Health Terminologies and Classifications Observation on SNOMED and ICD

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James Read Memorial Lecture
SNOMED CT Implementation Showcase
Crystal City, VA   11 Oct 2013

Health Care Is
An Information Intensive Industry

- Control of Health Care Costs ...
- Improved Quality of Care ...
- Improved Health Outcomes ...
- Appropriate Use of Health Technology...
- Compassionate Resource Management...

☞ ... depend upon information

☞ … Ultimately Patient Data

Medical Concepts
Events, Observations, Interventions

- How should we represent it? Language:
  - Nuance, detail, unfettered combination
  - Timely, current, never obsolete
  - Natural, friendly, established
  - [Ambiguous, imprecise, unpredictable]
- Codes:
  - Concise, precise
  - Structured, consistent, well formed
  - Analyzable, manipulable
  - [Rigid, tedious, high maintenance]

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Will Big Data Save Us?

Genetics inMedicine | REVIEW

Genet Med 15: 802-809;

Oct, 2013

Some experiences and opportunities for big data in translational research

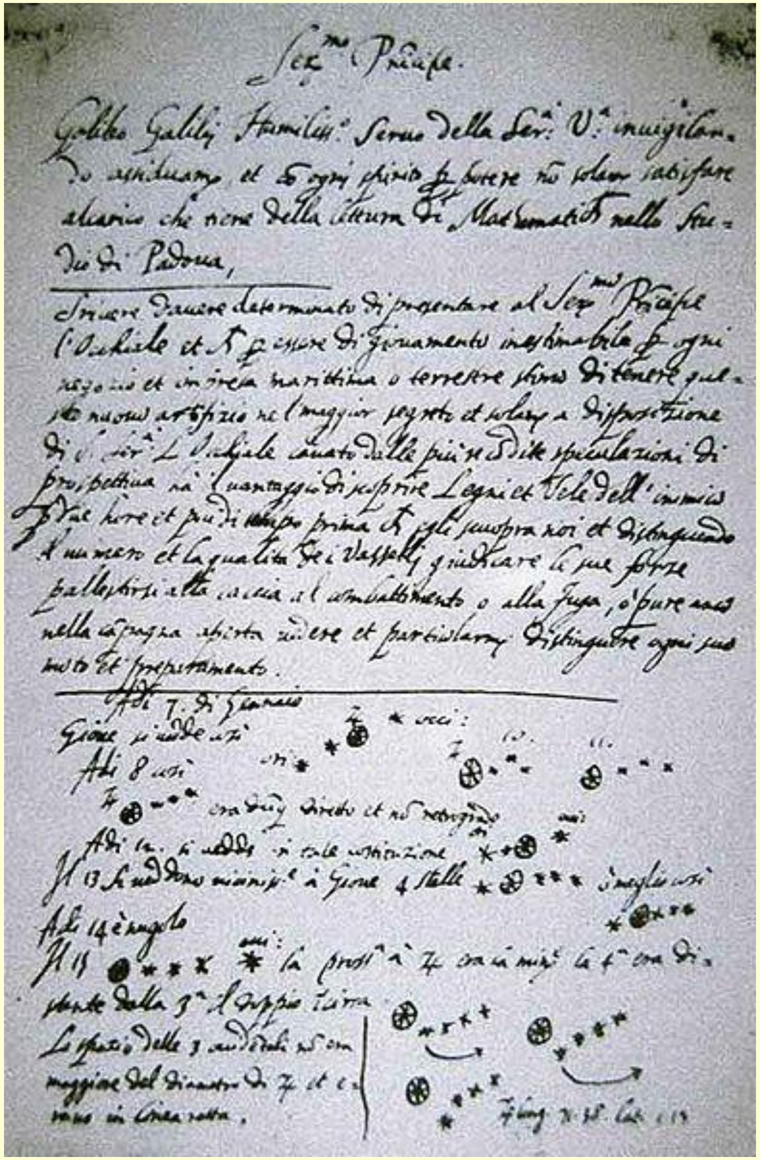
Christopher G. Chute, MD, DrPH[1], Mollie Ullman-Cullere, MS, MSE[2], Grant M. Wood, BS[3], Simon M. Lin, MD[4], Min He, PhD[4] and Jyotishman Pathak, PhD[1]

Health care has become increasingly information intensive. The advent of genomic data, integrated into patient care, significantly accelerates the complexity and amount of clinical data. Translational research in the present day increasingly embraces new biomedical discovery in this data-intensive world, thus entering the domain of "big data." The Electronic Medical Records and Genomics consortium has taught us many lessons, while simultaneously advances in commodity computing methods enable the academic community to affordably manage and process big data. Although great promise can emerge from the adoption of big data methods and philosophy, the heterogeneity and complexity of clinical data, in particular, pose additional challenges for big data inferencing and clinical application. However, the ultimate comparability and consistency of heterogeneous clinical information sources can be enhanced by existing and emerging data standards, which promise to bring order to clinical data chaos. Meaningful Use data standards in particular have already simplified the task of identifying clinical phenotyping patterns in electronic health records.

Genet Med advance online publication 5 September 2013

Key Words: clinical data representation; big data; genomics; health information technology standards

Origins of Big Science
Astronomy



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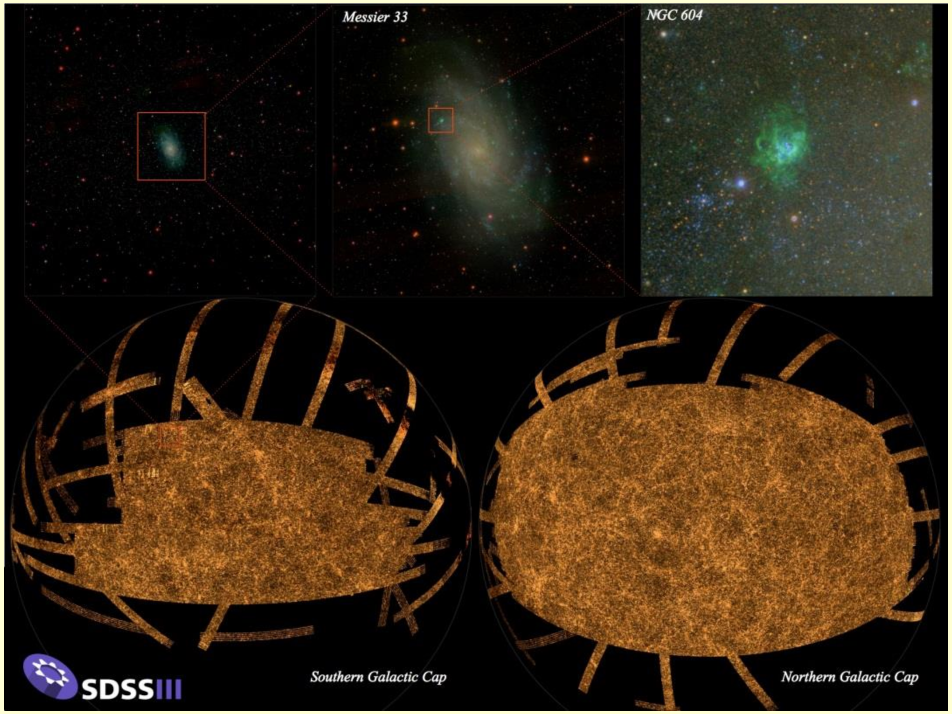
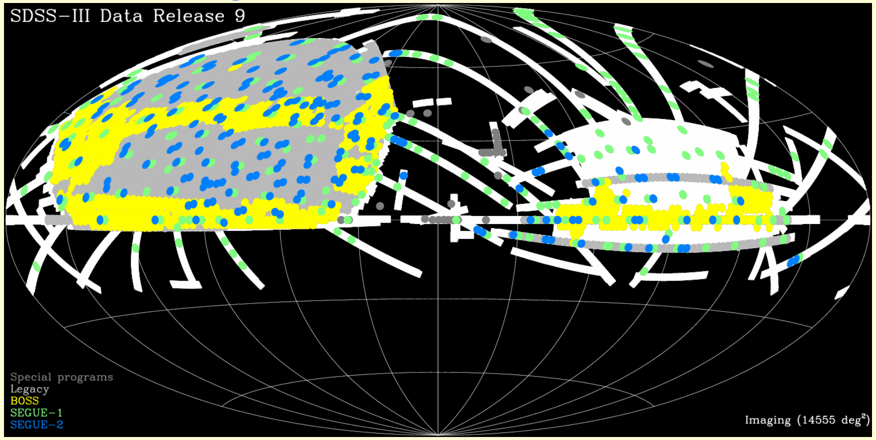
Sloan Digital Sky Survey III – DR9

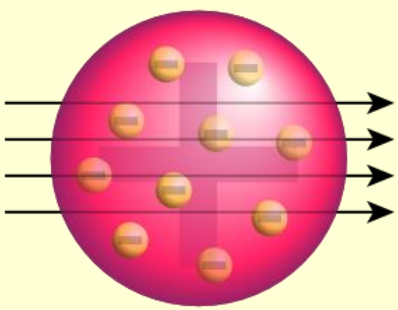


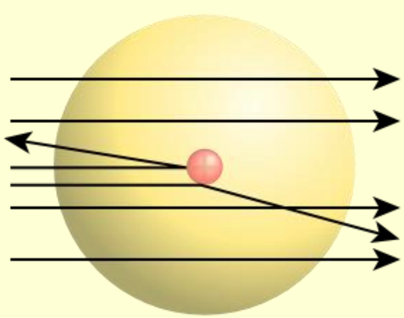
- Images
- Spectra
- Object catalog
- Metadata

