

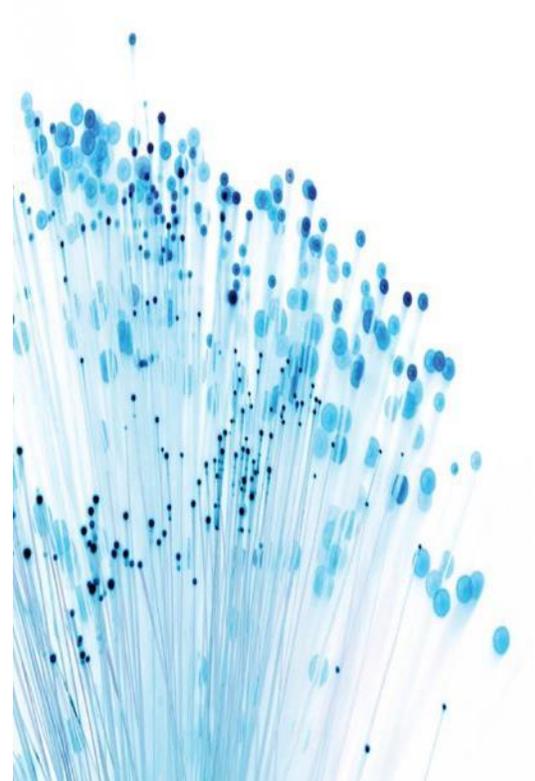
# Cognitive Computing in Healthcare

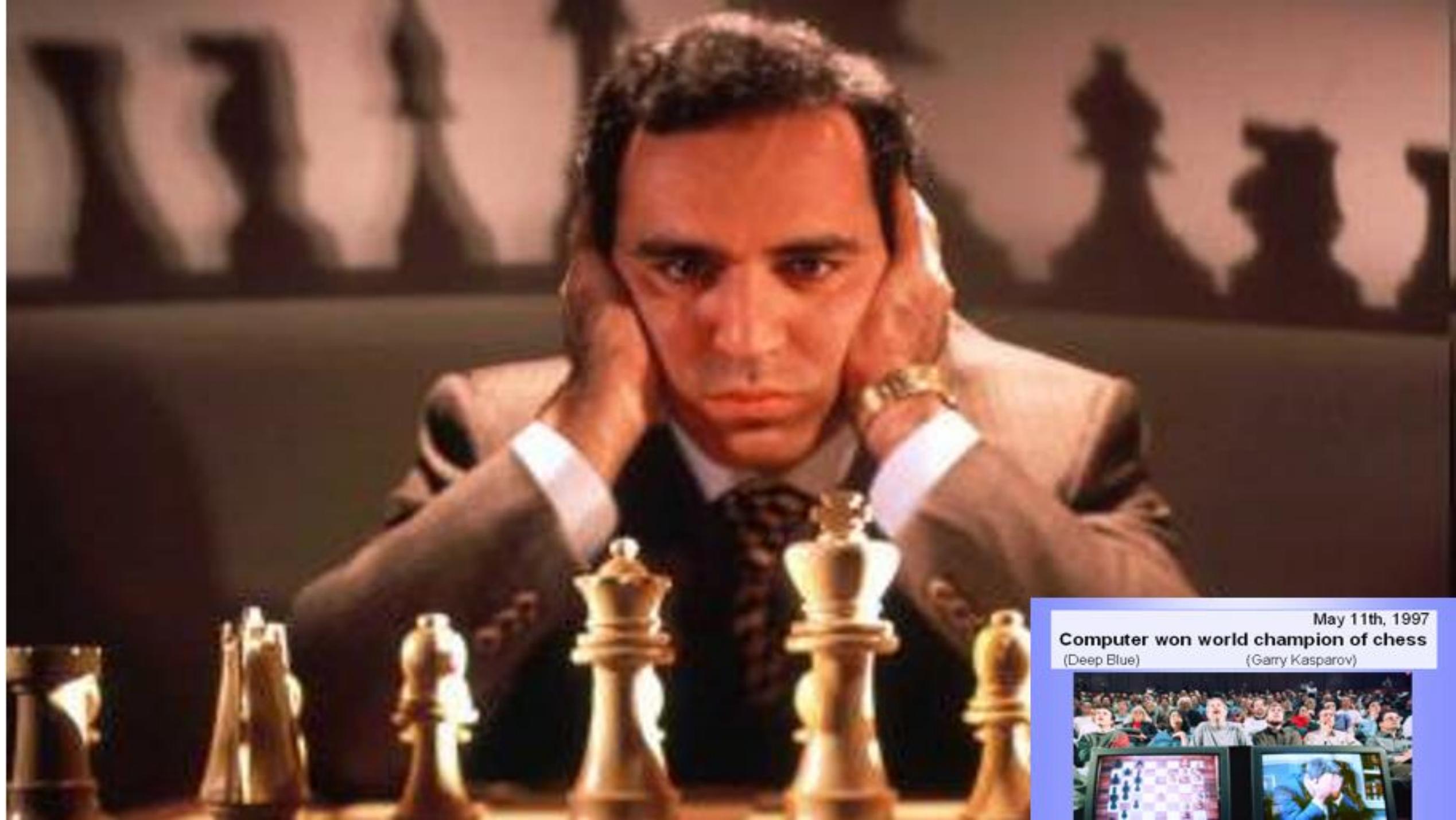
April 2017



# Topics

- Watson and Cognitive computing
- Watson for Oncology, Genomics, Clinical Trails
- Radiology





May 11th, 1997

**Computer won world champion of chess**

(Deep Blue)

(Garry Kasparov)



THINK



मोचिए

**\$24,000**

Who is Stoker?

(I FOR ONE WELCOME OUR  
NEW COMPUTER OVERLORDS)

\$1,000

**\$77,147**

Who is Bram  
Stoker?

