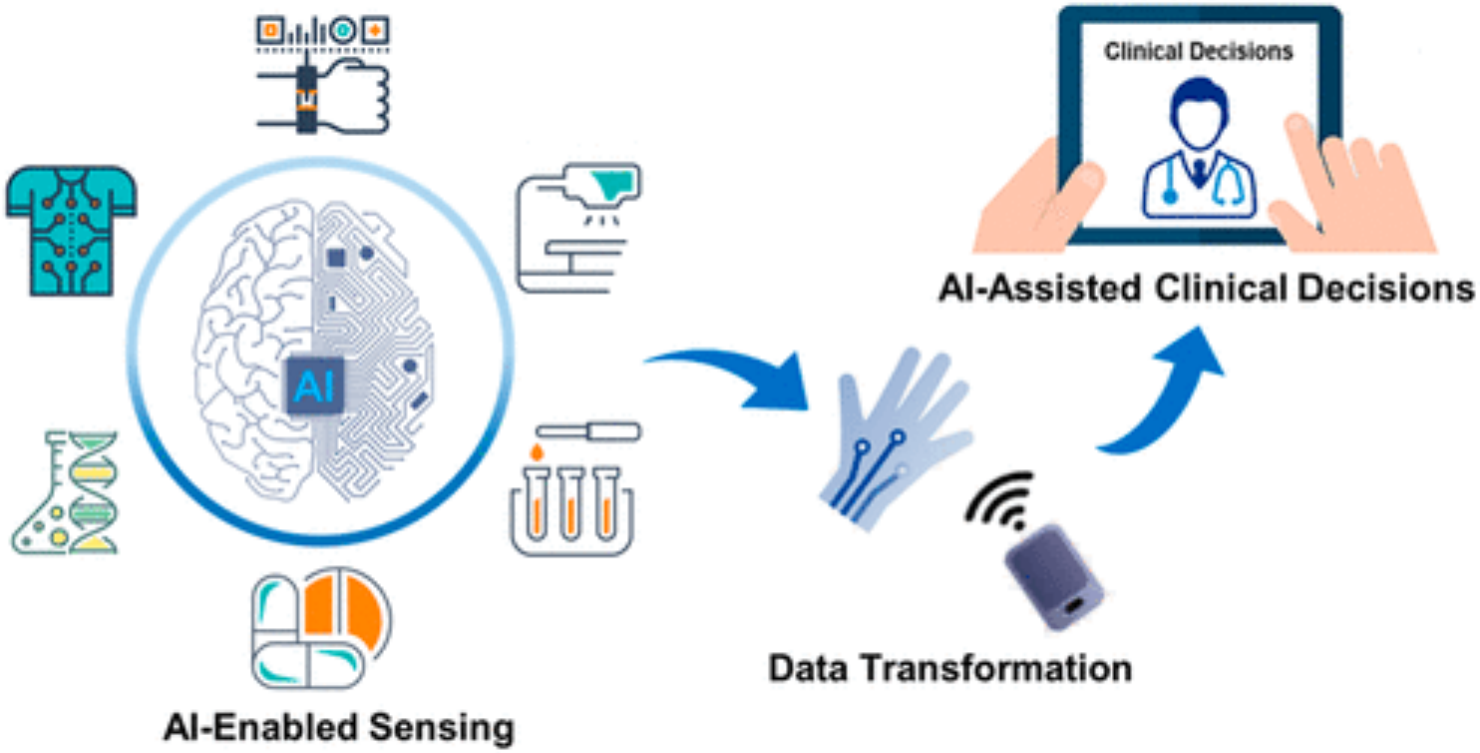
Artificial Intelligence

Intelligent Oncology: Response



- **Prediction of treatment outcome**
- **reduces cancer overtreatment**
- **Response assessment**
- **Prediction cancer Treatment complications**

Intelligent Oncology: Follow Up
AI and tele-oncology



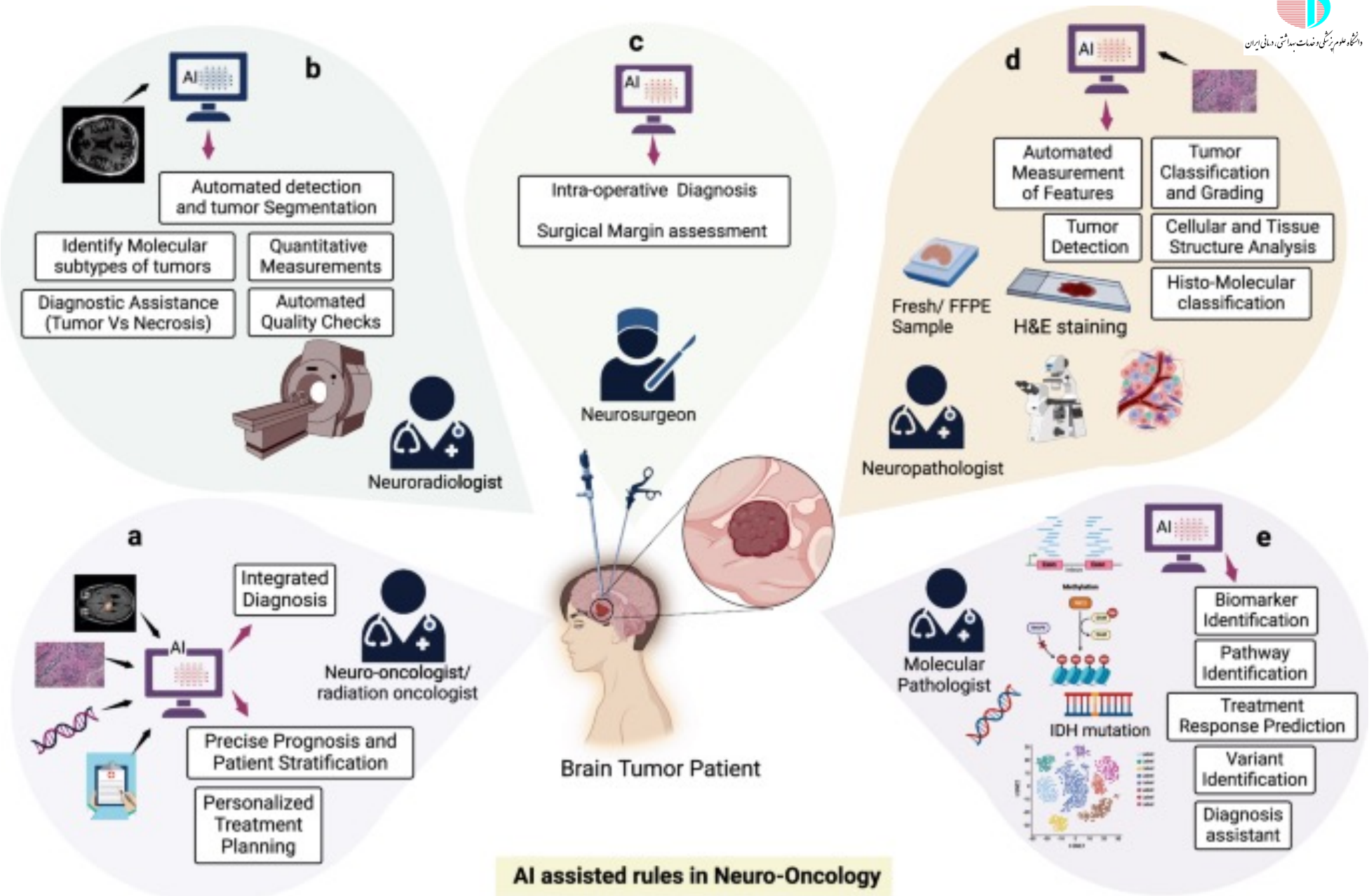
Prediction of gene mutations
Cancer care as a mathematical optimization problem
Cancer Recurrence Prediction
Predicting Mortality and Morbidity

Cancer Radiology

- January 2021: Visage Breast Density (Visage Imaging)

- The software application is intended for use with compatible full-field digital mammography to aid radiologists in the assessment of breast tissue composition

Claudio Luchini Et al, “Artificial intelligence in oncology: current applications and future perspectives” *British Journal of Cancer*, vol. 126, pages4–9, 2022.