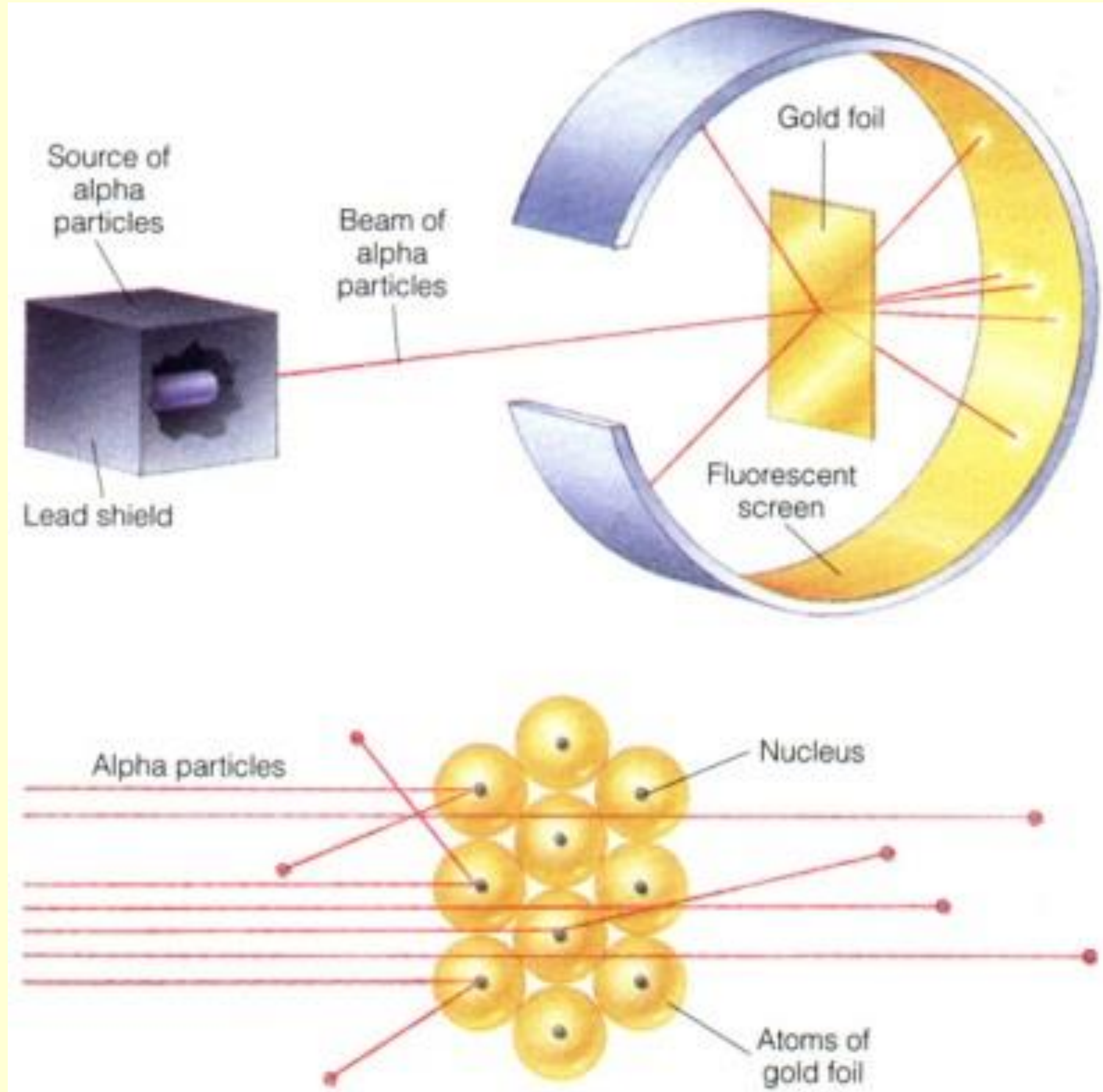


Total area of imaging	31,637 square degrees
Image field size	1361x2048 pixels
Number fields	938,046 (excluding supernovae runs)
Catalog objects	1,231,051,050
Number of unique, primary sources	
Total	469,053,874
Stars	260,562,744
Galaxies	208,478,448
Unknown	12,682

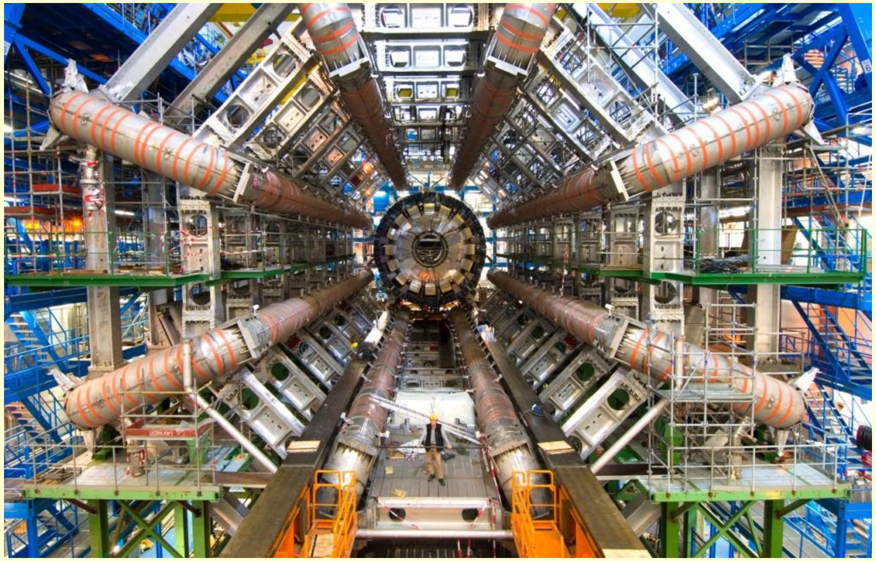
Rutherford "Table-top" Experiment

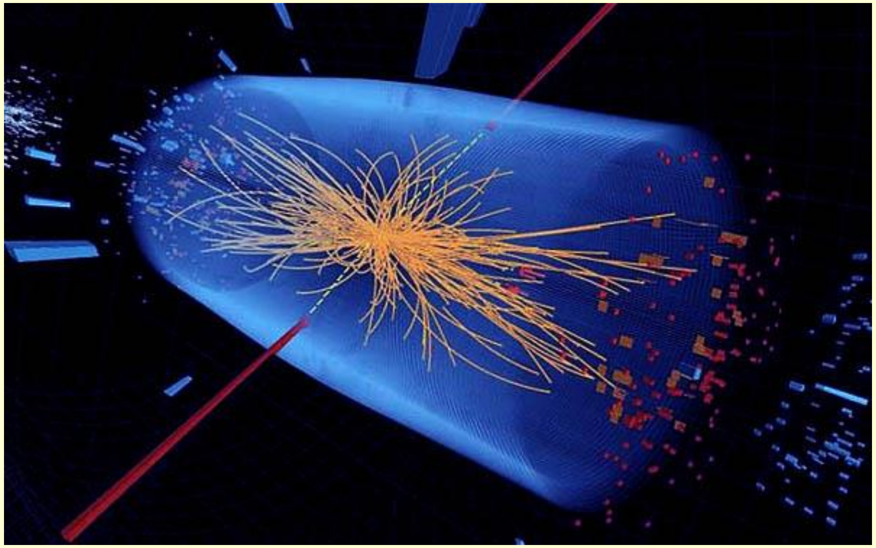






That Higgs Boson





- 600 institutions
- 10,000 scientists
  - 2 Nobel prizes
- 800 trillion collisions
- 200PB of data =
  - 2×10^{17} bytes of data

Boarding on an astronomical number in its own right!

- $\$13.25 \cdot 10^9$ USD

Dimensionality of Higgs "Big Data"

- Mass
- Direction
- Energy

- **Medicine is more complicated than that**

Dimensionality of Big Data

- Broad
  - Small amounts of data; Huge number observations
  - National Claims data
- Deep
  - Large amounts of data; Few observation
  - NGS Complete Genome
- Rich
  - Broad and Deep
  - Clinical Phenotyping data (EMRs)
    - Labs, Vitals, Exam, Waveform, Images, Omics, …
    - Social, environmental, diet,

Does Big Data Change Criteria for Scientific Evidence?

that “society will need to shed some of its obsession for causality in exchange for simple correlations: not knowing *why* by only *what*. This overturns centuries of established practices and challenges our most basic understanding of how to make decisions and comprehend reality.”

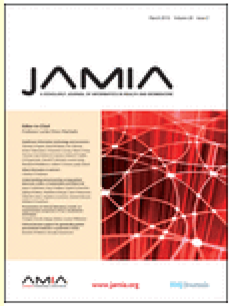
Mayer-Schönberger, V. and K. Cukier, *Big data : a revolution that will transform how we live, work, and think*. 2013, Boston: Houghton Mifflin Harcourt. 242 p.

Actionable Knowledge: More than just Google Search

- Well known “spurious association” problem
  - Reproducibility
- Power Issues [Have I seen a “patient like that”]
  - Single drug vs. single side effect
  - Stratify across cells by:
    - Age and Sex
    - Co-morbidity
    - Lab values (nomal vs non-normal)
    - Image findings
    - Waveform findings
    - Genetic profile (and other “omics”)

Counterfactual:
Mining Gold from Dirty Big Data

Brief communication



Mar 2013

Web-scale pharmacovigilance: listening to signals from the crowd

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▸ Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/amiajnl-2012-001482).

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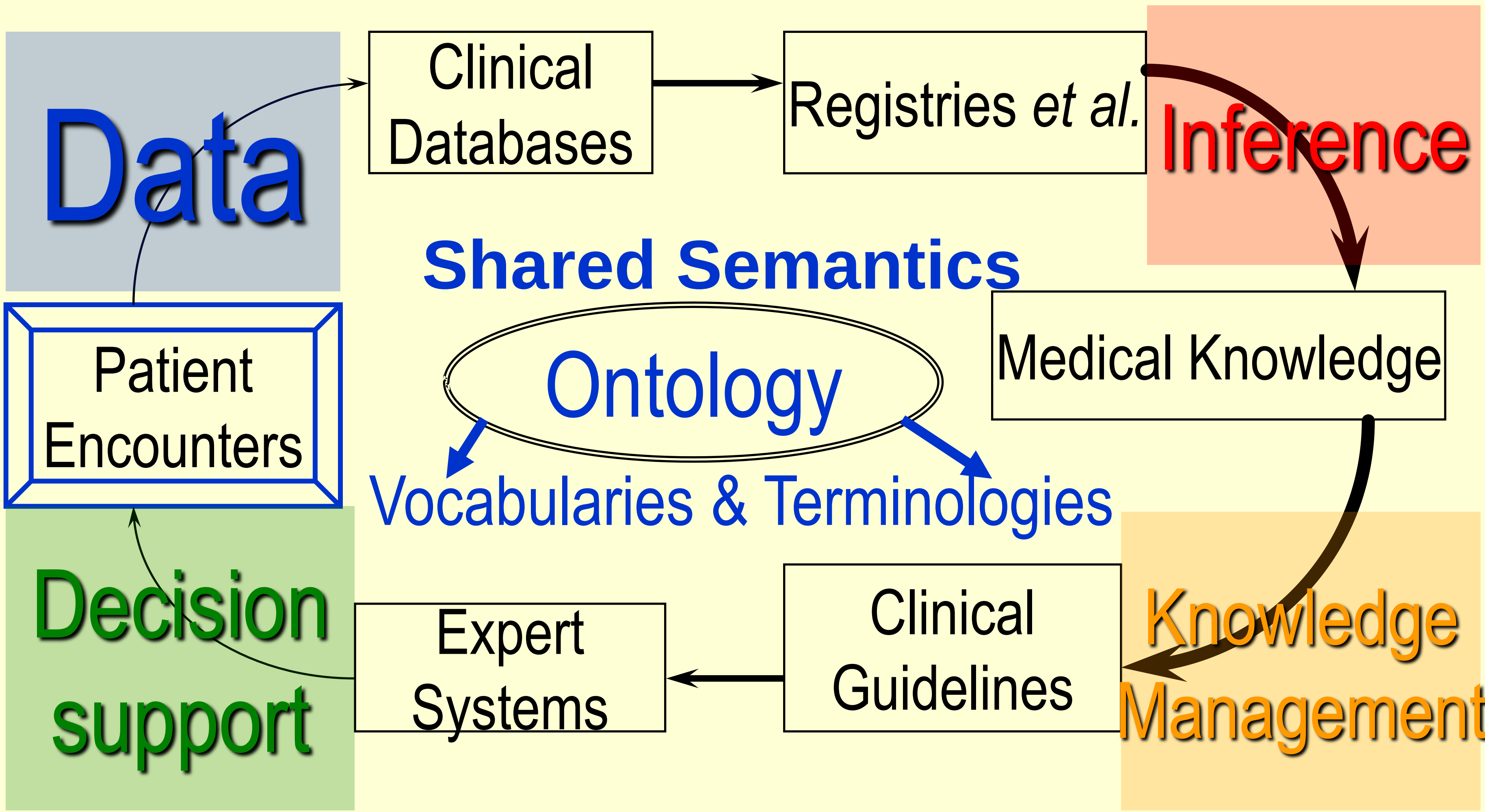
ABSTRACT
Adverse drug events cause substantial morbidity and mortality and are often discovered after a drug comes to market. We hypothesized that Internet users may provide early clues about adverse drug events via their online information-seeking. We conducted a large-scale study of Web search log data gathered during 2010. We pay particular attention to the specific drug pairing of paroxetine and pravastatin, whose interaction was reported to cause hyperglycemia *after* the time period of the online logs used in the analysis. We also examine sets of drug pairs known to be associated with hyperglycemia and those not associated with hyperglycemia. We find that anonymized signals on drug interactions can be mined from search logs. Compared to analyses of other sources such as electronic health records (EHR), logs are inexpensive to collect and mine. The results demonstrate that logs of the search activities of populations of computer users can contribute to drug safety surveillance.