\$ 17,973

**\$21,600**

WHO IS  
BRAM STOKER?

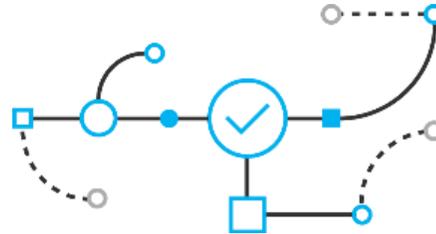
\$5600

# There are three capabilities that differentiate cognitive systems from traditional programmed computing systems.



## Understanding

Cognitive systems understand like humans do, whether that's through natural language or the written word; vocal or visual.



## Reasoning

They reason. They can understand information but also the underlying ideas and concepts. This reasoning ability can become more advanced over time. It's the difference between the reasoning strategies we used as children to solve mathematical problems, and then the strategies we developed when we got into advanced math like geometry, algebra and calculus.



## Learning

They never stop learning. As a technology, this means the system actually gets more valuable with time. They develop “expertise”. Think about what it means to be an expert - it's not about executing a mathematical model. We don't consider our doctors to be experts in their fields because they answer every question correctly. We expect them to be able to reason and be transparent about their reasoning, and expose the rationale for why they came to a conclusion.

# Natural Language Processing In Healthcare

Diseases

Symptoms

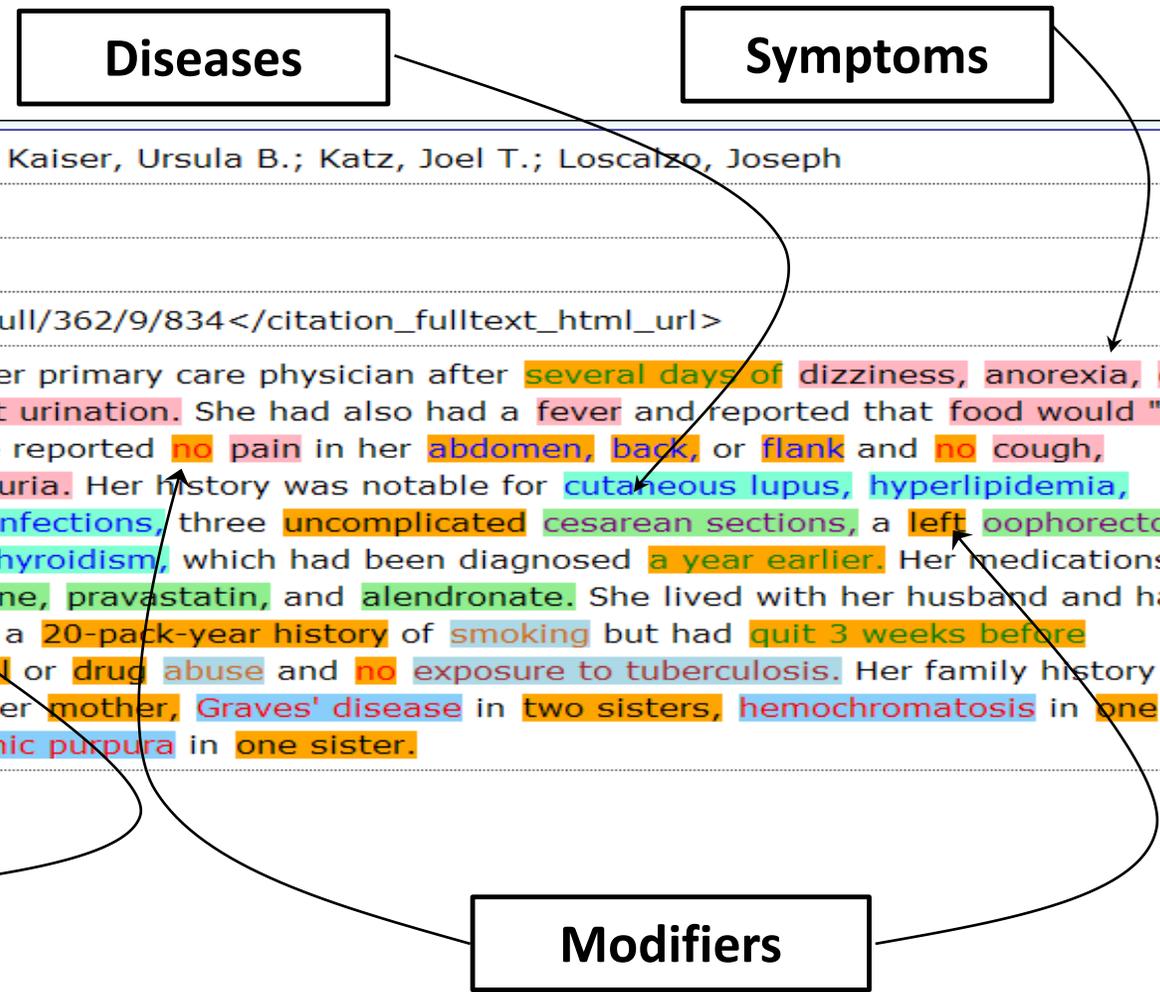
Relations  
causeOf  
modifierOf  
negationOf  
partOf  
remedyOf  
resultOf