AI assisted rules in Neuro-Oncology

Type of Cancer Data

Radiomics Data	Description: radiomics involves extracting quantitative features from medical imaging data, such as MRI or CT scans.
	Purpose: it aims to capture and analyze the texture, shape, and intensity patterns of tumors, providing additional information for diagnosis, prognosis, and treatment planning.
Pathological Data	Description: pathological data involves the examination of tissue samples from the tumor through biopsy or resection.
	Purpose: pathological analysis helps determine the tumor's histological type, grade, and molecular characteristics, aiding in treatment decisions.
Genomic Data	Description: genomic data involves analyzing the genetic makeup of tumors through techniques like next-generation sequencing (NGS).
	Purpose: it provides insights into genetic mutations, alterations, and expression patterns, guiding personalized treatment approaches.

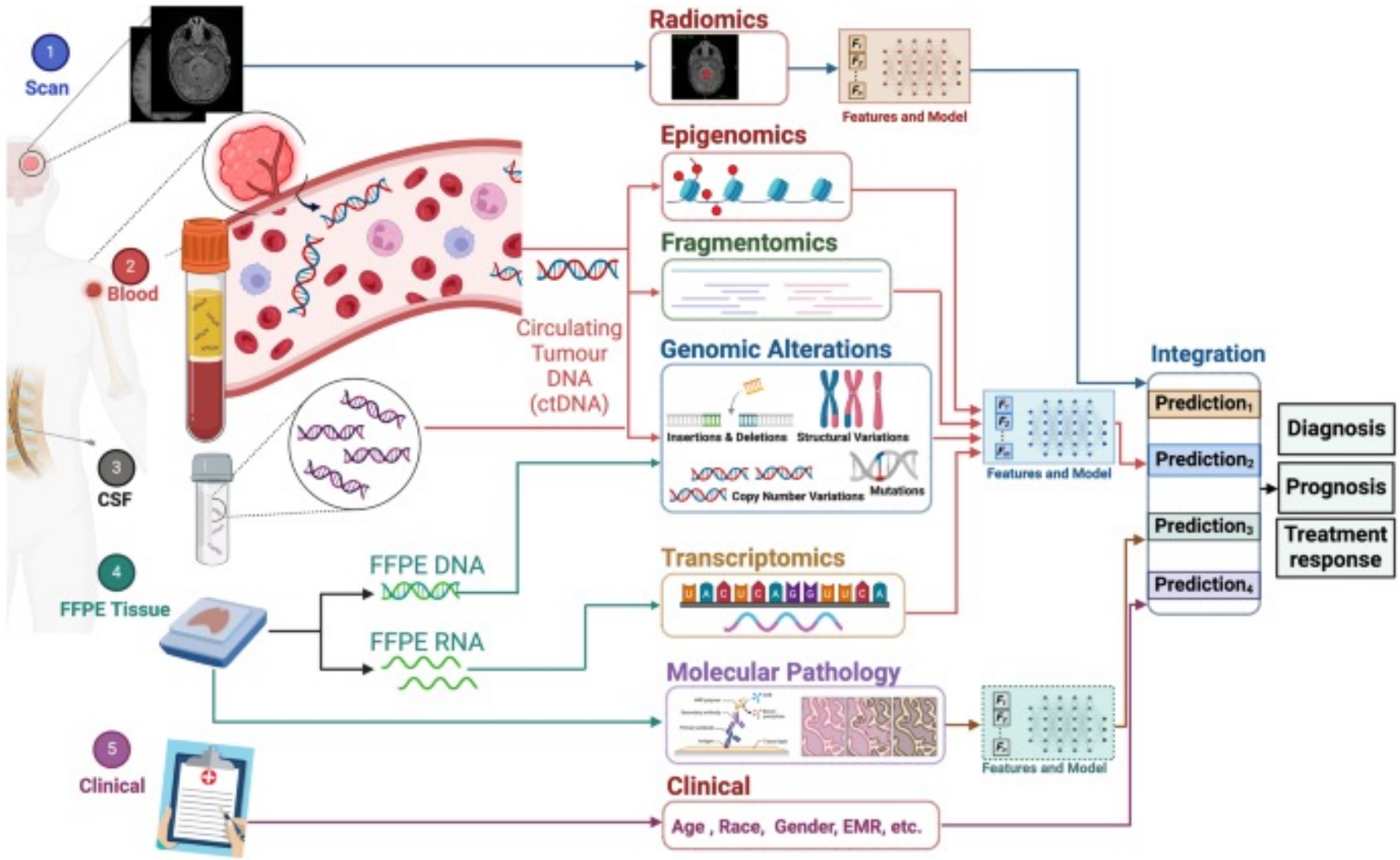
Type of Cancer Data

Clinical Data:	Description: clinical data encompasses patient-related information, including demographics, medical history, and treatment records.
	Purpose: integration of clinical data with other datasets aids in understanding patient-specific factors influencing tumor behavior and treatment responses.
Multimodal Data (MRI and CT)	Description: multimodal data combines information from different imaging modalities, commonly MRI and CT scans.
	Purpose: combining data from multiple modalities enhances the overall understanding of the tumor's characteristics, offering a more comprehensive view.
Multi-parametric MRI	Description: multi-parametric MRI involves acquiring images using various sequences such as T1-weighted, T2-weighted, FLAIR, DWI, and SWI.
	Purpose: different sequences provide diverse information about the tumor's structure, function, and blood supply, aiding in accurate diagnosis.

Type of Cancer Data

MR Spectroscopy and Perfusion Imaging	Description: MR spectroscopy assesses the chemical composition of tissues, while perfusion imaging measures blood flow.
	Purpose: these techniques provide information on metabolic activity and vascularization, assisting in tumor characterization.
Next-generation Sequencing (NGS)	Description: NGS is a high-throughput sequencing technology that analyzes DNA, RNA, or both.
	Purpose: in brain tumor analysis, NGS helps identify genetic mutations, fusions, and variations, guiding targeted therapies.
Circulating Tumor DNA (ctDNA) Analysis:	Description: ctDNA analysis involves detecting tumor-derived genetic material circulating in the bloodstream.
	Purpose: it enables non-invasive monitoring of tumor dynamics, treatment response, and the emergence of resistance.

Multimodal integration for enhanced diagnosis, prognosis, and treatment response prediction in brain tumors