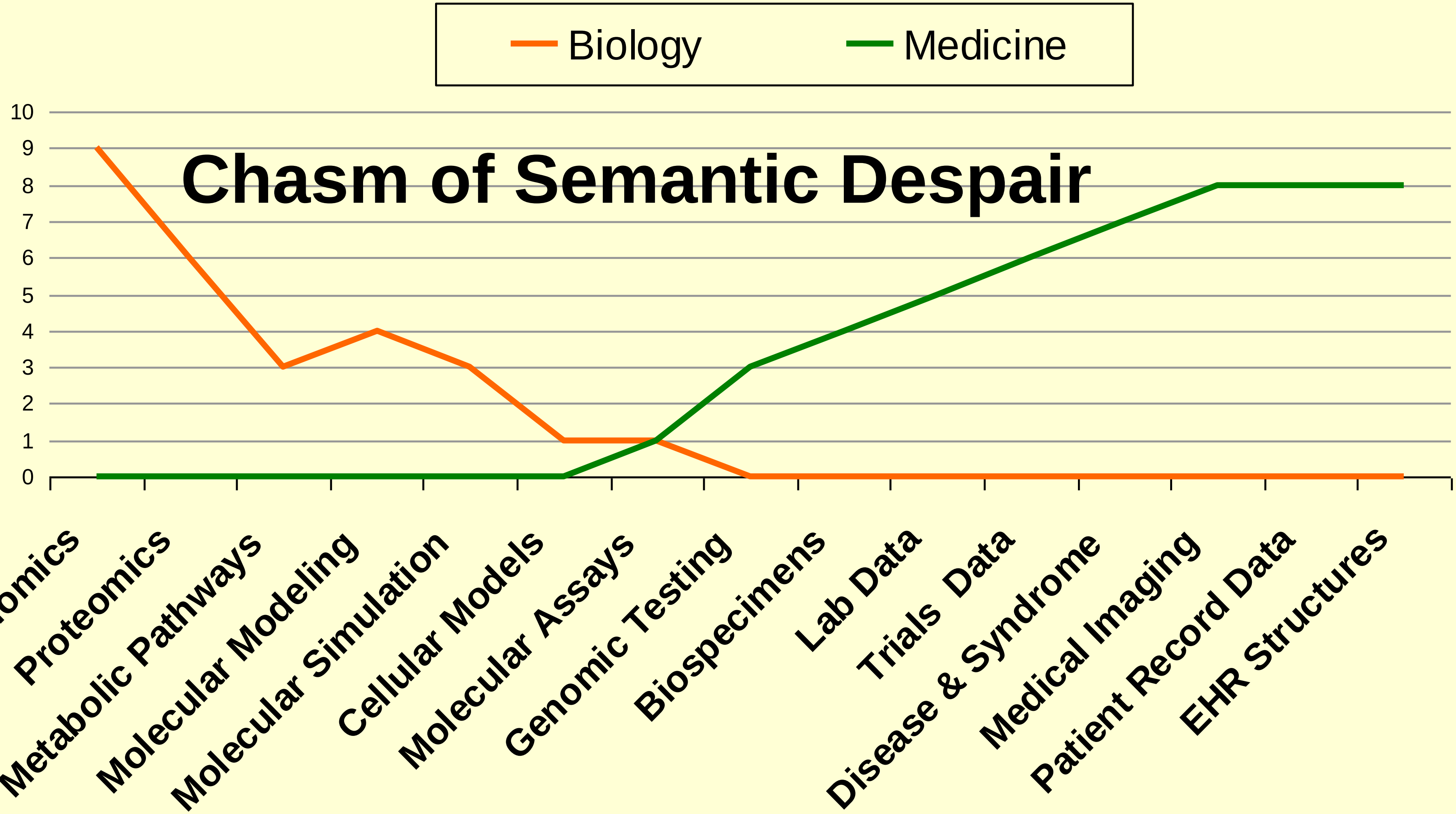
case an interaction between paroxetine (an anti-depressant) and pravastatin (a cholesterol-lowering drug), which was recently reported to create hyper-glycemia.[13 14] This association was extracted from the US Food and Drug Administration adverse event reporting system (AERS) using a data-mining algo-rithm that aggregates reports to identify drug–drug interactions.[13] The finding was confirmed in a retro-spective analysis of the electronic health records of three regionally distinct medical institutions and con-firmed in a mouse model.[14] We hypothesized that patients taking these two drugs might experience symptoms of hyperglycemia and may have conducted internet searches on these symptoms and concerns related to hyperglycemia before the association was reported in 2011.

METHODS
We analyzed the search logs of millions of consent-ing web users who opted to share search activities

From Practice-based Evidence to Evidence-based Practice



The Continuum Of Biomedical Informatics
Bioinformatics meets Medical Informatics



Blois, 1988
Medicine and the nature of vertical reasoning

- Molecular: receptors, enzymes, vitamins, drugs
- Genes, SNPs, gene regulation
- Physiologic pathways, regulatory changes
- Cellular metabolism, interaction, meiosis,…
- Tissue function, integrity
- Organ function, pathology
- Organism (Human), disease
- Sociology, environment, nutrition, mental health…

Terminology as Crucial Requirement

Without Terminology Standards...

- Health Data is *non*-comparable
- Health Systems *cannot* Interchange “Data”
- Secondary Uses (Research) are *not* practical
- Big Data methodologies cannot leverage epidemiologic principles for observational data
  - Adjustment for confounding
    - Stratification
    - Multivariate models
    - Machine learning features

Natural and *Political*

OBSERVATIONS

Mentioned in a following INDEX,

and made upon the

Bills of Mortality.

1910
1665
245

BY

Capt. *JOHN GRAUNT*,

Fellow of the *Royal Society*.

With reference to the *Government*, *Religion*, *Trade*, *Growth*, *Air*, *Diseases*, and the several Changes of the said CITY.

——*Non, me ut miretur Turba, laboro,*
Contentus paucis Lectoribus.——

The Third EDITION,
much Enlarged.

LONDON,
Printed by *John Martyn*, and *James Allestry*,
Printers to the *Royal Society*, and are to be sold at the
sign of the *Bell* in St. *Pauls* Church-yard.
MDCLXV.

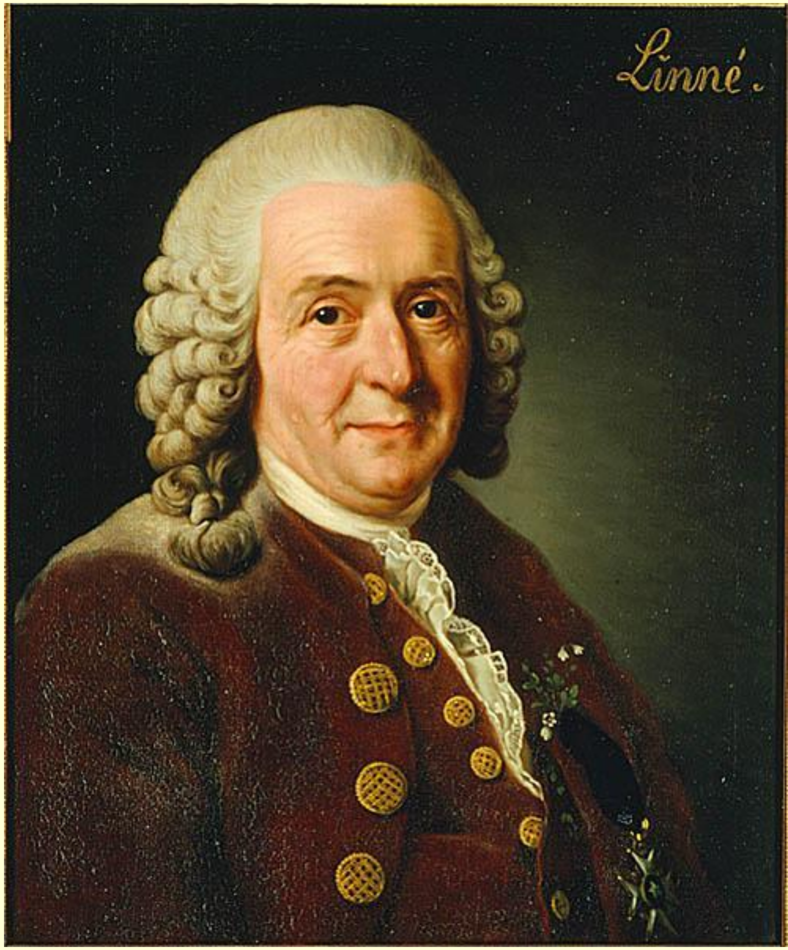
The Table of CASUALTIES.