1 Chamarthi, Bindu; Morris, Charles A.; Kaiser, Ursula B.; Katz, Joel T.; Loscalzo, Joseph  
2 Stalking the Diagnosis  
3 362/9/834  
4 [http://content.nejm.org/cgi/content/full/362/9/834</citation\\_fulltext\\_html\\_url>](http://content.nejm.org/cgi/content/full/362/9/834</citation_fulltext_html_url>)  
5 A 58-year-old woman presented to her primary care physician after several days of dizziness, anorexia, dry mouth, increased thirst, and frequent urination. She had also had a fever and reported that food would "get stuck" when she was swallowing. She reported no pain in her abdomen, back, or flank and no cough, shortness of breath, diarrhea, or dysuria. Her history was notable for cutaneous lupus, hyperlipidemia, osteoporosis, frequent urinary tract infections, three uncomplicated cesarean sections, a left oophorectomy for a benign cyst, and primary hypothyroidism, which had been diagnosed a year earlier. Her medications were levothyroxine, hydroxychloroquine, pravastatin, and alendronate. She lived with her husband and had three healthy adult children. She had a 20-pack-year history of smoking but had quit 3 weeks before presentation. She reported no alcohol or drug abuse and no exposure to tuberculosis. Her family history included oral and bladder cancer in her mother, Graves' disease in two sisters, hemochromatosis in one sister, and idiopathic thrombocytopenic purpura in one sister.

Entity Types / Roles  
FAMILY-DISEASE  
FAMILY-SUBSTANCE-ABUSE  
FINDING-BLOODPRESSURE  
FINDING-GENERIC  
FINDING-HEARTRATE  
FINDING-HEIGHT  
FINDING-OXYGEN-SATURATIO  
FINDING-RESPIRATORYRATE  
FINDING-TEMPERATURE  
FINDING-WEIGHT  
MODIFIER-ANATOMY  
MODIFIER-GENERIC  
MODIFIER-NEGATION  
MODIFIER-TIME  
PATIENT-ACTIVITY-EVENT  
PATIENT-AGE  
PATIENT-ALLERGY  
PATIENT-FEMALE  
PATIENT-HAZARD-EXPOSURE  
PATIENT-HEALTHSTATE  
PATIENT-LOCATION  
PATIENT-MALE  
PATIENT-NAME  
PATIENT-OCCUPATION

Medications

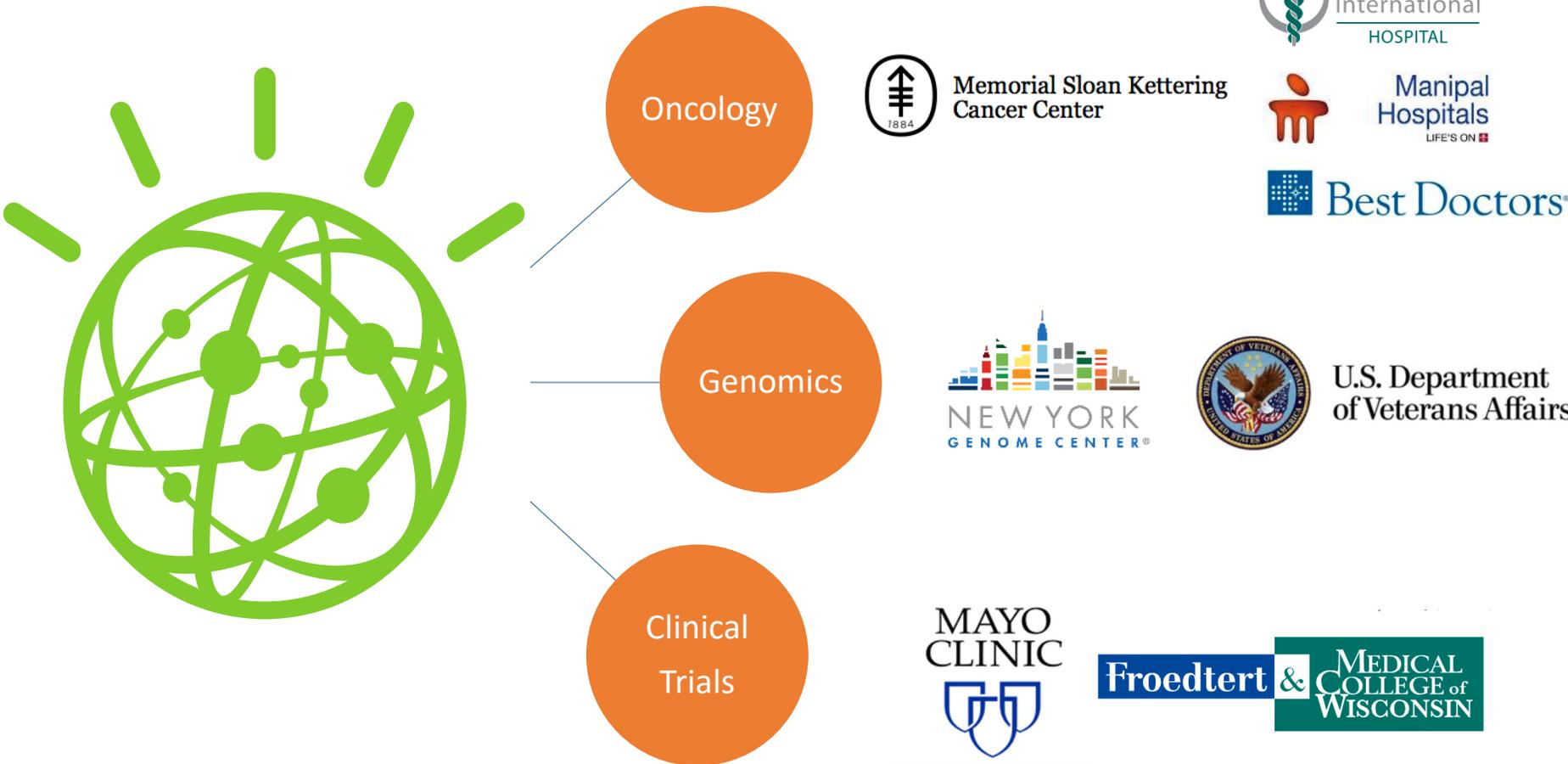
Modifiers



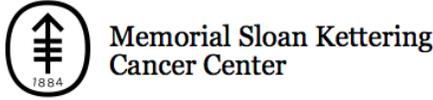
# Watson reads medical journals and literature as source of knowledge.