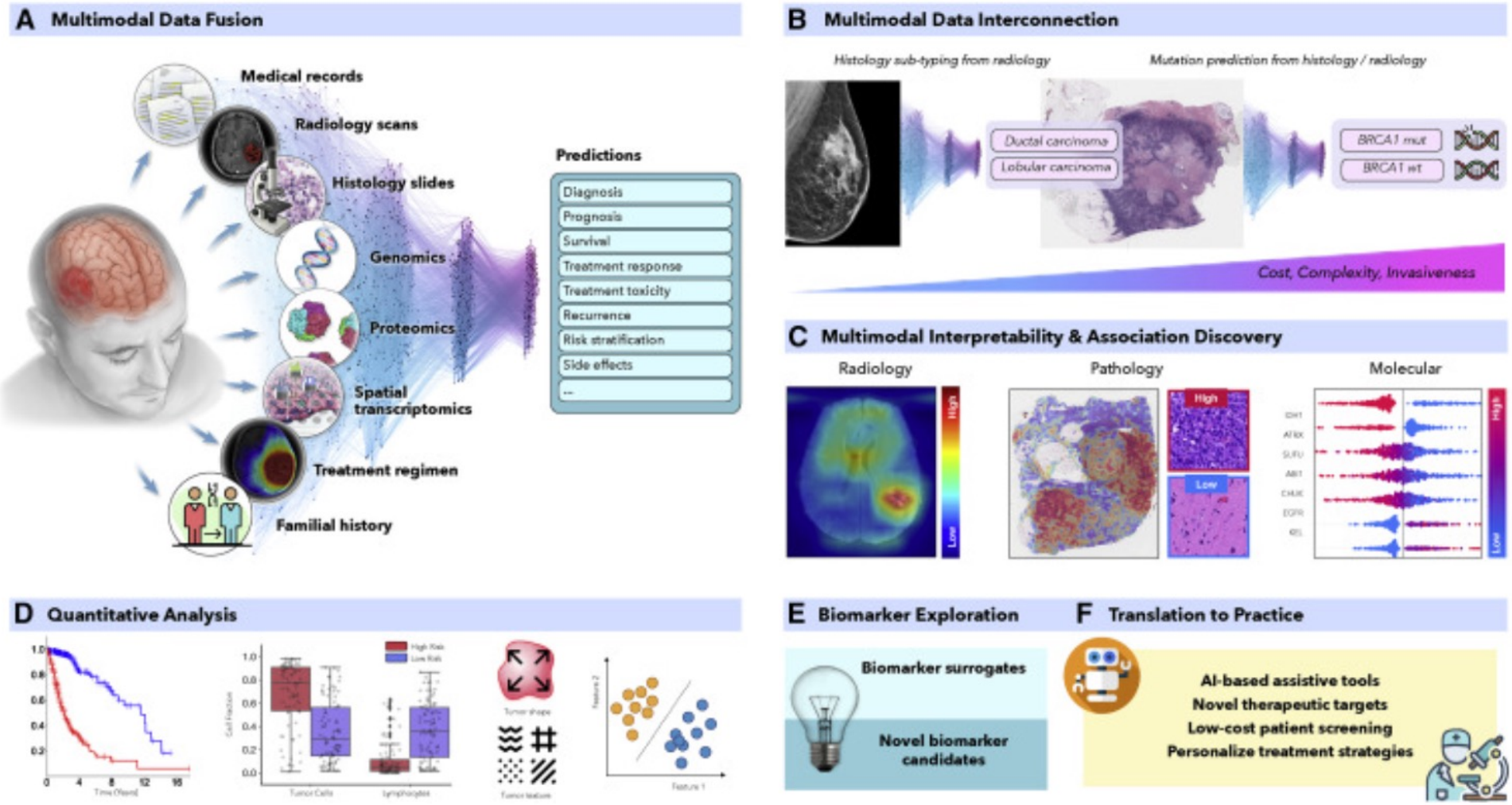
Numerous public datasets

- The Cancer Imaging Archive (TCIA) is notable among general brain tumor datasets, offering a comprehensive repository of medical imaging data, including MRI, CT, and PET scans for various tumor types.
- Specific tumor types, resources such as the NCI TARGET dataset include dedicated sections for glioblastoma (TCGA-GBM) and lower-grade gliomas (TCGA-LGG)

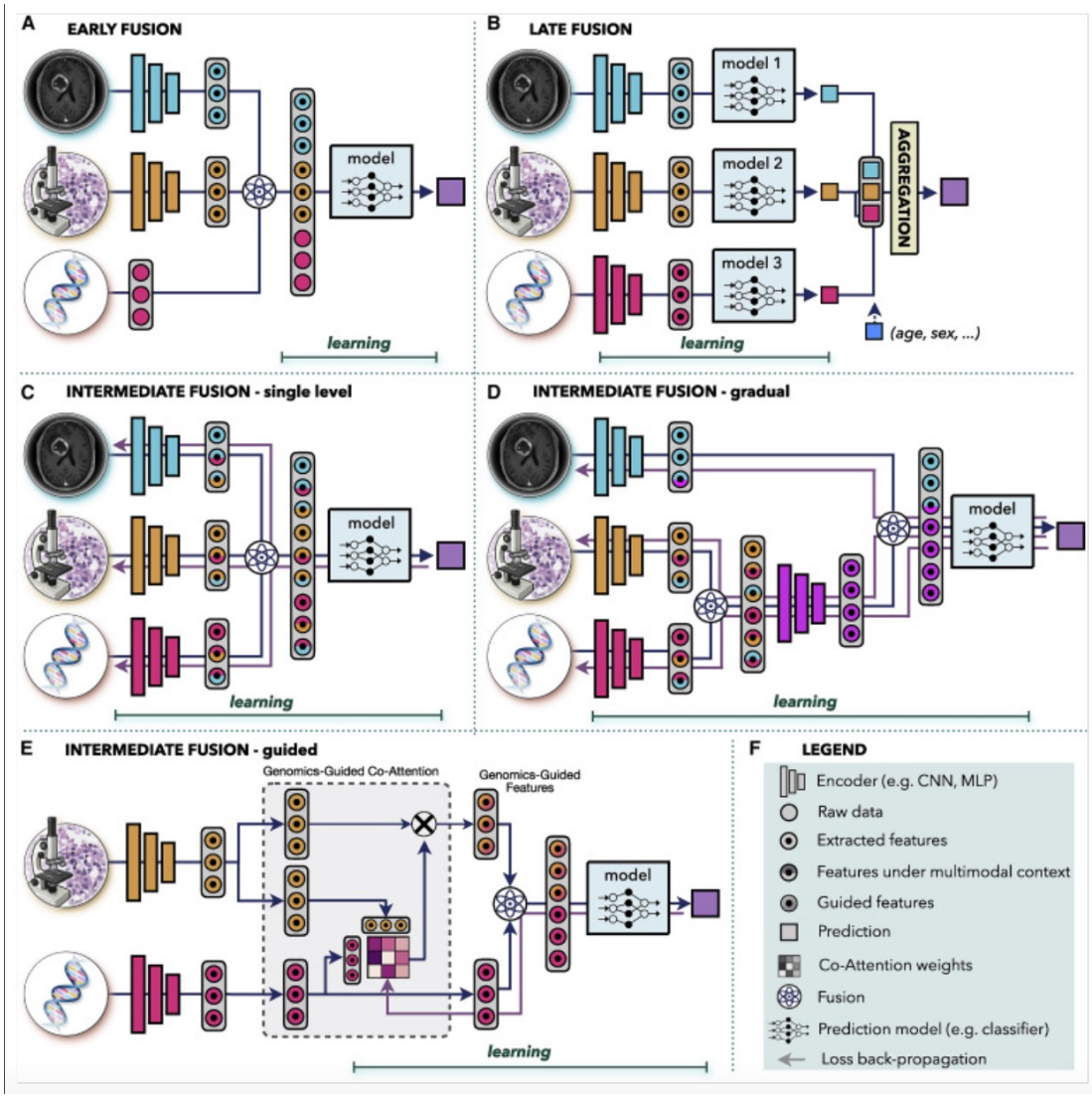
AI-enhanced preprocessing for precision brain tumor analysis