The Years of our Lord	1647	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1629	1630	1631
Abortive and Stil-born	335	329	327	351	389	381	384	433	483	419	463	467	421	544	499	439	410
Aged	916	835	889	696	780	834	864	974	743	892	869	1176	909	1095	579	712	661
Ague and Fever	1260	884	751	970	1038	1212	282	1371	689	875	999	1800	2303	2148	956	1091	1115
Apoplex and Suddenly	68	74	64	74	106	111	118	86	92	102	113	138	91	67	22	36	
Bleach			1	3	7	2				1							
Blasted	4	1			6	6			4		5	5	3	8	13	8	10
Bleeding	3	2	5	1	3	4	3	2	7	3	5	4	7	2	5	2	5
Bloody Flux, Scouring and Flux	155	176	802	289	833	762	200	386	168	368	362	233	346	251	449	438	352
Burnt and Scalded	3	6	10	5	11	8	5	7	10	5	7	4	6	6	3	10	7
Calenture	1			1		2	1	1			3						
Cancer, Gangrene and Fistula	26	29	31	19	31	53	36	37	73	31	24	35	63	52	20	14	23
Wolf				8													
Canker, Sore-mouth and Thrush	66	28	54	42	68	51	53	72	44	81	19	27	73	68	6	4	4
Child-bed	161	106	114	117	206	213	158	192	177	201	236	225	226	194	150	157	[illegible]
Chrisoms and Infants	1369	1254	1065	990	1237	1280	1050	1343	1089	1393	1162	1144	858	1123	2596	2378	2035
Colick and Wind	103	71	85	82	76	102	80	101	85	120	113	179	116	167	48	57	
Cold and Cough							41	36	21	58	30	31	33	24	10	58	51
Consumption and Cough	2423	2200	2388	1988	2350	2410	2286	2868	2606	3184	2757	3610	2982	3414	1827	1910	1713
Convulsion	684	491	530	493	569	653	606	828	702	1027	807	841	742	1031	52	87	18
Cramp			1														1
Cut of the Stone		2	1	3		1	1	2	4	1	3	5	6	4			
Dropsie and Tympany	185	434	421	508	444	556	617	704	660	706	631	931	646	872	235	252	279
Drowned	47	40	30	27	49	50	53	30	43	49	63	60	57	48	43	33	29
Excessive drinking			2														
Executed	8	17	29	43	24	12	19	21	19	22	20	18	7	18	19	13	12
Fainted in a Bath					1												
Falling-Sickness	3	2	2	3		3	4	1	4	3	1		4	5	3	10	7
Flox and small Pox	139	400	1190	184	525	1279	139	812	1294	823	835	409	1523	354	72	40	58
Found dead in the Streets	6	6	9	8	7	9	14	4	3	4	9	11	2	6	18	33	20
French-Pox	18	29	15	18	21	20	20	20	29	23	25	53	51	31	17	12	12
Frighted	4	4	1		3		2		1	1				9	1		

World Health

Flawed Information Model

- Carolus Linnaeus
  Carl von Linné
  - *Genera Morborum* (1763)
- Underscored Content Difficulty
  - Pathophysiology vs Manifestation
    e.g. Rabies as psychiatric disease



- Lacked the Germ Theory of Disease
  - Was not incorporated into an information model

The Genomic Era

- The genomic transformation of medicine far exceeds the introduction of antibiotics and aseptic surgery
- The binding of genomic biology and clinical medicine will accelerate
- The implications for shared semantics across the basic science and clinical communities are unprecedented

VIEWPOINT

JAMA
April 10, 2013, Vol 309, No. 14

Genomic Medicine, Health Information Technology, and Patient Care

Christopher G. Chute, MD, DrPH
Isaac S. Kohane, MD, PhD

CELEBRATING THE TENTH ANNIVERSARY OF COMPLETING the draft human genome sequence in 2011, authors from the National Human Genome Research Institute of the US National Institutes of Health outlined the influence of genomic understanding across 5 domains: structure, the biology of the genome, the biology of disease, medicine, and improvements in health care.[1] The authors assert that this is the era of enhanced genomic understanding of medicine, which is expected to usher in improvements in health care effectiveness by the end of this decade. It is thus fitting to explore how health information technology will contribute to or hamper the promise of genomic medicine.

pital and medical practice in the country. Given the accelerating pace of genomic discovery, this is neither efficient nor scalable. Any expectation that a clinician can or should “know” the vast permutation of emerging genomic influences on disease risk, treatment, or prognosis, as well as the interactions of these influences with drugs or other diseases or, most confusingly, their co-occurrence with other genomic or environmental factors, is unrealistic.

The state of the art for academic medical centers in 2013 is determining a small number of relatively high-profile genomic variants from some or all of their patients at risk for specific drug treatments and integrating these findings into the electronic health records (EHRs) of those patients. Then, if a drug such as warfarin, clopidogrel, mercaptopurine, or codeine is ordered and a clinically significant drug-gene interaction is known, an alert to the physician or pharmacist is made, and in some settings an alternative recommended

Naming System
Universally Needed

"The distinction of the genera of diseases, the distinction of the species of each, and often even that of the varieties, I hold to be a necessary foundation of every plan of physic, whether dogmatical or empirical."

- William Cullen, Edinburgh, 1785

  Synopsis Nosologie Methodicae

Weights and Measures William Farr

“The nomenclature is of as much importance in this department of inquiry, as weights and measures in the physical sciences, and should be settled without delay.”

- First Annual Report of the Registrar-General of Births, Deaths, and Marriages in England. London: 1839 p. 99.

What was it that James Read (and others) was trying to do?

- Use computers in General Practice?
- Create a coding system?
- Manage clinical documentation?

- Support secondary use – analytics
- Discover what helps and what hurts – effectiveness
- Computer aided management – decision support

Then What Makes for A Good Coding System?

- Cimino desiderata – ~~NEC~~ ~~NOS~~
- Terminology vs. Classification
- Whither Ontology?

- What kind of coding system are we talking about?
  - Atomic reference terminology?
  - Problem list coding scheme?
  - Human entry terms?
  - NLP mapping space?
  - Foundation for analytics and secondary use?
  - Clinical decision support triggers, authoring?
  - Reimbursement?

Monolith vs Federation

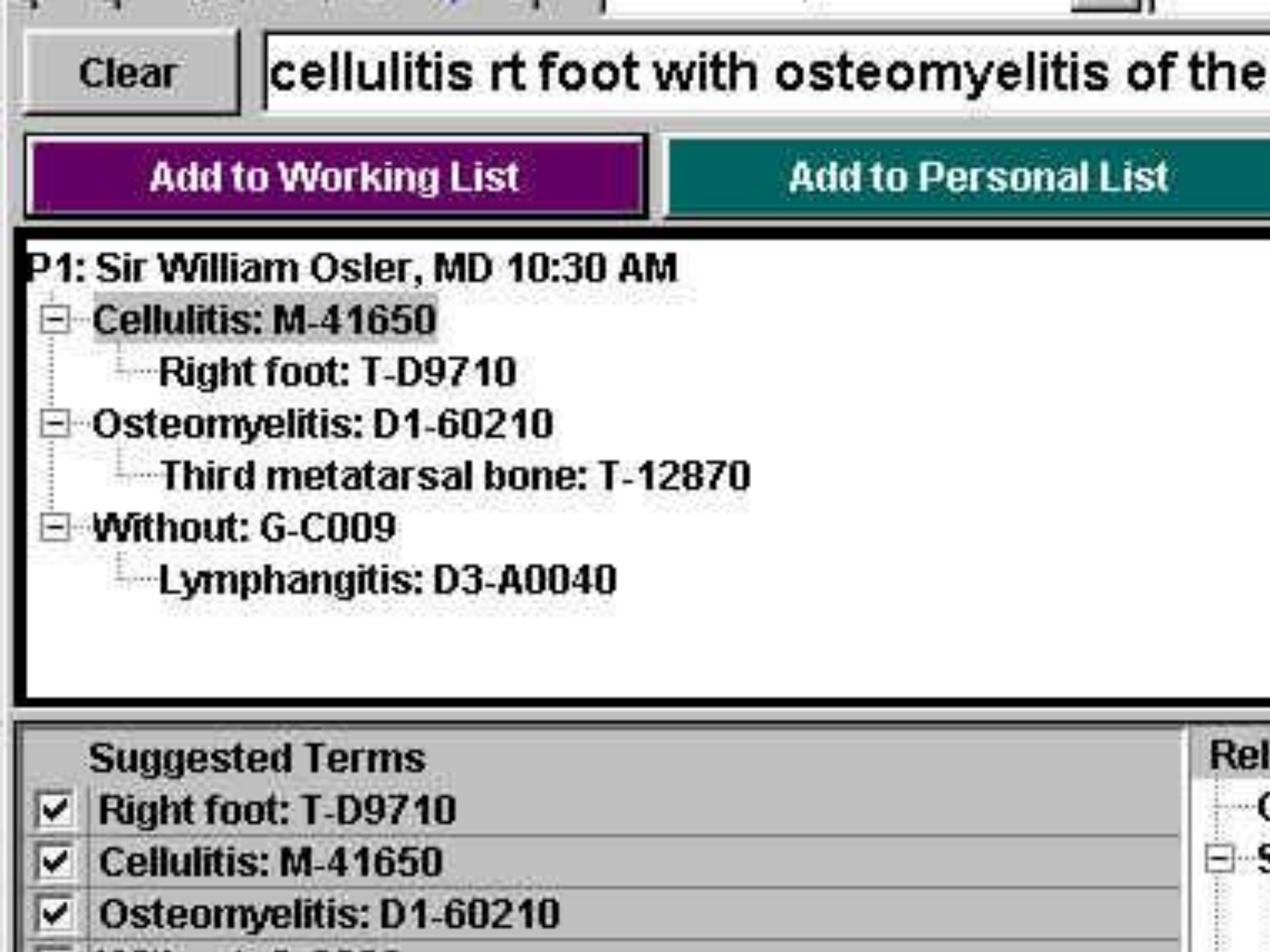
- Domains in Healthcare proliferate
  - Diseases to biological pathways to genes
- Should all concepts be represented in a single terminological framework?
- Is the alternative of a suite of coordinated, interlocking, non-overlapping, nomenclatures preferable
- How should terminologies relate to classifications?

Whither SNOMED?

- Terminology vs. Classification issue is gracefully evolving!
- Reference terminology vs. Entry terms must be reconciled
  - Target for NLP processing
  - Ultimately target for speech recognition parsing
- Integration of genomic disease characteristics
- Should domain-specific terminologies derive?
  - Moral equivalent of Linearizations for SNOMED?
  - Are such derivatives entry terminologies?

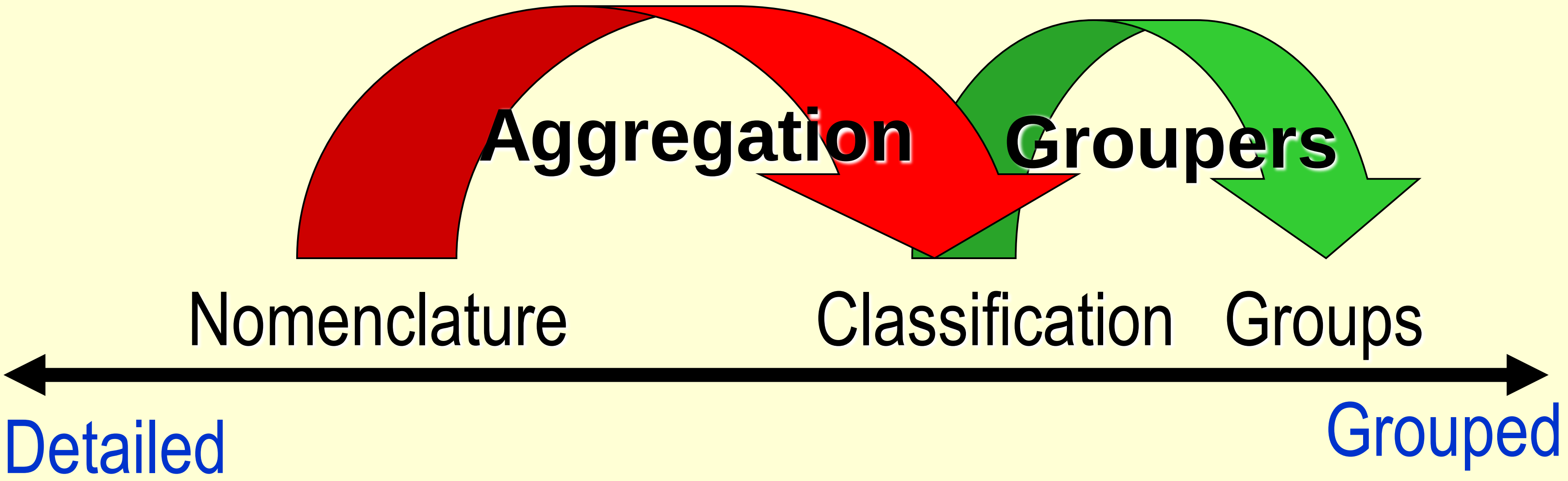
Celebrate Collaboration Achievements

- WHO – ICD “The Common Ontology”
- GMDNA – Device nomenclature
- LOINC – Peace and happiness finally
- Drugs –coordination clearly emerging