# The big picture in oncology



Oncology



Genomics



Clinical Trials



# Watson for Oncology: Evidence-Based, Personalized Treatment Plans

## Cloud Based

- SAAS Cloud Based Solution
- Triple redundancy
- Speed

## Expansion

- ❖ Second and Third line treatment options
- ❖ New cancers

## Localization

- ✓ Clinical Attributes
- ✓ Drug Formularies & Dosing
- ✓ Supporting Guidelines & Evidence
- ✓ Other Local Considerations

The screenshot displays the 'Patient attributes to identify treatment plan options' section. It includes a 'Required' dropdown menu, a 'Please Verify' checkbox, and a 'Please Verify' message: 'Attributes below correctly reflect the patient's condition.' Below this, there are several input fields for patient information: Gender (Female), Age (62 years old), Menopausal status (Postmenopausal), Performance status (ECOG 0 - Asymptomatic), M Stage (M0 - No clinical or radiologic evidence of distant disease), Primary tumor site (7.4), Histology (Lobular), and Tumor grade (Intermediate - moderately differentiated).



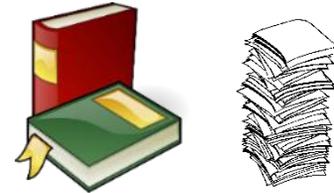
This is another screenshot of the IBM Watson for Oncology interface, showing the same patient attributes section as the first screenshot. It includes the 'Required' dropdown, the 'Please Verify' checkbox, and the 'Please Verify' message. The input fields for patient information are: Gender (Female), Age (62 years old), Menopausal status (Postmenopausal), Performance status (ECOG 0 - Asymptomatic), M Stage (M0 - No clinical or radiologic evidence of distant disease), Primary tumor site (7.4), Histology (Lobular), and Tumor grade (Intermediate - moderately differentiated).

## Corpus

The Corpus contains Health line Medical Taxonomy to varied sources from:

ASCO, EBSCO information services, Elsevier, MMS, NCCN guidelines, US Government, Wiley

- ❑ 250 textbooks
- ❑ 200 medical journals
- ❑ 15 million pages of Oncology text
- ❑ >10,000 oncology cases



## Training

## Refresh

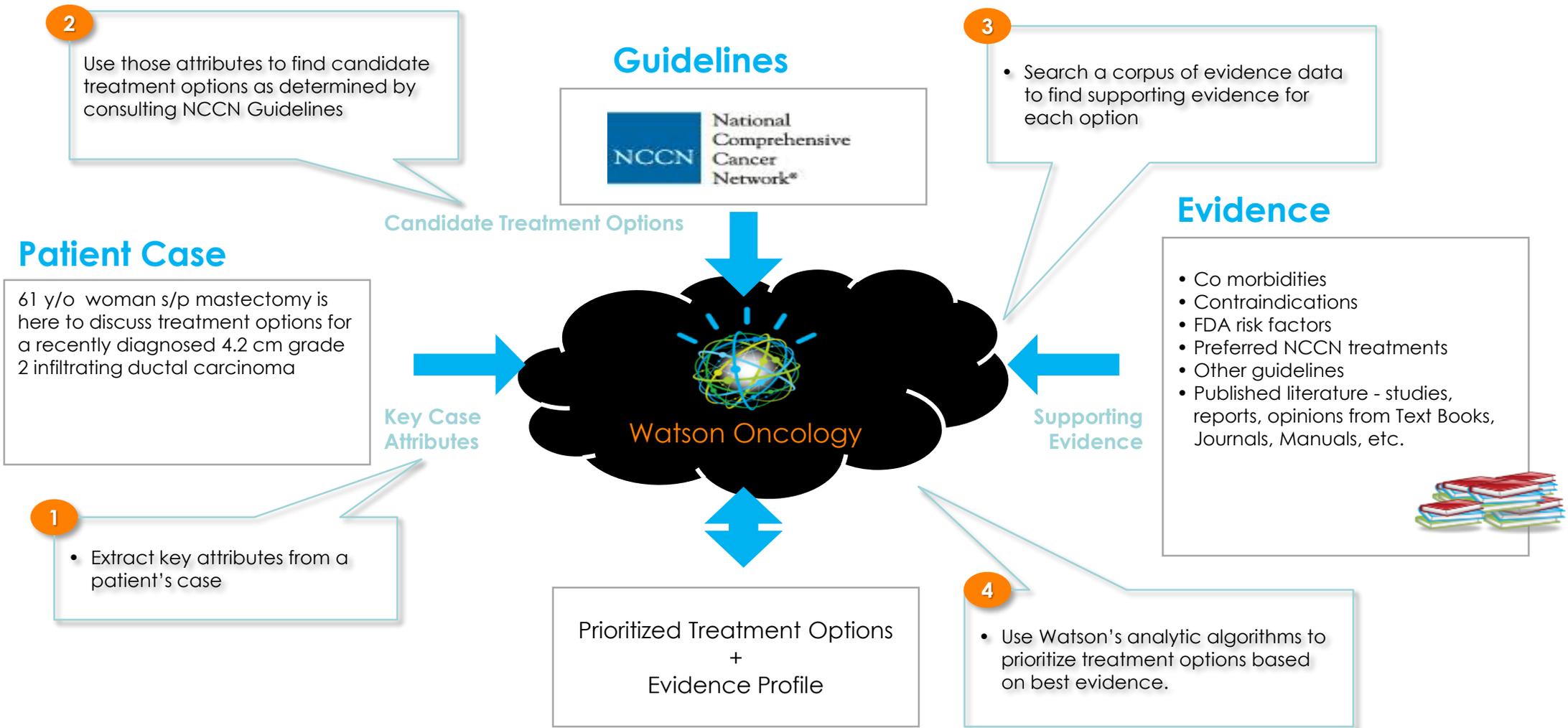


- Continuous training by MSKCC oncologists
- Refresh and Maintenance of corpus
- New cases