- BrainNet viewer, correct artifacts and distortions in MRI images

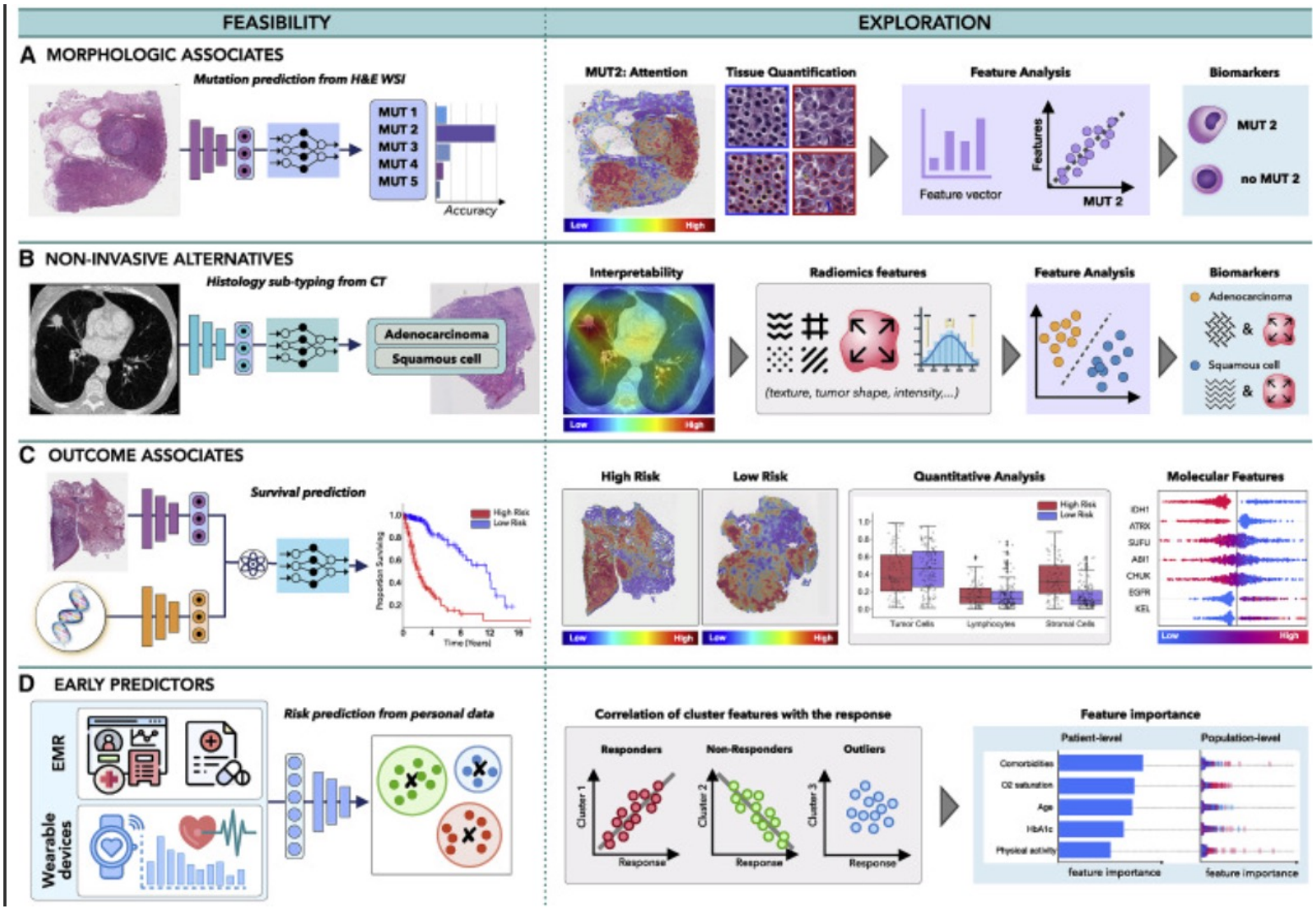
Multi-modal data



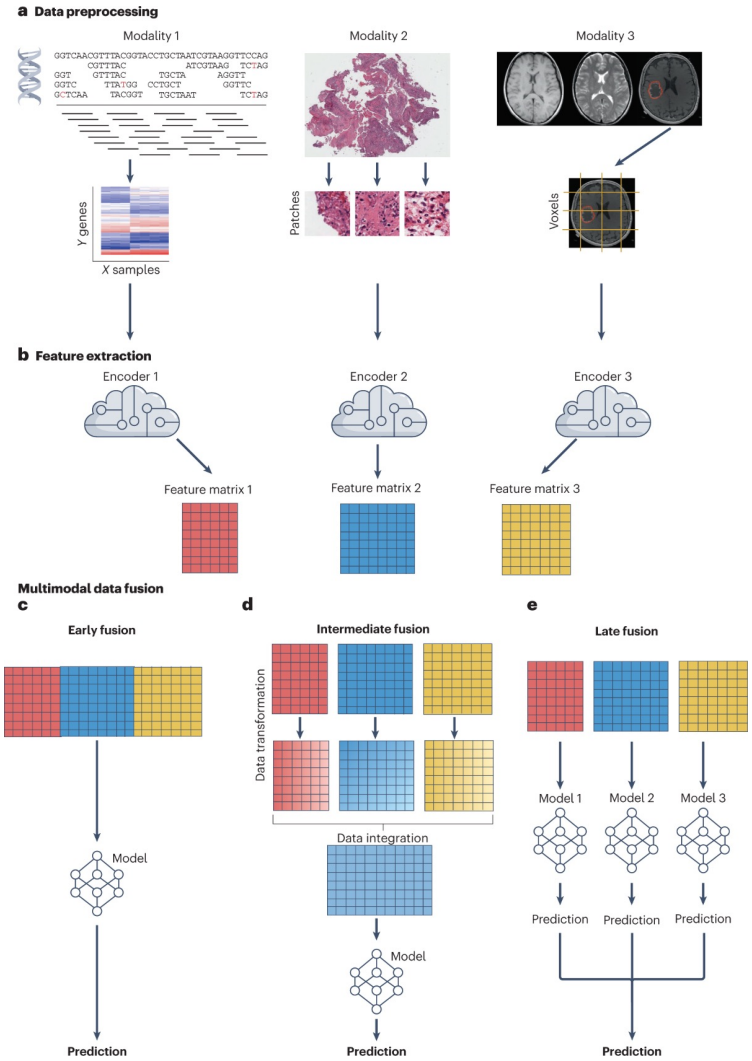
Multi-modal data

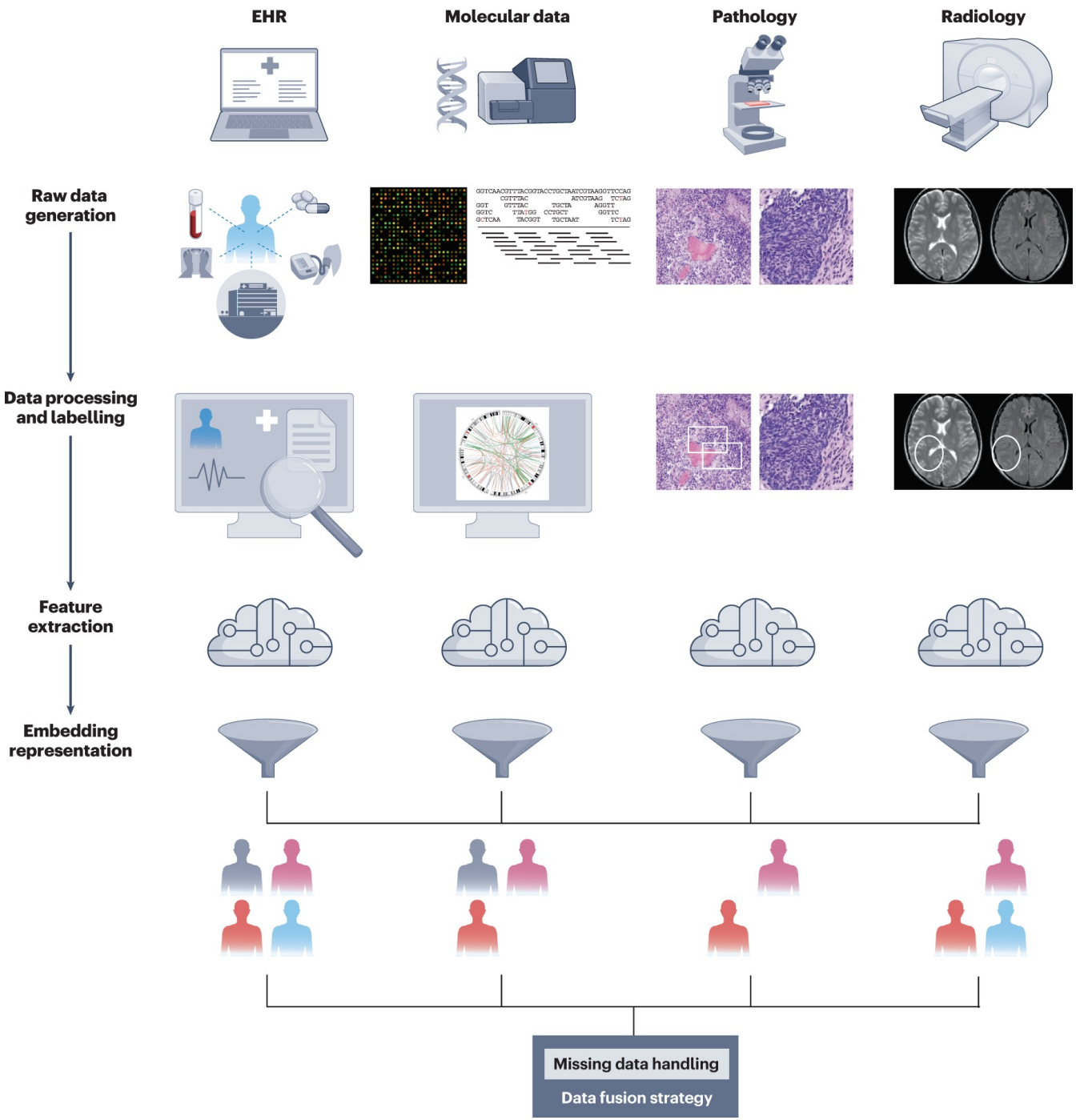


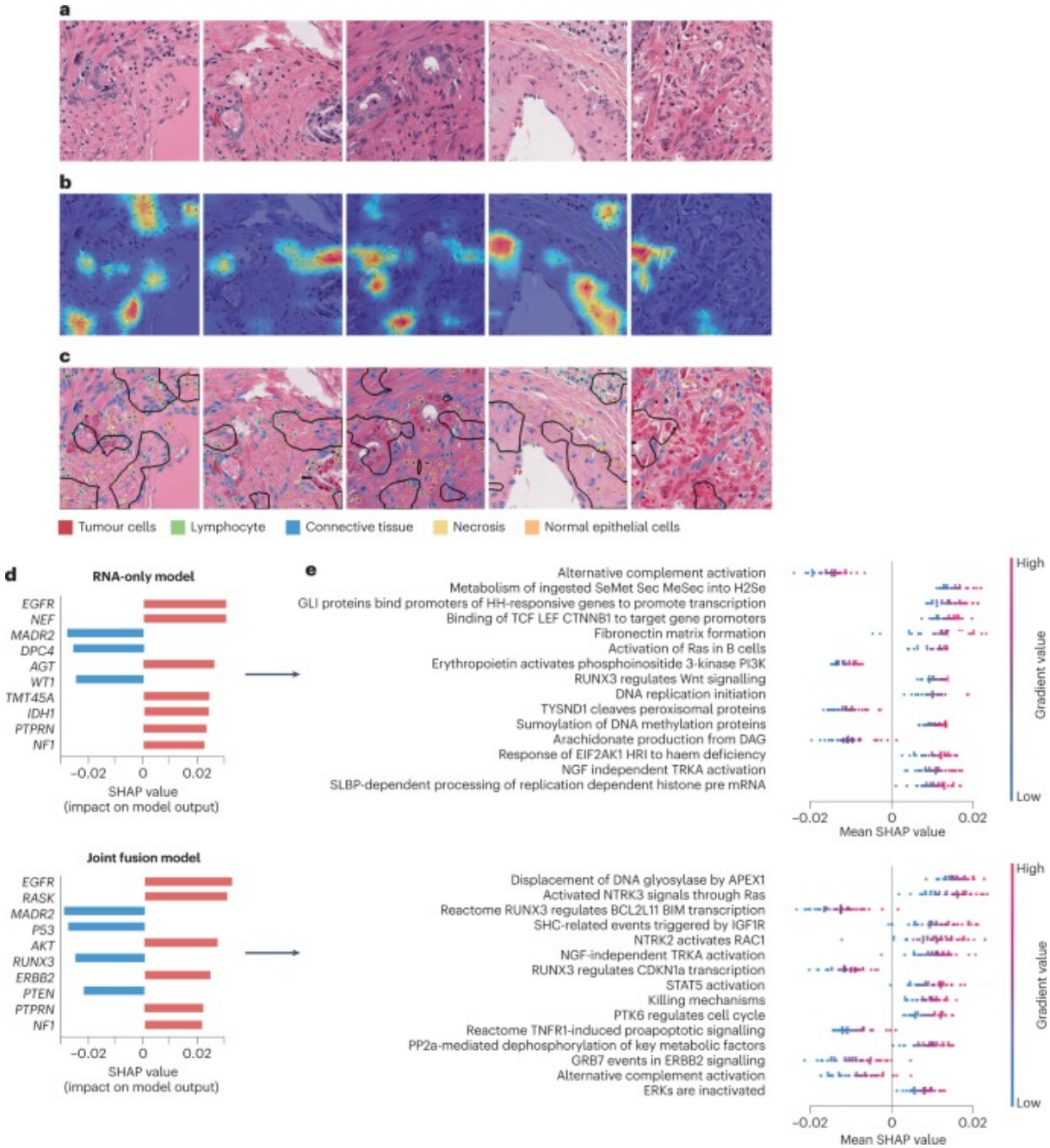
Multi-modal data



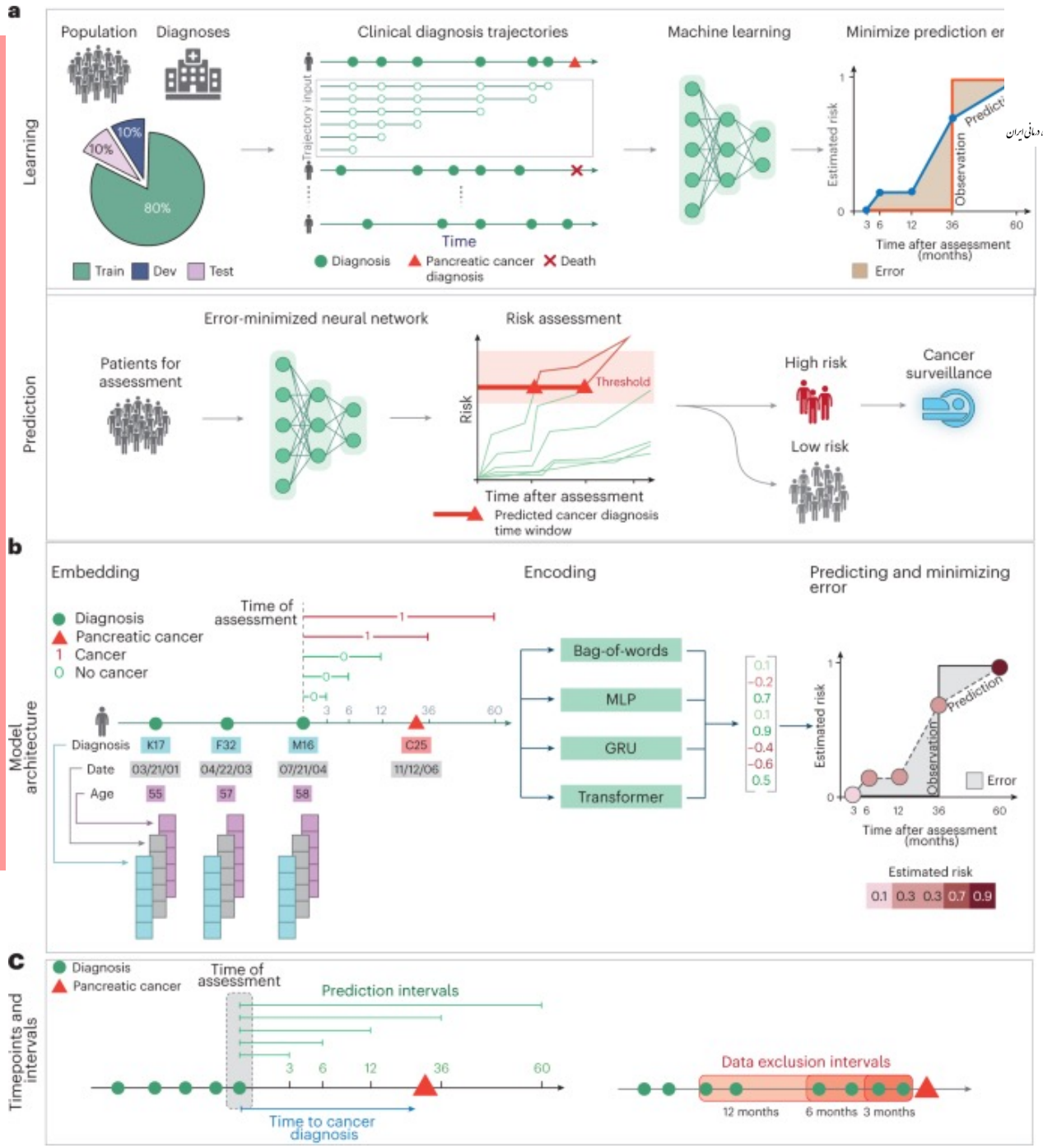
Multimodal data fusion for cancer biomarker discovery with deep learning




EHR
Molecular data
Pathology
Radiology
Raw data generation
Data processing and labelling
Feature extraction
Embedding representation
Missing data handling
Data fusion strategy


a
b
c
Tumour cells
Lymphocyte
Connective tissue
Necrosis
Normal epithelial cells
d
RNA-only model
EGFR
NEF
MADR2
DPC4
AGT
WT1
TMT45A
IDH1
PTPRN
NF1
-0.02
0
0.02
SHAP value
(impact on model output)
e
Alternative complement activation
Metabolism of ingested SeMet Sec MeSec into H2Se
GLI proteins bind promoters of HH-responsive genes to promote transcription
Binding of TCF LEF CTNNB1 to target gene promoters
Fibronectin matrix formation
Activation of Ras in B cells