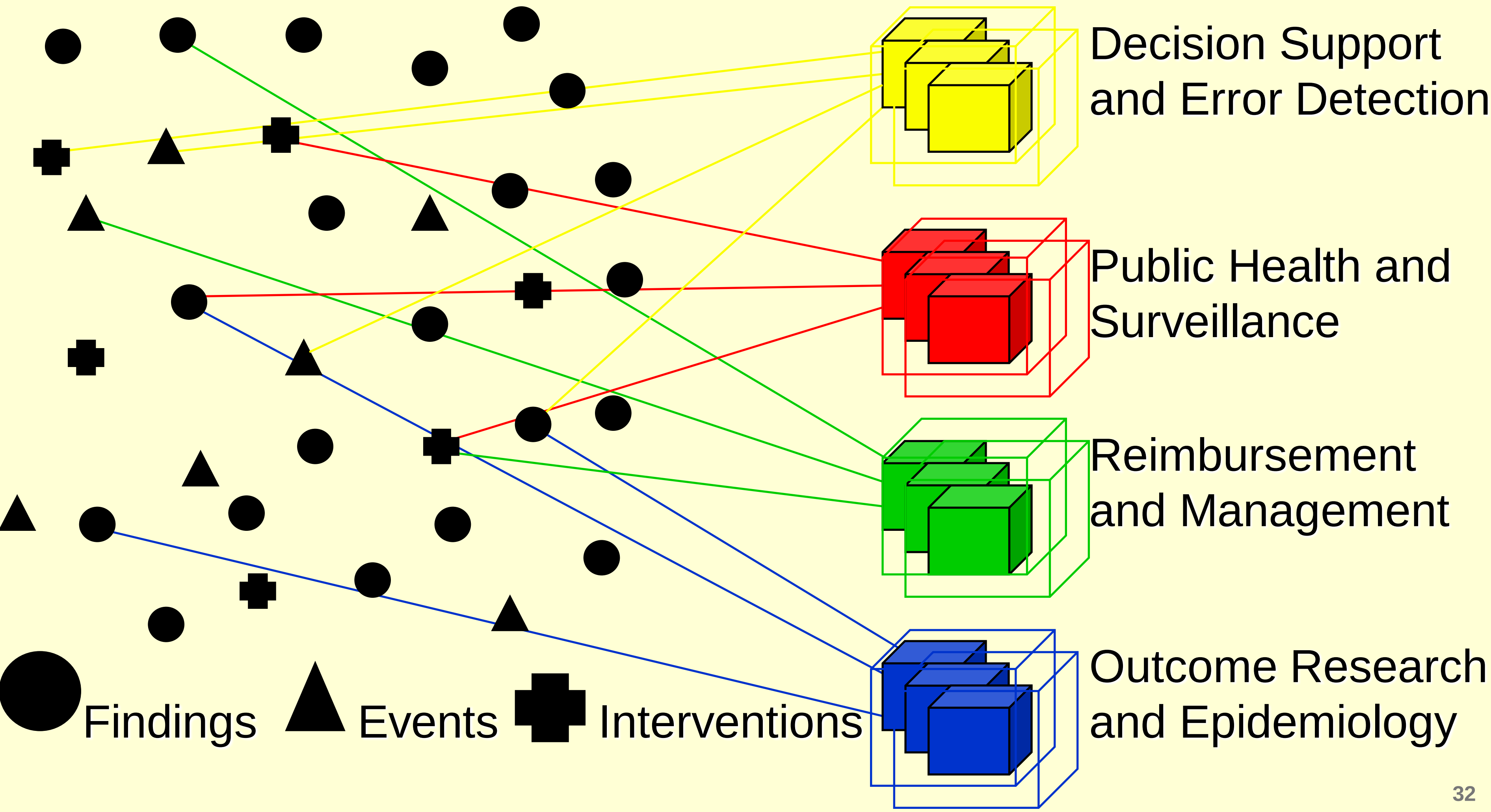

Clear
cellulitis rt foot with osteomyelitis of the
Add to Working List
Add to Personal List
P1: Sir William Osler, MD 10:30 AM
Cellulitis: M-41650
Right foot: T-D9710
Osteomyelitis: D1-60210
Third metatarsal bone: T-12870
Without: G-C009
Lymphangitis: D3-A0040
Suggested Terms
Right foot: T-D9710
Cellulitis: M-41650
Osteomyelitis: D1-60210

Familiar Points Along Continuum Modern Health Vocabularies

- Nomenclature – Highly Detailed Descriptions (SNOMED)
- Classification – Organized Aggregation of Descriptions into a Rubric (ICDs)
- Groupings – High Level Categories of Rubrics (DRGs)



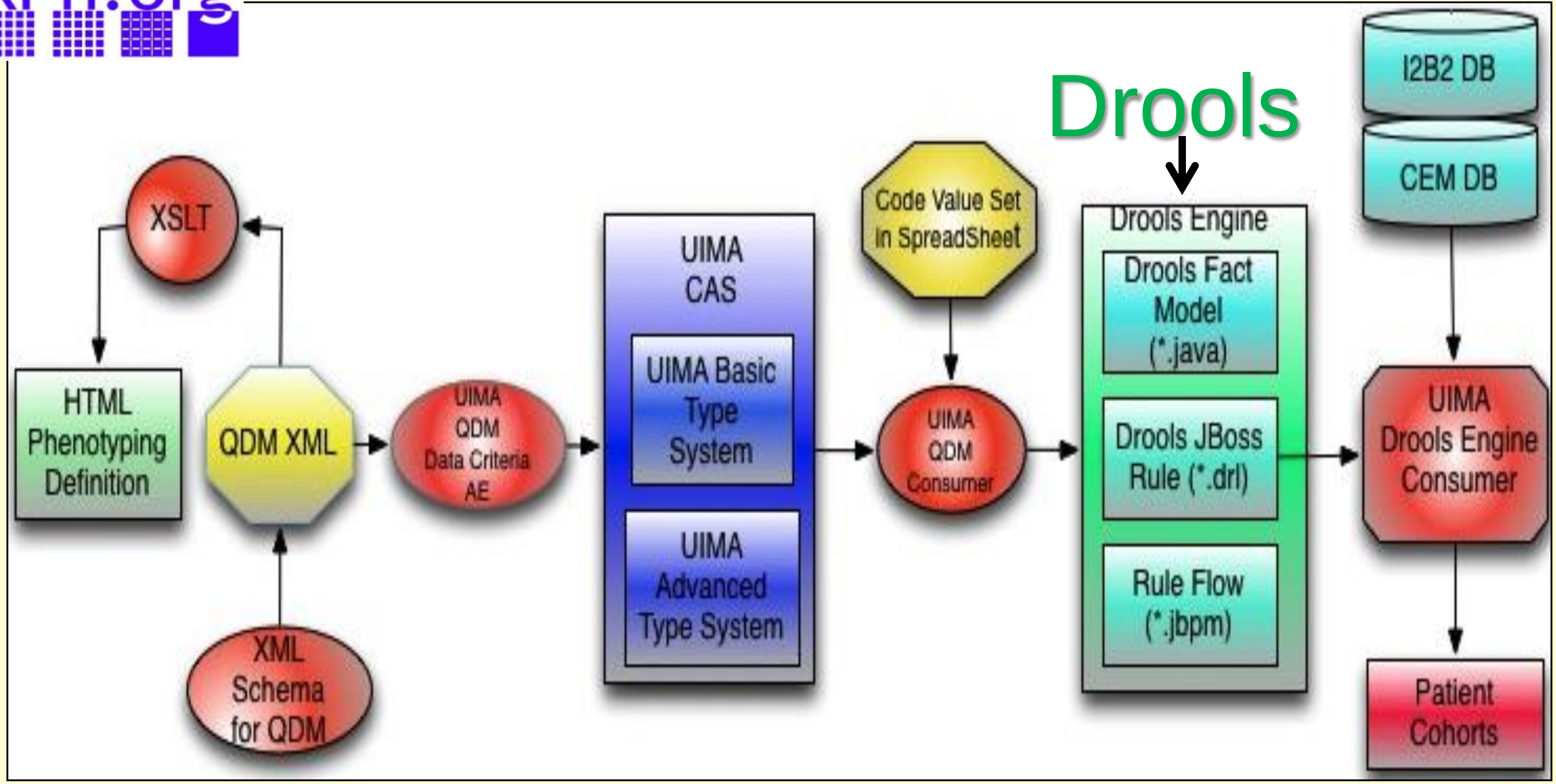
Aggregation Logics by domain rule-based aggregations



Modeling and Executing Electronic Health Records Driven Phenotyping Algorithms using the NQF Quality Data Model and JBoss® Drools Engine

Dingcheng Li, PhD[1], Gopu Shrestha, MS[1], Sahana Murthy, MS[1] Davide Sottara, PhD[2] Stanley M. Huff, MD[3] Christopher G. Chute, MD, DrPH[1] Jyotishman Pathak, PhD[1]
[1]Mayo Clinic, Rochester, MN [2]University of Bologna, Italy [3]Intermountain Healthcare, Salt Lake City, UT

SHARPn.org



[Li et al., AMIA 2012; (Epub ahead of print)]