Memorial Sloan Kettering  
Cancer Center™

# Watson for Oncology: From Patient Case to Treatment Options in 4 steps



+ View more

DEMOGRAPHICS  
Age: 62 Gender: Female

DISEASE STATUS  
Cancer type: Breast cancer Cancer stage: IIB

TREATMENT HISTORY  
Surgery: Not specified Chemotherapy: Not specified

x Treatment Plan Options for: Stage IIB neoadjuvant with Case Notes

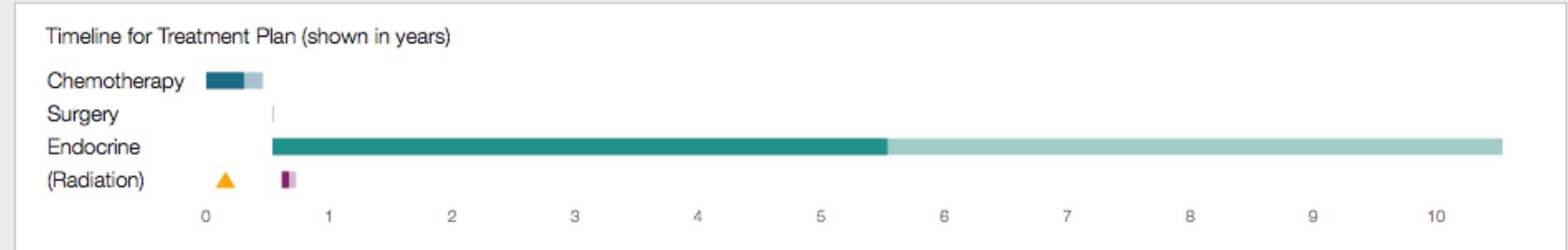
Select a clinical trial

Chemotherapy followed by surgery followed by endocrine therapy and radiation therapy >

More treatment plan options

Chemotherapy followed by surgery followed by endocrine therapy and radiation therapy ⓘ

Save treatment plan options



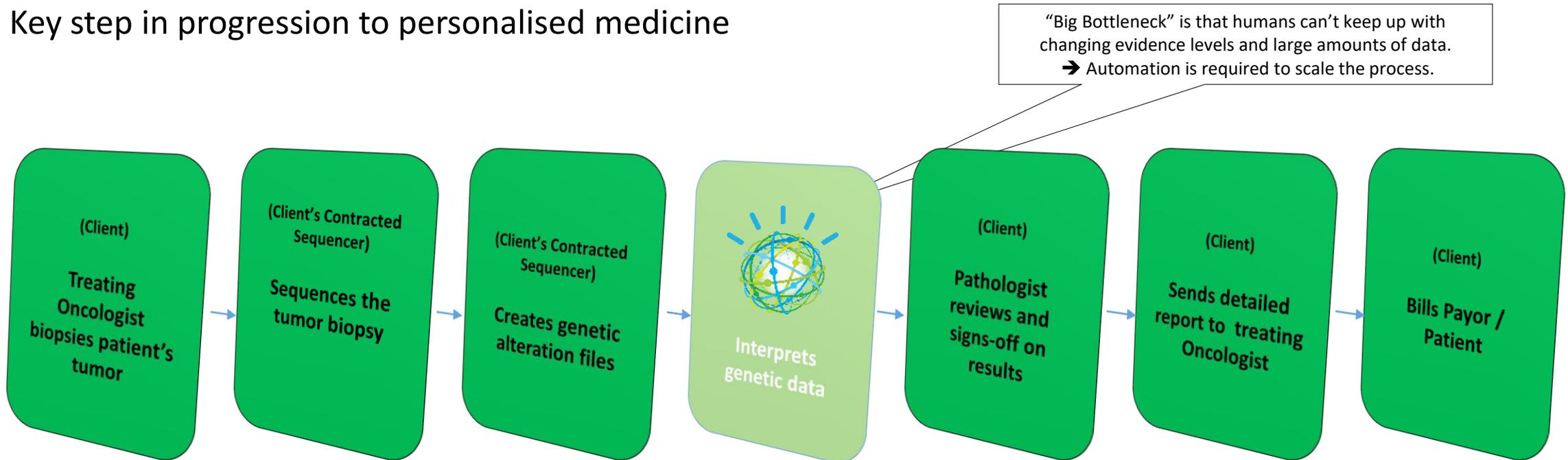
Chemotherapy	Surgery	Endocrine	Radiation
<input type="checkbox"/> Dose-dense AC (Doxorubicin / Cyclophosphamide) followed by T (Paclitaxel) ⓘ	<input type="checkbox"/> Referral to surgery	<input type="checkbox"/> Letrozole at least 5 years <input type="checkbox"/> Anastrozole at least 5 years	<input type="checkbox"/> Referral to radiation oncology
<input type="checkbox"/> FEC (Fluorouracil / Epirubicin / Cyclophosphamide) followed by Docetaxel <input type="checkbox"/> TAC (Docetaxel / Doxorubicin / Cyclophosphamide)		<input type="checkbox"/> Tamoxifen	

# Watson for Genomics

As the cost of Next Generation Sequencing decreases, there will be an increase in tumor genome sequencing resulting in massive quantities of genetic data to analyze.

It is extremely complex and labor-intensive (can take from days to weeks) to Identify the genetic alterations driving the cancer and matching them with molecular targeted therapies.