Erythropoietin activates phosphoinositide 3-kinase PI3K
RUNX3 regulates Wnt signalling
DNA replication initiation
TYSND1 cleaves peroxisomal proteins
Sumoylation of DNA methylation proteins
Arachidonate production from DAG
Response of EIF2AK1 HRI to haem deficiency
NGF independent TRKA activation
SLBP-dependent processing of replication dependent histone pre mRNA
High
Gradient value
Low
-0.02
0
0.02
Mean SHAP value
Joint fusion model
EGFR
RASK
MADR2
P53
AKT
RUNX3
ERBB2
PTEN
PTPRN
NF1
-0.02
0
0.02
SHAP value
(impact on model output)
Displacement of DNA glyosylase by APEX1
Activated NTRK3 signals through Ras
Reactome RUNX3 regulates BCL2L11 BIM transcription
SHC-related events triggered by IGF1R
NTRK2 activates RAC1
NGF-independent TRKA activation
RUNX3 regulates CDKN1a transcription
STAT5 activation
Killing mechanisms
PTK6 regulates cell cycle
Reactome TNFR1-induced proapoptotic signalling
PP2a-mediated dephosphorylation of key metabolic factors
GRB7 events in ERBB2 signalling
Alternative complement activation
ERKs are inactivated
High
Gradient value
Low
-0.02
0
0.02
Mean SHAP value