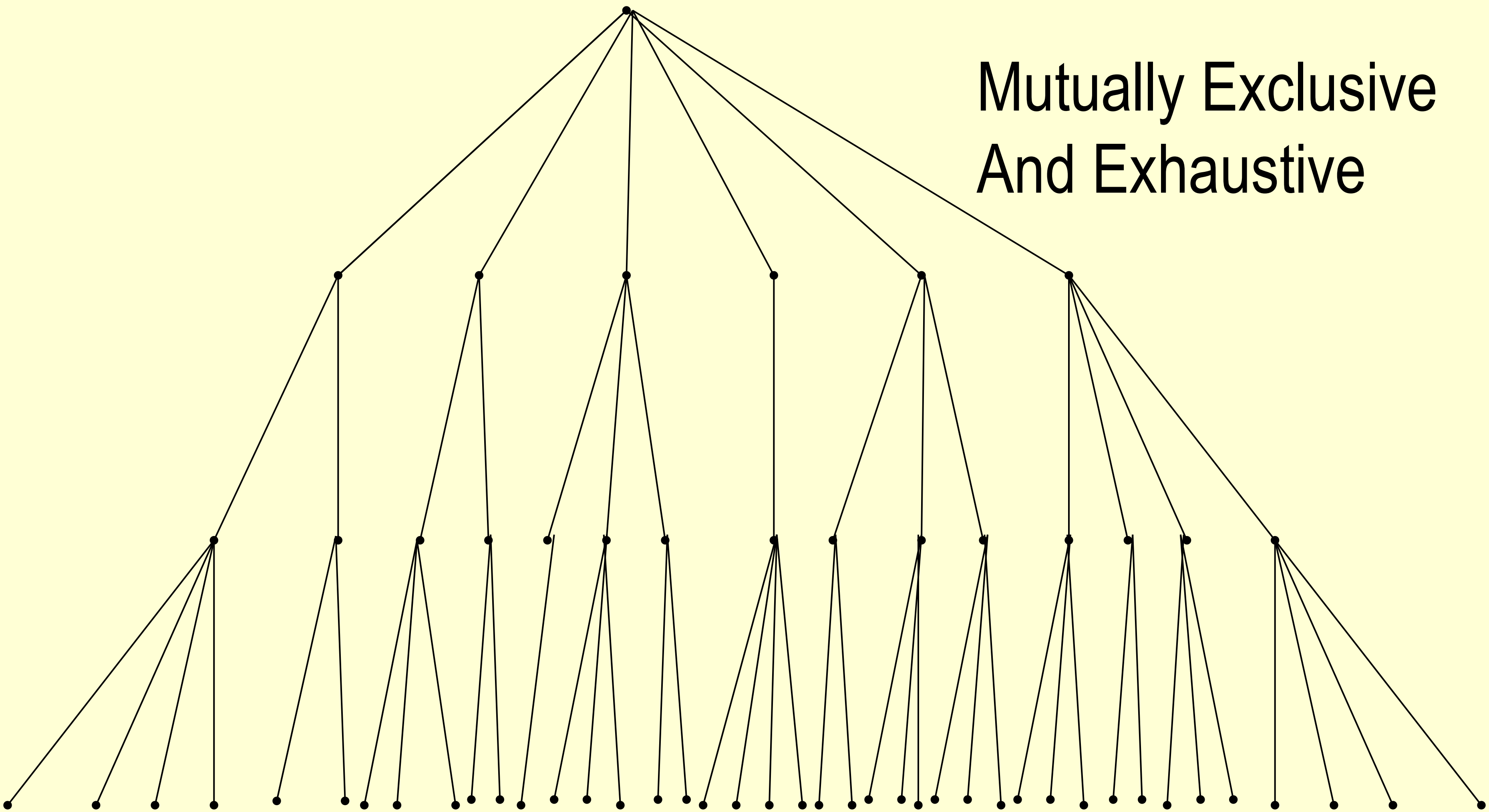
Initial Premises for ICD-11 development 2007

- Rubrics defined by Aggregation Logics from terminologies [Clinical Criteria phenotypes]
- Human language definitions will be explicit ✓
- “core” representation will be in description logic based ontology [Common Ontology, queries]
- A linear serialization will be derived as a view to maintain longitudinal consistency
  - May require corresponding “rules” for practical use
  - [sanctioning rules, also post-coordination]

ICD11 Use Cases

- Scientific consensus of clinical phenotype
- Public Health Surveillance
  - Mortality
  - Public Health Morbidity
- Clinical data aggregation
  - Metrics of clinical activity
  - Quality management
    - Patient Safety
  - Financial administration
    - Case mix
    - Resource allocation

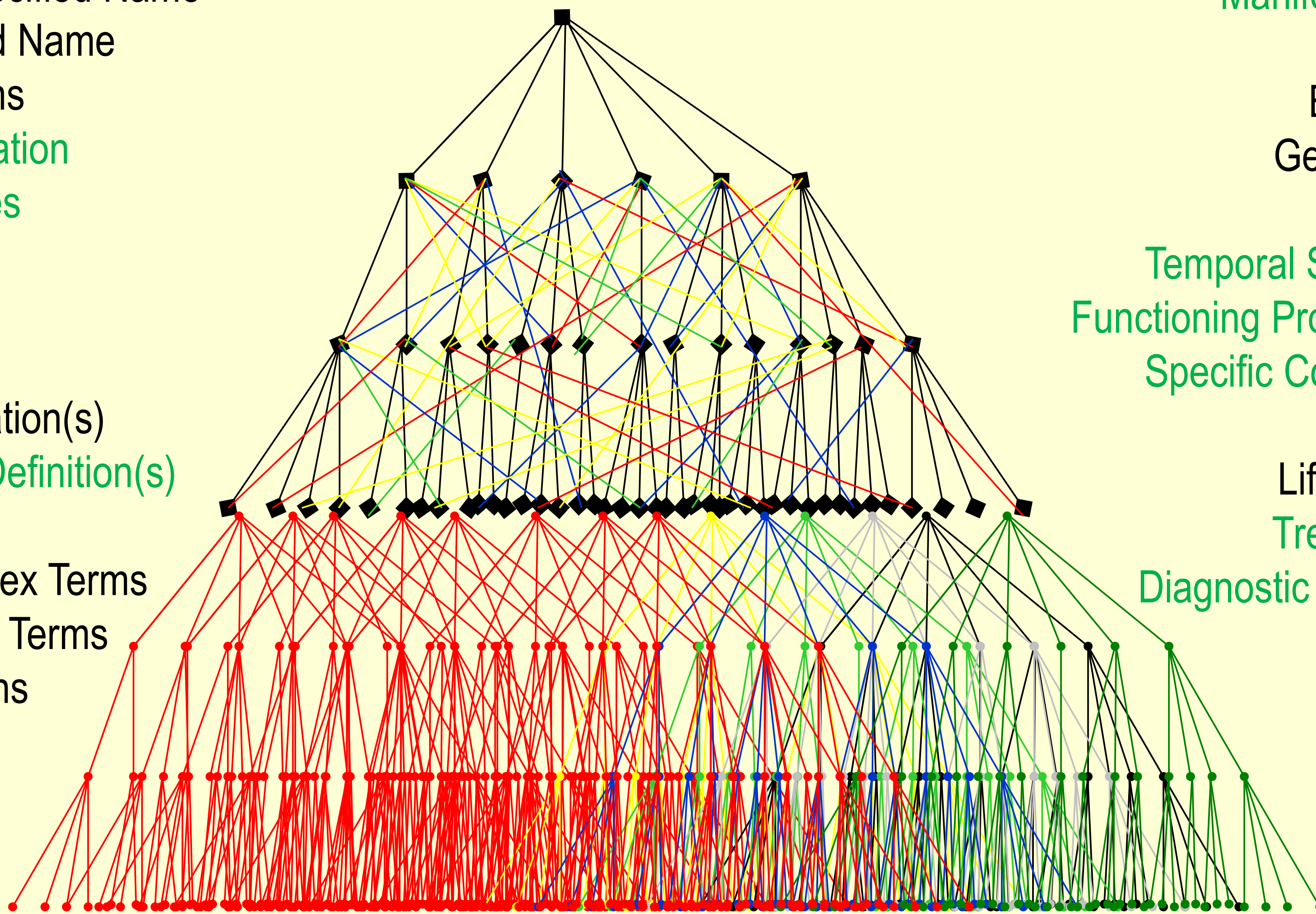
Traditional Hierarchical System
ICD-10 and family



Mutually Exclusive
And Exhaustive

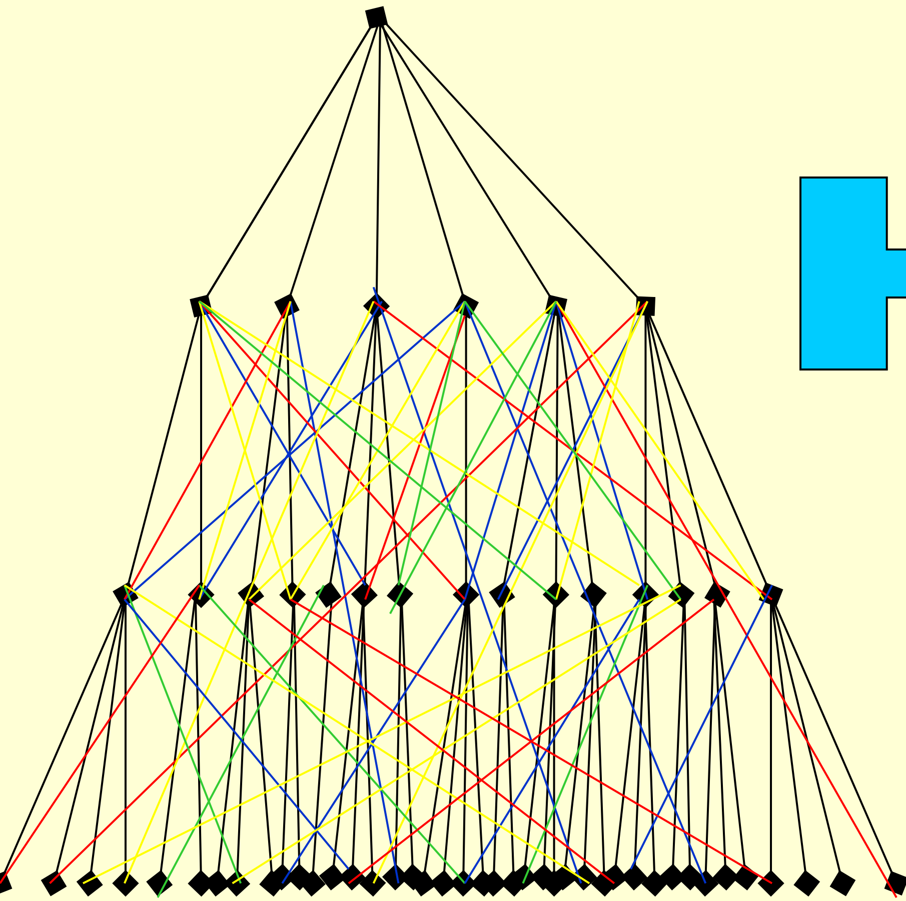
The ICD11 Foundation Layer a Semantic Network

ICD Concept Title
Fully Specified Name
Preferred Name
Synonyms
Classification
Properties
Parents
Type
Use and
Linearization(s)
Textual Definition(s)
Terms
Base Index Terms
Inclusion Terms
Exclusions



Body System/Structure
Manifestation
Causal
Etiology
Genomics
Agents
Temporal Severity
Functioning Properties
Specific Condition
Gender
Life Cycle
Treatment
Diagnostic Criteria