Key step in progression to personalised medicine

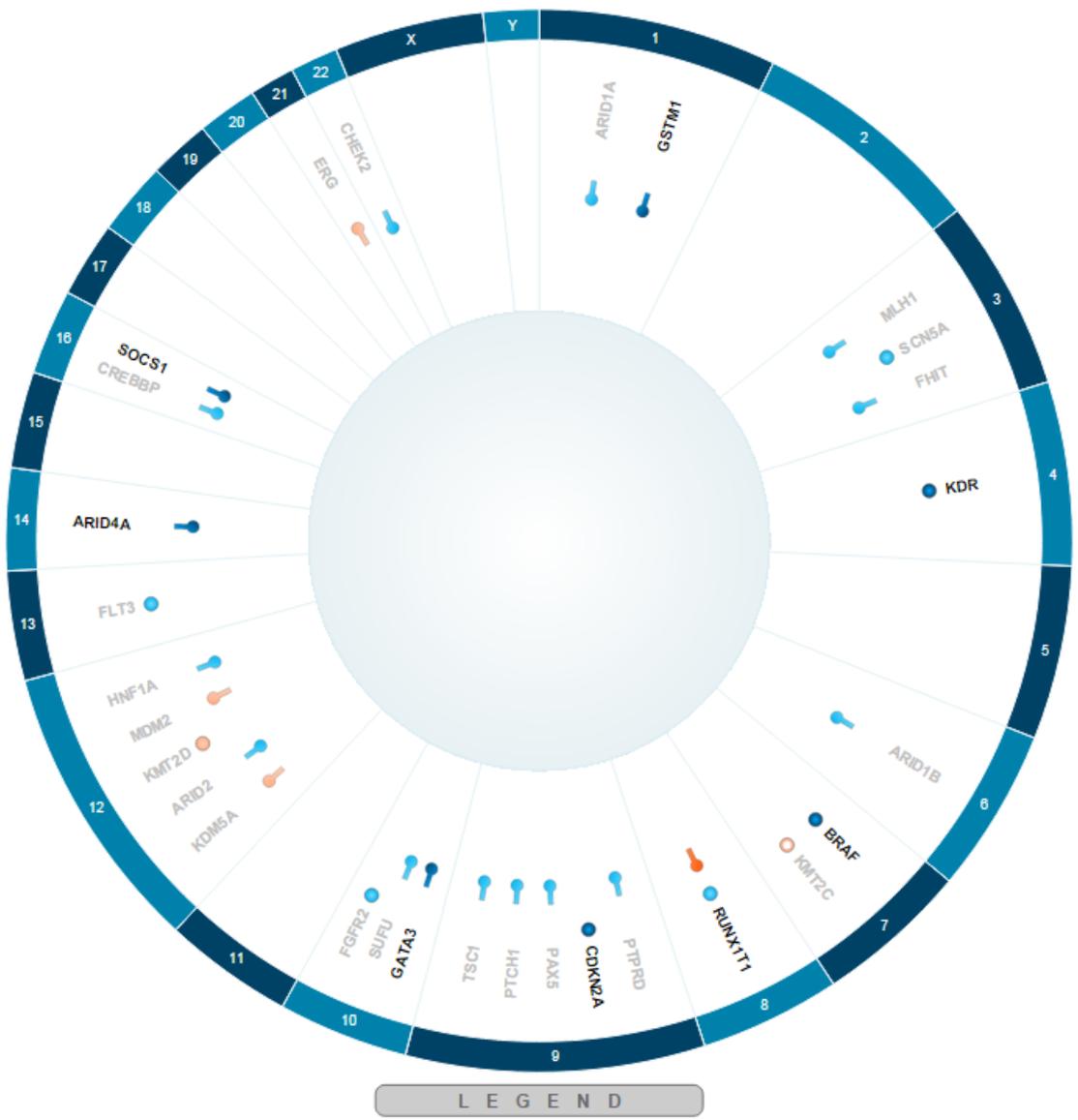


# Watson Genomics - Functionality Highlights

- Cloud based solution, multi-user and multi-tenant solution with a single code base
- No customization, configuration or integration required
- Security safeguards implemented and managed by IBM and industry standards
- All patient data uploaded to WfG is de-identified (de-identified mutated DNA)
  - Accepted input data includes somatic mutations, copy number variations and gene expression
  - Supports gene panels, whole exome and whole genome sequenced files
  - Natural Language Processing (NLP) used to extract information from extensive medical literature (over 23 millions articles)
  - 20+ structures and unstructured data sources ingested
- Analytics engine to identify relevant alterations, drugs and clinical trials for all types of cancer
- Pharmacogenomic rules implemented
- Report and interactive visualizations of the molecular profile, drugs and pathways
- Summary report shows target therapeutic options categorized by FDA approved, Investigational and Off Label
- Evidences presented via hyperlinks to sources for easy drill down