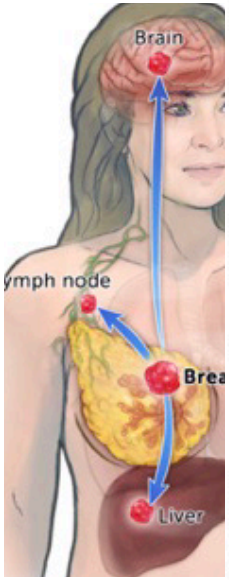
A deep learning algorithm to predict risk of pancreatic cancer from disease trajectories

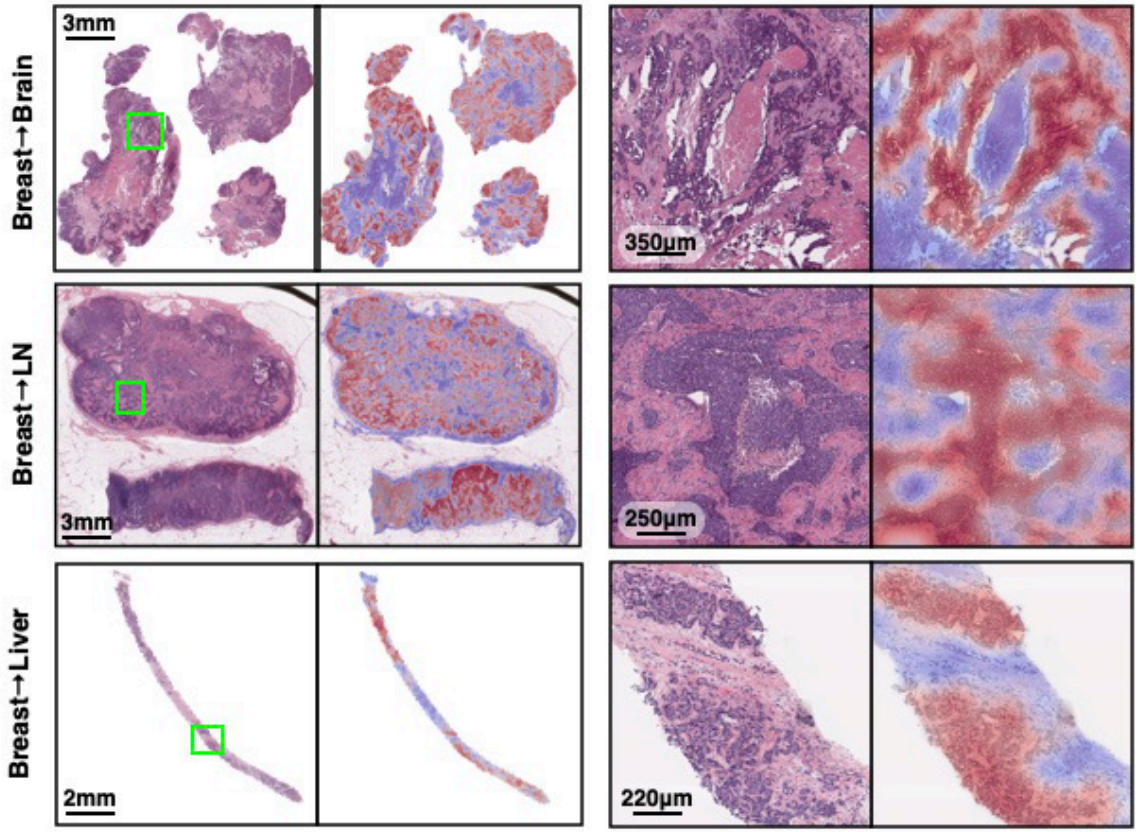


Nature Medicine **volume 29**, pages1113–1122 (2023)

AI-based pathology predicts origins for cancers of unknown primary

- Genomics and transcriptomics to identify the origin of a tumour.
- However, genomic testing is not always performed and lacks clinical penetration in low-resource settings.
- Deep Learning

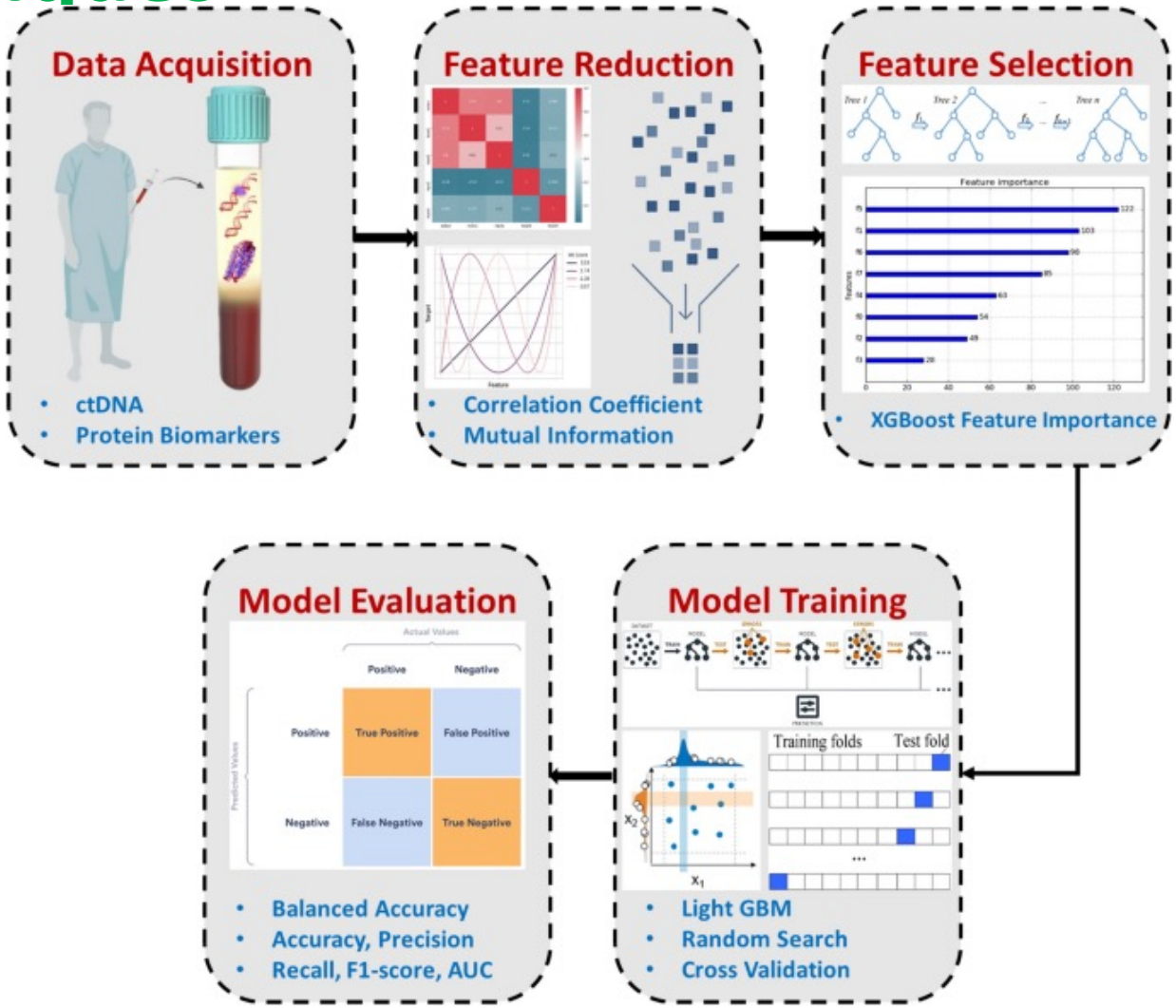




Nature **volume 594**, pages106–

Precision cancer classification using liquid biopsy and advanced machine learning techniques