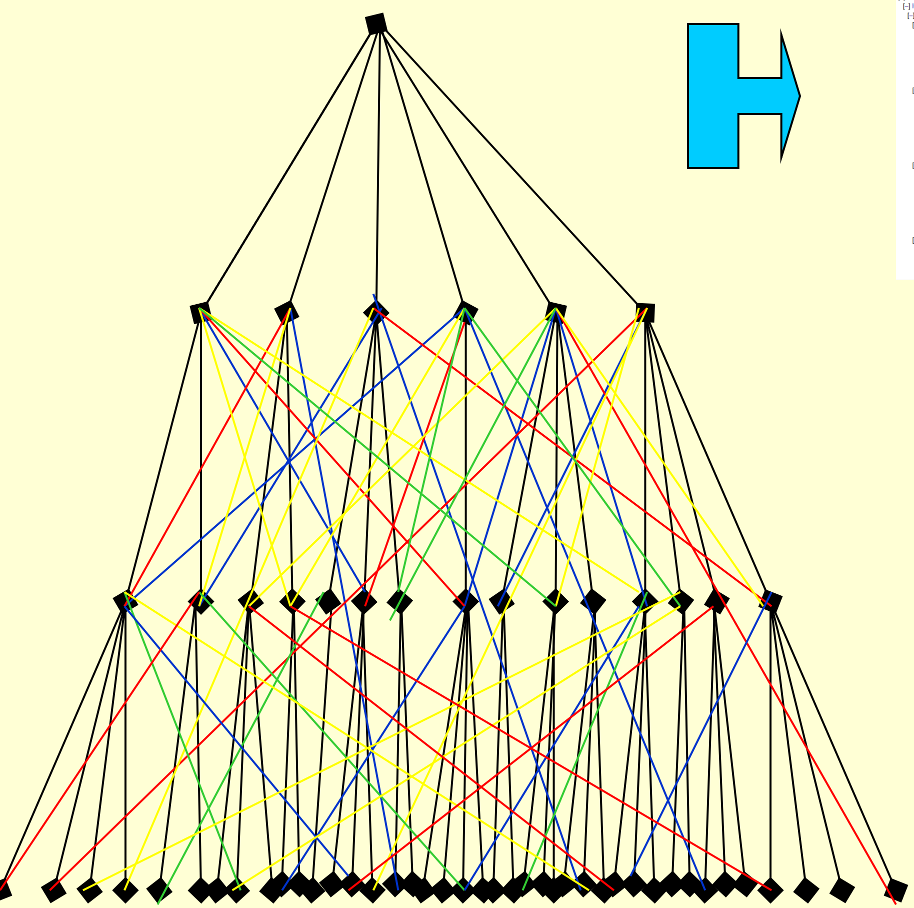
Algorithmic Serialization of the Foundation Component into a *Linearization*



Mutually Exclusive
And Exhaustive

- [–] ICD10WHO
  - [–] ICD10 Certain conditions originating in the perinatal period (CHAPTER XVI)(P00-P96)
    - [–] ICD10 Birth trauma(P10-P15)
      - [–] ICD10 Birth injury to peripheral nervous system(P14)
        - [+] ICD10 Birth injuries to other parts of peripheral nervous system(P14.8)
        - [+] ICD10 Birth injury to peripheral nervous system unspecified(P14.9)
        - [+] ICD10 Erb's paralysis due to birth injury(P14.0)
        - [+] ICD10 Klumpke's paralysis due to birth injury(P14.1)
        - [+] ICD10 Other brachial plexus birth injuries(P14.3)
        - [+] ICD10 Phrenic nerve paralysis due to birth injury(P14.2)
      - [–] ICD10 Birth injury to scalp(P12)
        - [+] ICD10 Birth injury to scalp unspecified(P12.9)
        - [+] ICD10 Bruising of scalp due to birth injury(P12.3)
        - [+] ICD10 Cephalhaematoma due to birth injury(P12.0)
        - [+] ICD10 Chignon due to birth injury(P12.1)
        - [+] ICD10 Epicranial subaponeurotic haemorrhage due to birth injury(P12.2)
        - [+] ICD10 Monitoring injury of scalp of newborn(P12.4)
        - [+] ICD10 Other birth injuries to scalp(P12.8)
      - [–] ICD10 Birth injury to skeleton(P13)
        - [+] ICD10 Birth injuries to other parts of skeleton(P13.8)
        - [+] ICD10 Birth injury to femur(P13.2)
        - [+] ICD10 Birth injury to other long bones(P13.3)
        - [+] ICD10 Birth injury to skeleton unspecified(P13.9)
        - [+] ICD10 Fracture of clavicle due to birth injury(P13.4)
        - [+] ICD10 Fracture of skull due to birth injury(P13.0)
        - [+] ICD10 Other birth injuries to skull(P13.1)
      - [–] ICD10 Intracranial laceration and haemorrhage due to birth injury(P10)
        - [+] ICD10 Cerebral haemorrhage due to birth injury(P10.1)
        - [+] ICD10 Intraventricular haemorrhage due to birth injury(P10.2)
        - [+] ICD10 Other intracranial lacerations and haemorrhages due to birth injury(P10.8)
        - [+] ICD10 Subarachnoid haemorrhage due to birth injury(P10.3)

Linearizations for multiple use-cases
Morbidity, Mortality, Quality, …

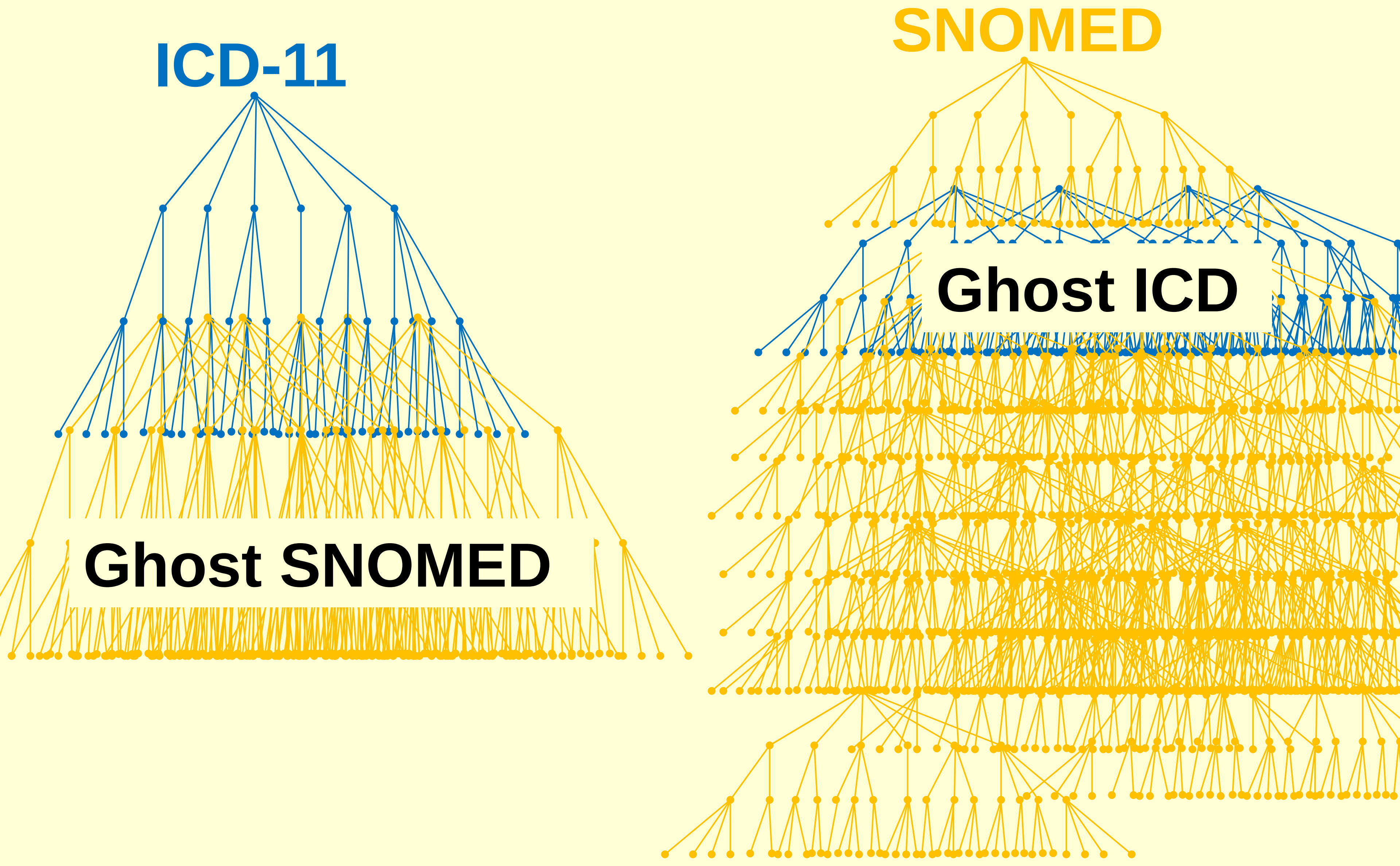


[–] ICD10WHO
[–] ICD10 Certain conditions originating in the perinatal period (CHAPTER XVI)(P00-P96)
[–] ICD10 Birth trauma(P10-P15)
[–] ICD10 Birth injury to peripheral nervous system(P14)
[+] ICD10 Birth injuries to other parts of peripheral nervous system(P14.8)
[+] ICD10 Birth injury to peripheral nervous system unspecified(P14.9)
[+] ICD10 Erb's paralysis due to birth injury(P14.0)
[+] ICD10 Klumpke's paralysis due to birth injury(P14.1)
[+] ICD10 Other brachial plexus birth injuries(P14.3)
[+] ICD10 Phrenic nerve paralysis due to birth injury(P14.2)
[–] ICD10 Birth injury to scalp(P12)
[+] ICD10 Birth injury to scalp unspecified(P12.9)
[+] ICD10 Bruising of scalp due to birth injury(P12.3)
[+] ICD10 Cephalhaematoma due to birth injury(P12.0)
[+] ICD10 Chignon due to birth injury(P12.1)
[+] ICD10 Epicranial subaponeurotic haemorrhage due to birth injury(P12.2)
[+] ICD10 Monitoring injury of scalp of newborn(P12.4)
[+] ICD10 Other birth injuries to scalp(P12.8)
[–] ICD10 Birth injury to skeleton(P13)
[+] ICD10 Birth injuries to other parts of skeleton(P13.8)
[+] ICD10 Birth injury to femur(P13.2)
[+] ICD10 Birth injury to other long bones(P13.3)
[+] ICD10 Birth injury to skeleton unspecified(P13.9)
[+] ICD10 Fracture of clavicle due to birth injury(P13.4)
[+] ICD10 Fracture of skull due to birth injury(P13.0)
[+] ICD10 Other birth injuries to skull(P13.1)
[–] ICD10 Intracranial laceration and haemorrhage due to birth injury(P10)
[+] ICD10 Cerebral haemorrhage due to birth injury(P10.1)
[+] ICD10 Intraventricular haemorrhage due to birth injury(P10.2)
[+] ICD10 Other intracranial lacerations and haemorrhages due to birth injury(P10.8)
[+] ICD10 Subarachnoid haemorrhage due to birth injury(P10.3)