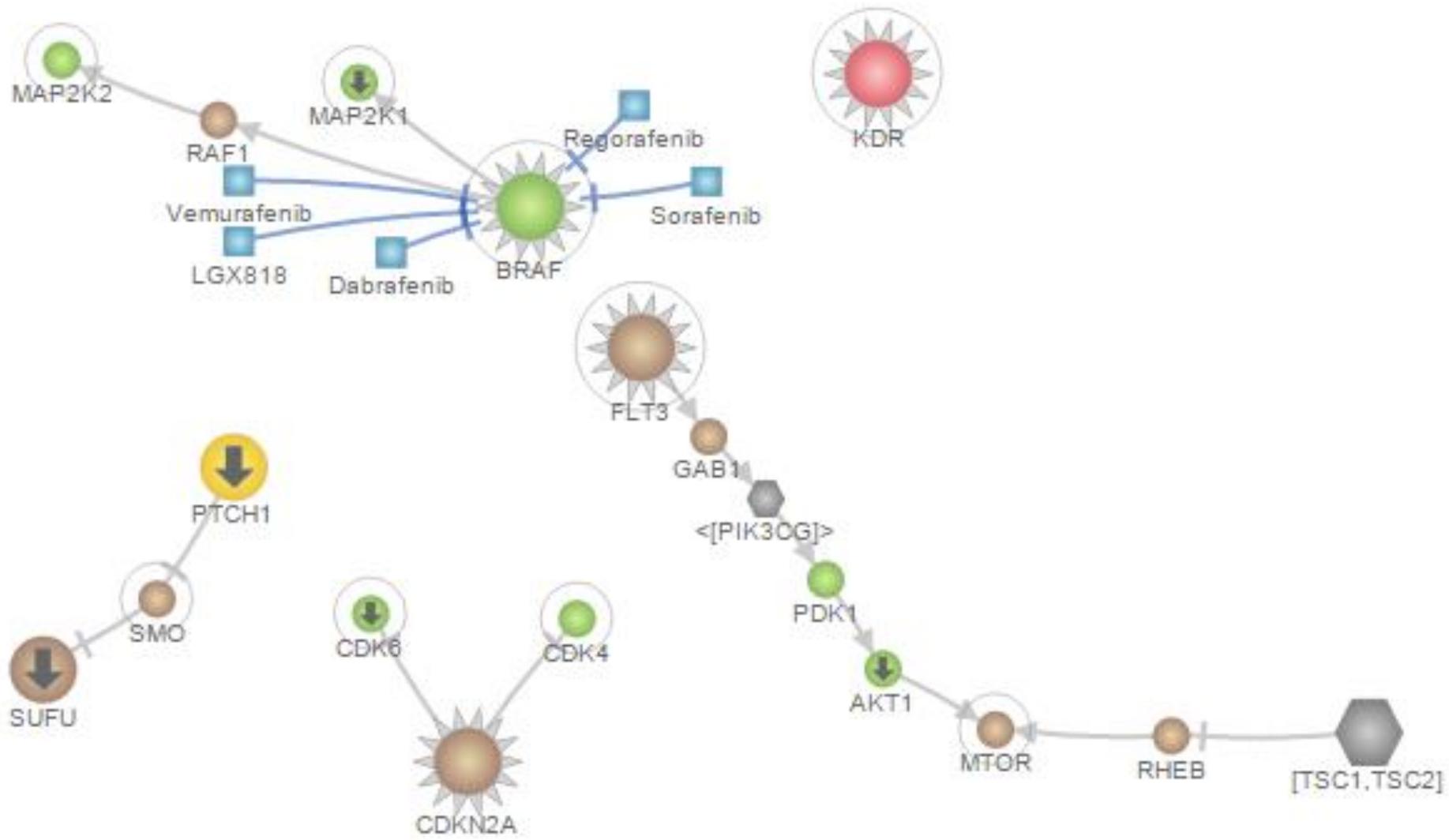
# Watson for Genomics: Molecular Profile analysis

Summary **Molecular Profile** Pathway Drugs



Select	Relevance	Gene	Alteration	
<input type="checkbox"/>	■■■	BRAF	V600E	+
<input type="checkbox"/>	■■■	RUNX1T1	Amplification L196F	+
<input type="checkbox"/>	■■■	GSTM1	Loss	+
<input type="checkbox"/>	■■■	GATA3	Loss	+
<input type="checkbox"/>	■■■	SOCS1	Loss	+
<input type="checkbox"/>	■■■	CDKN2A	H83D	+
<input type="checkbox"/>	■■■	KDR	R1032Q	+
<input type="checkbox"/>	■■■	ARID4A	Loss	+
<input type="checkbox"/>	■ ■ ■	ERG	Amplification	+
<input type="checkbox"/>	■ ■ ■	MDM2	Amplification	+
<input type="checkbox"/>	■ ■ ■	FHIT	Loss	+
<input type="checkbox"/>	■ ■ ■	PTCH1	Loss	+
<input type="checkbox"/>	■ ■ ■	KMT2D	E1186*	+
<input type="checkbox"/>	■ ■ ■	PAX5	Loss	+
<input type="checkbox"/>	■ ■ ■	ARID2	Loss	+
<input type="checkbox"/>	■ ■ ■	PTPRD	Loss	+

# Watson for Genomics: Pathway analysis



# Watson for Genomics: Drug Analysis

Overview

Literature

Clinical Trials

## Approved for NSCLC



Afatinib  
EGF  
Level 1



Erlotinib  
EG  
Level 1

## Investigational for NSCLC



BMS-690514  
EGFR  
Level 3



BAY846  
EGFR  
Level 3

## Off Label

Afatinib



Target:  
EGFR

Relationship to Driver Gene  
is Driver Gene

Description

Approved for first line treatment of metastatic NSCLC with EGFR exon 19 deletions and exon 21 L858R alterations.

Drug Sensitivity

EGFR exon 19 deletions  
Summary Blurb

Evidence

EGFR exon 21 L858R substitutions  
Summary Blurb

Evidence

Mechanism of action

Afatinib demonstrated inhibition of outophosphorylation and in vitro proliferation of cell lines expressing wild-type EGFR or those expressing selected EGFR exon 19 deletion mutations or exon 21 L858R mutations, including some with a secondary T790M mutation, at afatinib concentrations achieved, at least transiently, in patients. In addition, afatinib inhibited in vitro proliferation of cell lines overexpressing HER2.

Treatment with afatinib resulted in inhibition of tumor growth in nude mice implanted with tumors either overexpressing wild type EGFR or HER2 or in an EGFR L858R/T790M double mutant model.