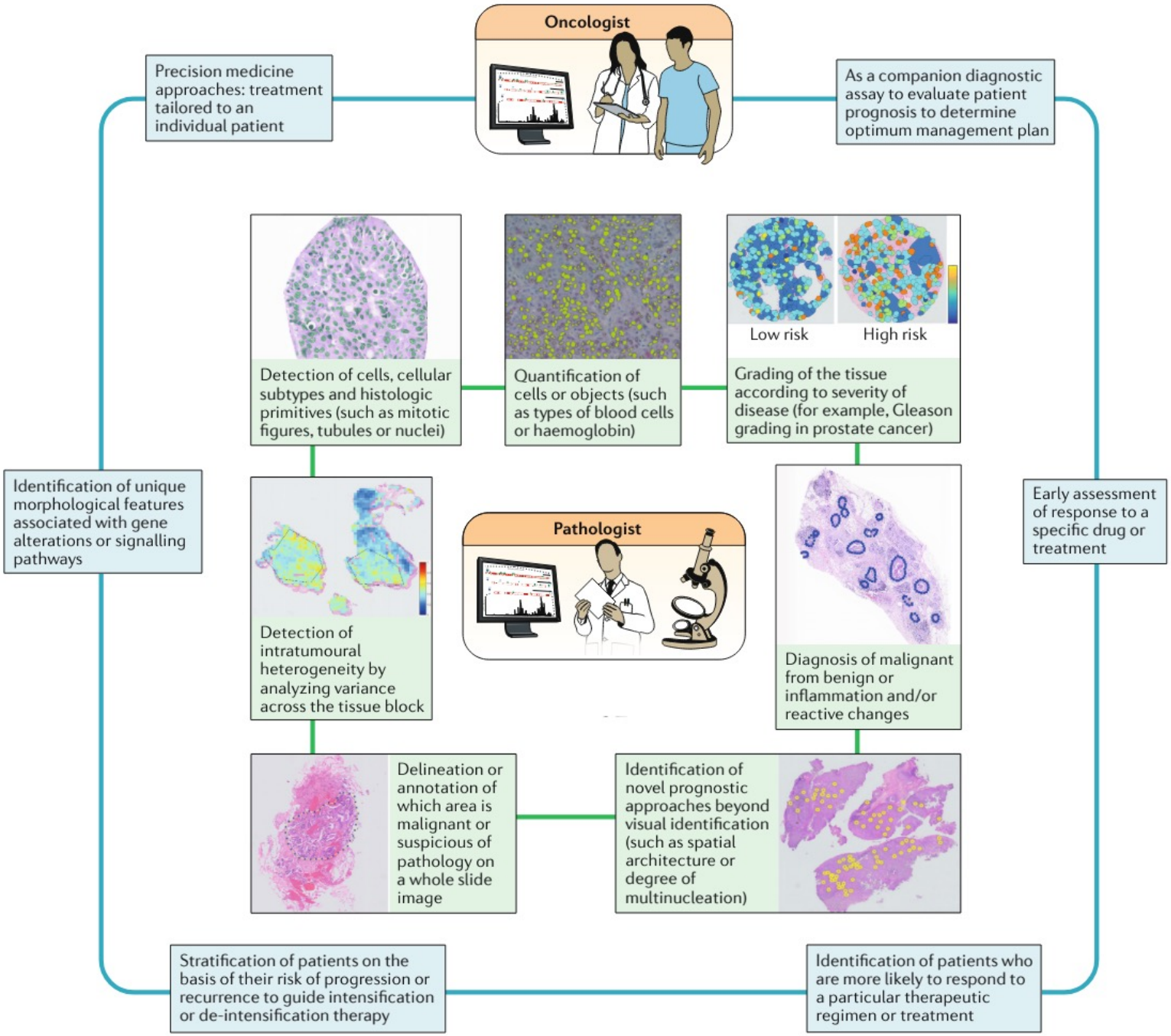
Precision cancer classification pipeline using liquid biopsy and advanced machine learning techniques.



Scientific Reports **volume 14**, Article number: 5841 (2024)

Brain Tumor Diagnosis during Surgery

combine an imaging technology called stimulated Raman histology (SRH) with the predictive power of AI to improve current intraoperative pathology practice

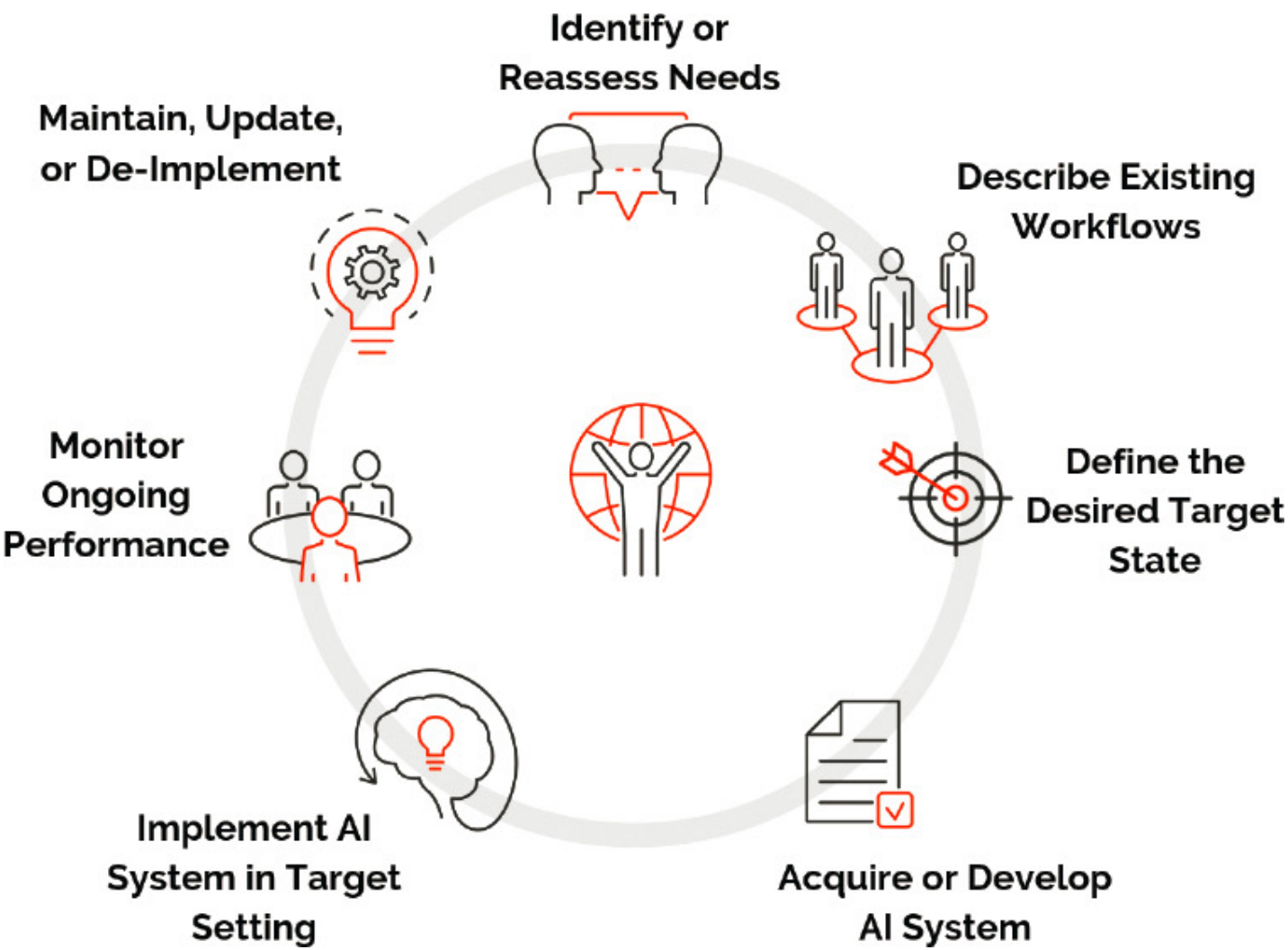

Oncologist
Precision medicine approaches: treatment tailored to an individual patient
As a companion diagnostic assay to evaluate patient prognosis to determine optimum management plan
Detection of cells, cellular subtypes and histologic primitives (such as mitotic figures, tubules or nuclei)
Quantification of cells or objects (such as types of blood cells or haemoglobin)
Low risk
High risk
Grading of the tissue according to severity of disease (for example, Gleason grading in prostate cancer)
Identification of unique morphological features associated with gene alterations or signalling pathways
Early assessment of response to a specific drug or treatment
Pathologist
Detection of intratumoural heterogeneity by analyzing variance across the tissue block
Diagnosis of malignant from benign or inflammation and/or reactive changes
Delineation or annotation of which area is malignant or suspicious of pathology on a whole slide image
Identification of novel prognostic approaches beyond visual identification (such as spatial architecture or degree of multinucleation)
Stratification of patients on the basis of their risk of progression or recurrence to guide intensification or de-intensification therapy
Identification of patients who are more likely to respond to a particular therapeutic regimen or treatment

Innovation through collaboration

How to get started with AI for hospital and clinic management systems

1. Identify your needs. What are the biggest challenges that your hospital or clinic is facing? What areas do you think AI could have the biggest impact?
2. Research AI solutions. There are a number of different AI solutions available for hospital and clinic management systems. Do some research to find solutions that are tailored to your specific needs.
3. Implement AI solutions carefully. It is important to implement AI solutions carefully and to monitor their performance closely. AI solutions should be integrated with your existing systems and workflows in a way that minimizes disruption.
4. Perform the task in a collaborative manner.