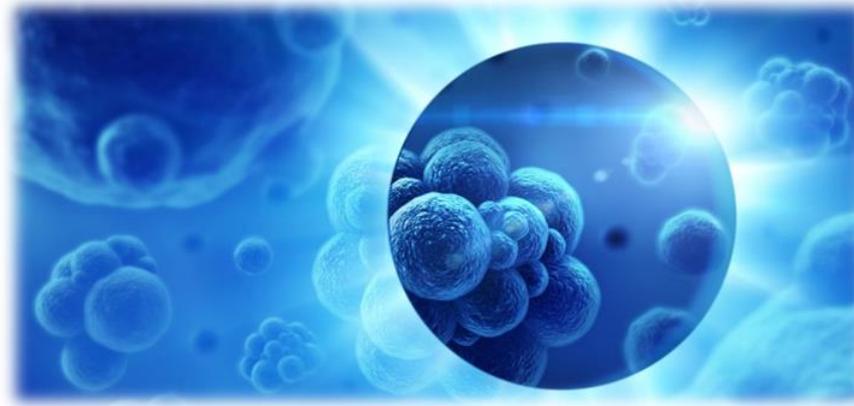
Drug Resistance

EGFR T790M  
Summary Blurb  
Evidence

# Watson Clinical Trials Matching

Overall only 3% of cancer patients are on clinical trials

## IBM Watson Clinical Trial Matching



### Business problem:

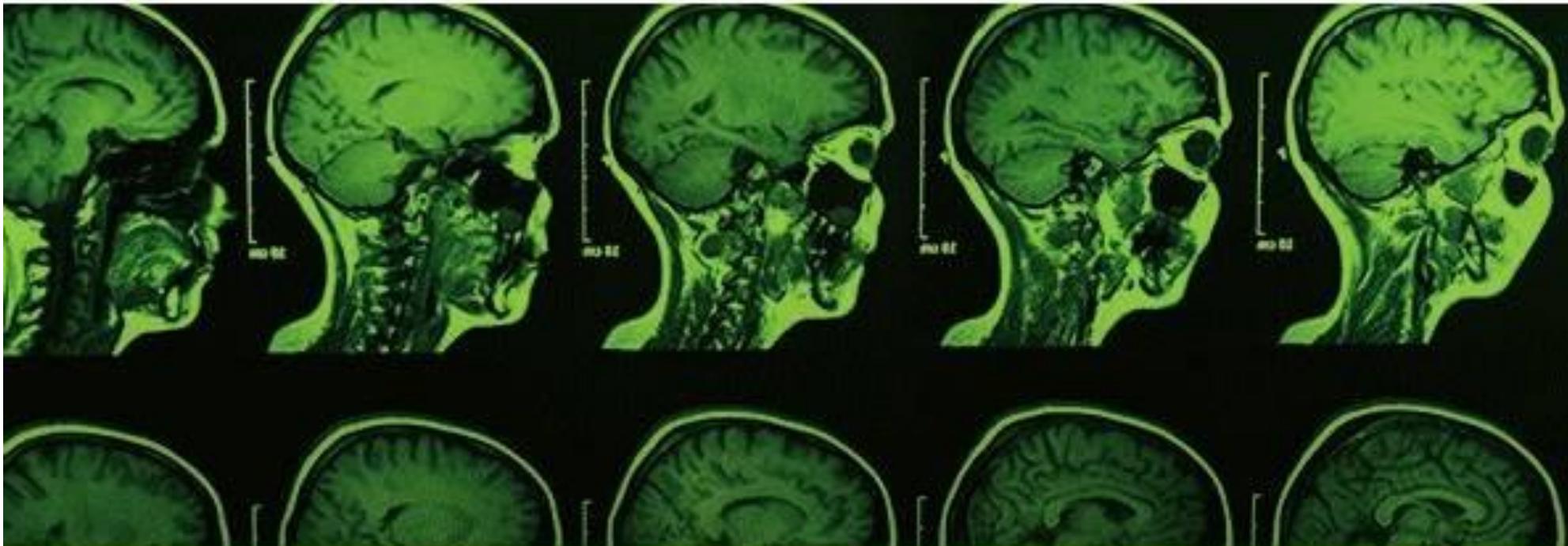
- No easy way to search eligibility criteria at point of care to match patients to clinical trials

### Solution:

- Identify all the relevant clinical attributes needed to search across clinical trials for a disease
- Instantly check the patient's eligibility
- Provide an ordered list of relevant clinical trials with the degree of match
- Provide criteria (inclusion / exclusion) level evaluation based on the patient's attributes
- Dynamically re-evaluate the case based on changes to clinical attributes

# Vision – Teaching Watson to See

THINK ACADEMY



**90%** of all medical data is image-based.

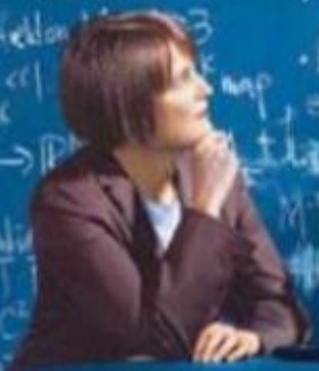
# Radiology Cognitive Assistant

- Cognitive applied to medical imaging may become the most disruptive technology Radiology has seen since the advent of digital imaging
- X-ray's, MRI's, CT-scans, Angiograms and many other medical images
- Radiology Challenges: Increasing volumes of images and limited amount of clinical information
  - Statistics show that eye fatigue is a common problem with radiologists
  - An emergency room radiologist may see as many as 200 cases a day, and some of these imaging studies (eg lower body CT angiography) can be 3000+ images per study.
  - Due to the volume overload, and limited amount of clinical information available as part of imaging studies, diagnosis errors can occur.
- “Grand challenge” research project in IBM Research
- IBM Watson project code name: Avicenna

You, *with* IBM.

Thank you

THINK



mathematical notes and equations covering the entire background wall.