What to do then?



Challenges and Questions

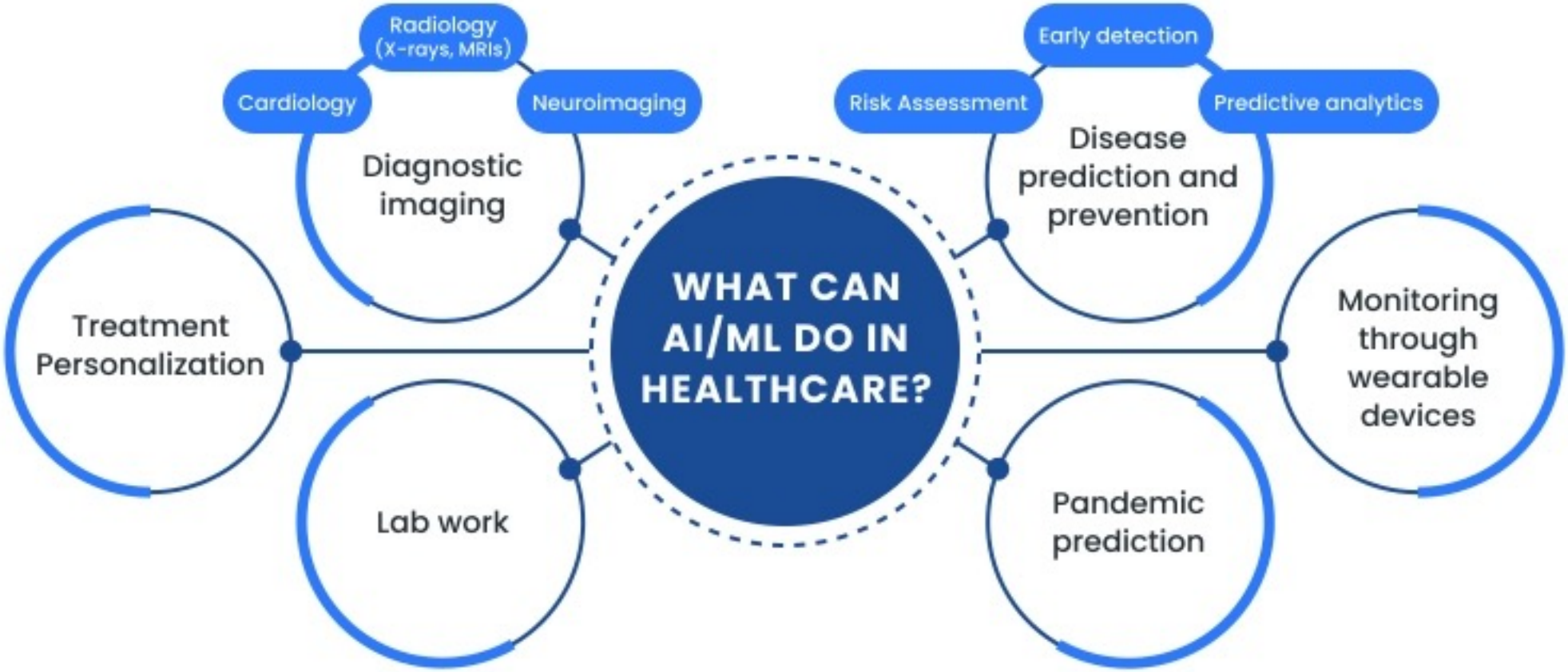
- How do we ensure the ethical use of AI in healthcare?
- What are the regulatory frameworks that need to be in place for the safe and effective use of AI?
- How do we measure the quality and accuracy of AI in healthcare?

Challenges and Ethical Considerations

data privacy,

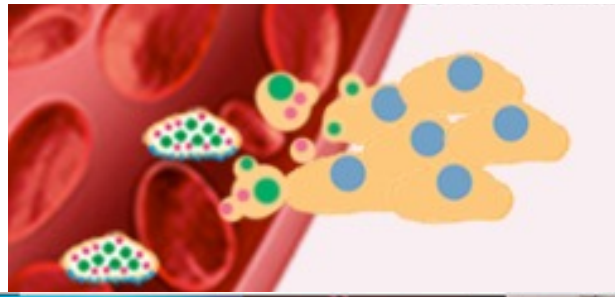
potential biases in datasets

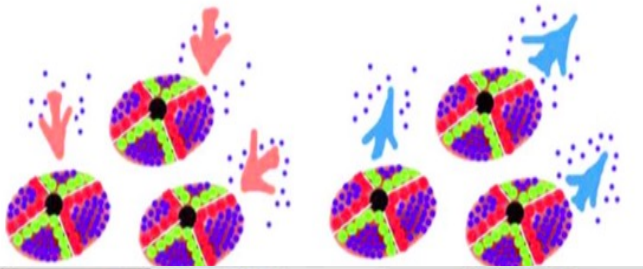
interpretability of algorithms,

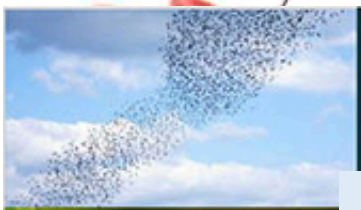


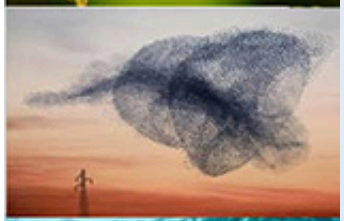
Note that!!

- AI may not replace human doctors.
- Since doctors are trained to not only diagnose and treat diseases but also to provide emotional support to patients.
- AI cannot replace the empathy and compassion that doctors bring to their work.









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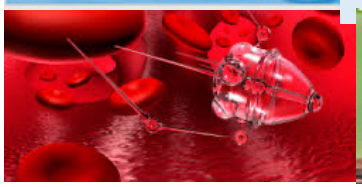
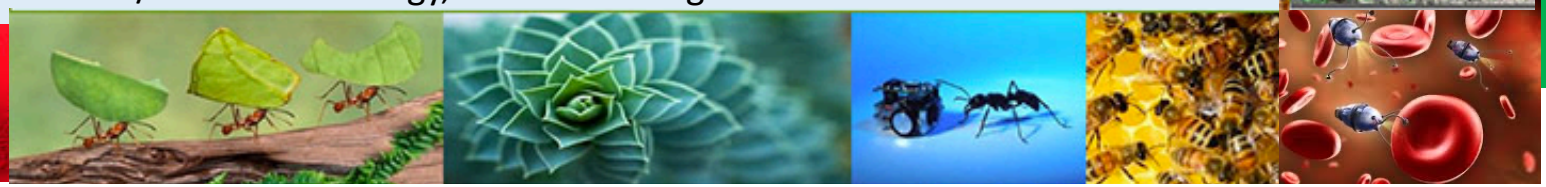
Research Interest:

Artificial Intelligence, Artificial Intelligence in Medicine, Complex Systems, Biomimicry, Cognitive Science, Swarm Intelligence, Nanomedicine, Targeted Drug Delivery, Early Detection of Disease, Swarm Nano Robotics, Cancer Research, Fuzzy Logic and Control, Soft Computing, Neural Networks, Machine Learning, Multi-agent Systems, Distributed Decision Making, Biomarkers, Biophysics, Nature Inspired Algorithms, Computational Cellular/Molecular Biology, Protein Folding





Artificial Intelligence for Good (AI for Good)