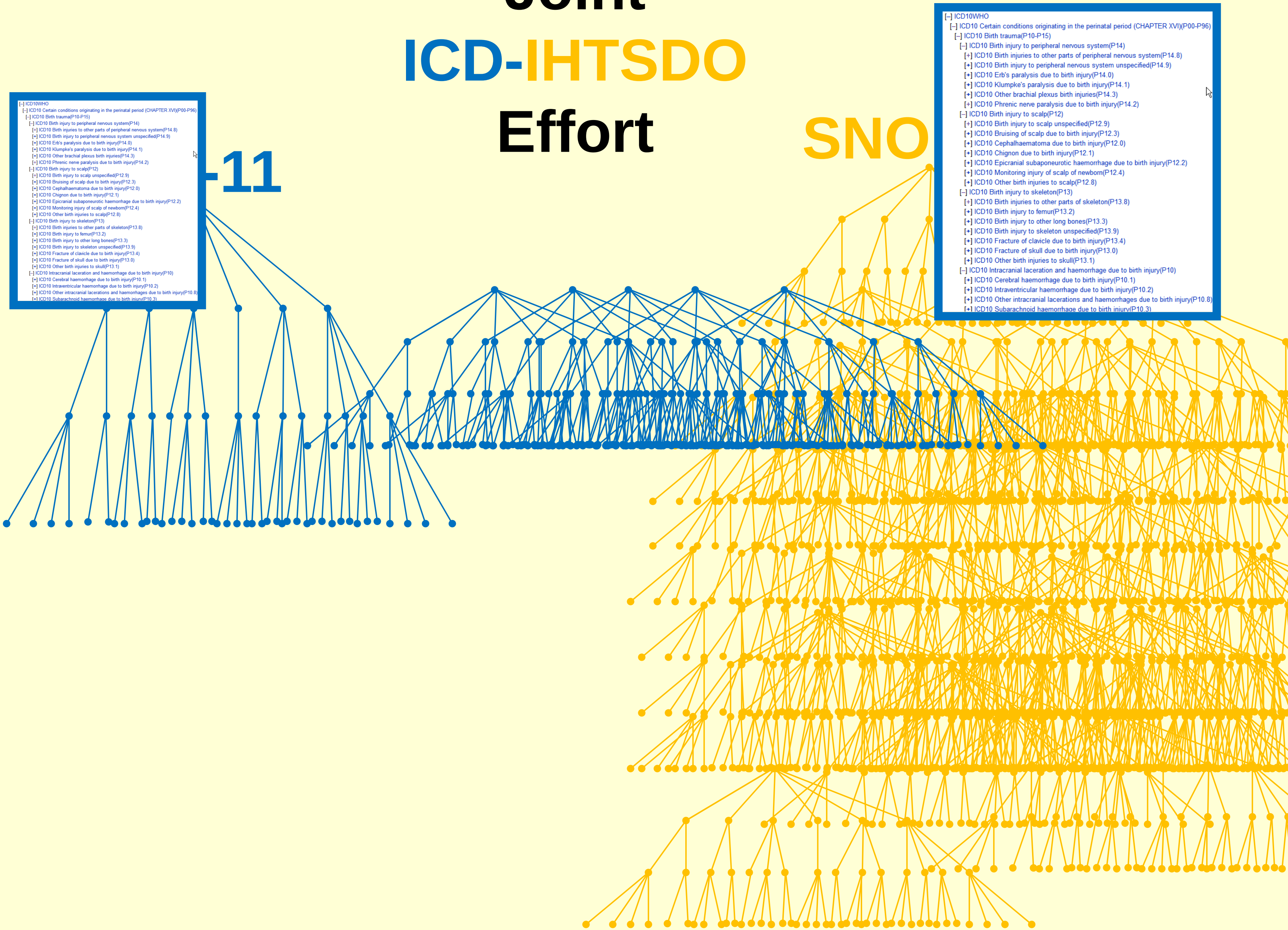
Relationship with IHTSDO SNOMED content

- IHT (SNOMED) will require high-level nodes that aggregate more granular data
  - Use-cases include mutually exclusive, exhaustive,…
  - Sounds a lot like ICD
- ICD-11 will require lower level terminology for value sets which populate content model
  - Detailed terminological underpinning
  - Sounds a lot like SNOMED
- Memorandum of Agreement – July 2010!
  - WHO right to use for authoring and interpretation

Potential Future States (2007)



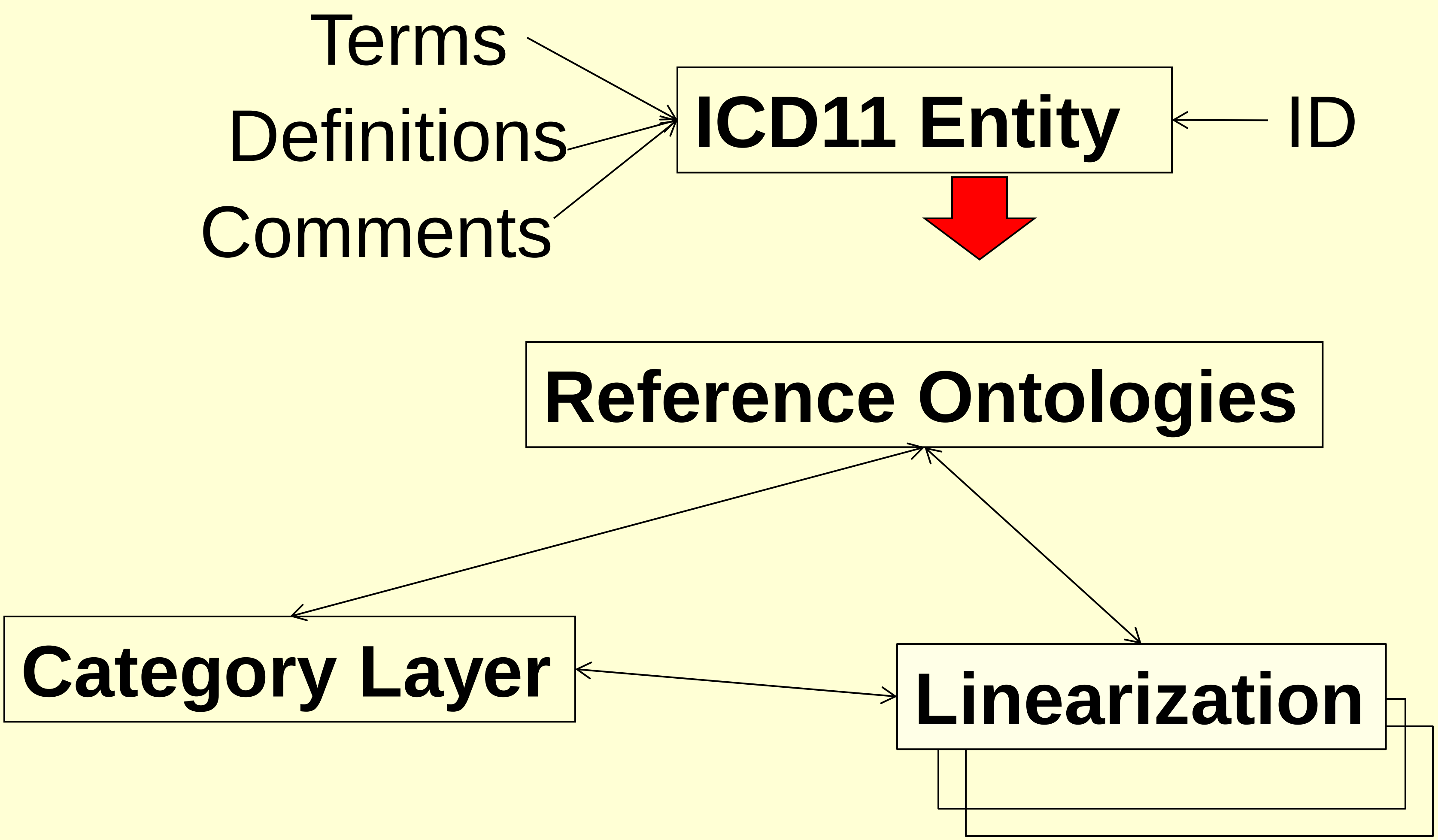
Joint ICD-IHTSDO Effort



ICD11/SNOMED "Shared Layer" vs Common Ontology

- Classification ↔ Terminology dissonance
  - Focus on higher levels of abstraction
- Thesaurus ↔ Description Logic dissonance
  - Pragmatic hierarchies – parent-child
  - Formal logic where all *is-a* are always true
- Common Ontology is:
  - Based on Description Logics and "queries"
  - Provides a shared scaffolding for
    - The Foundation Layer of ICD 11 and SNOMED
    - Ignores residual categories of linearizations

High Level Structure – Core Model



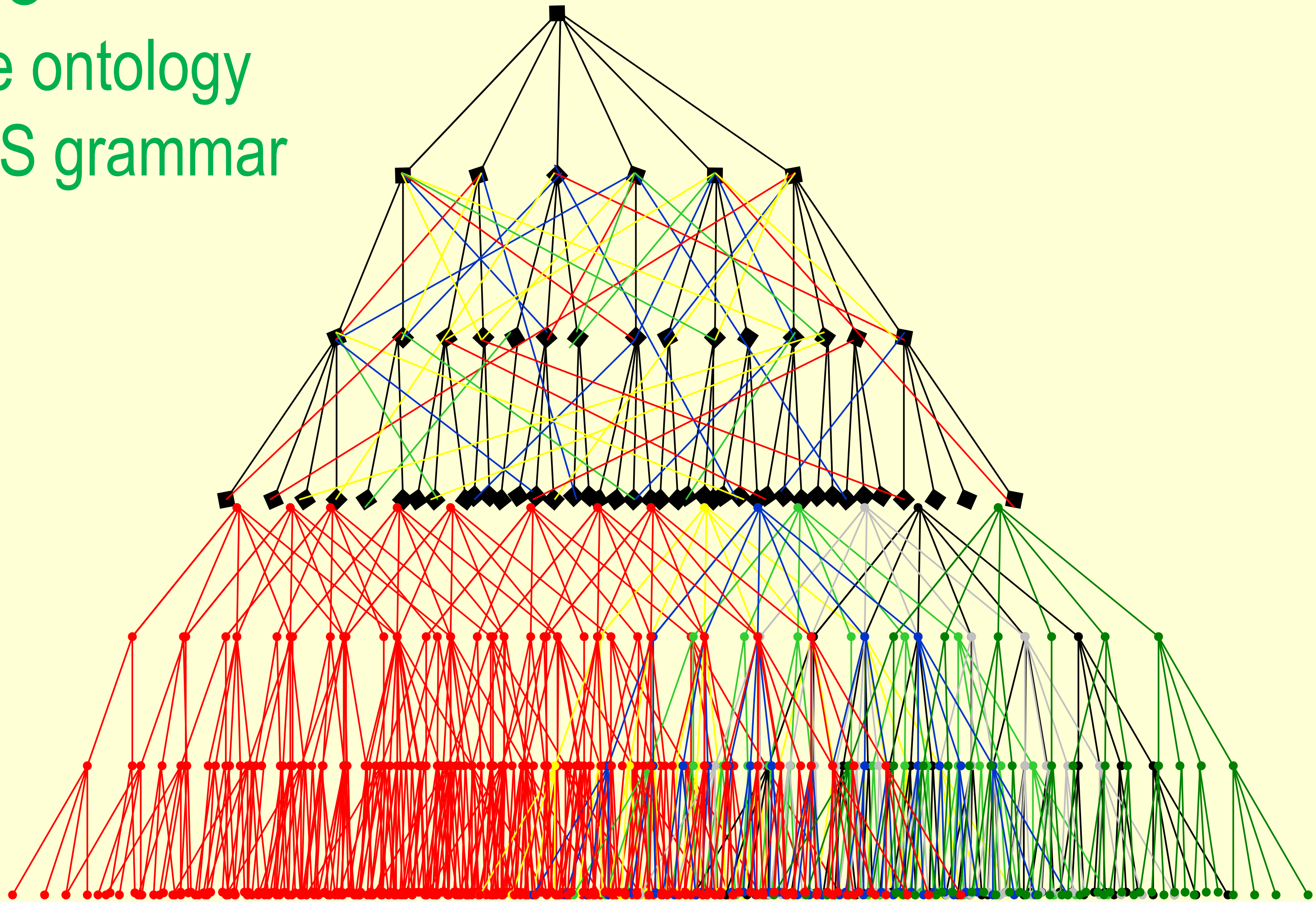
Permissive Partnerships for Ontologic Extensions

HUGO

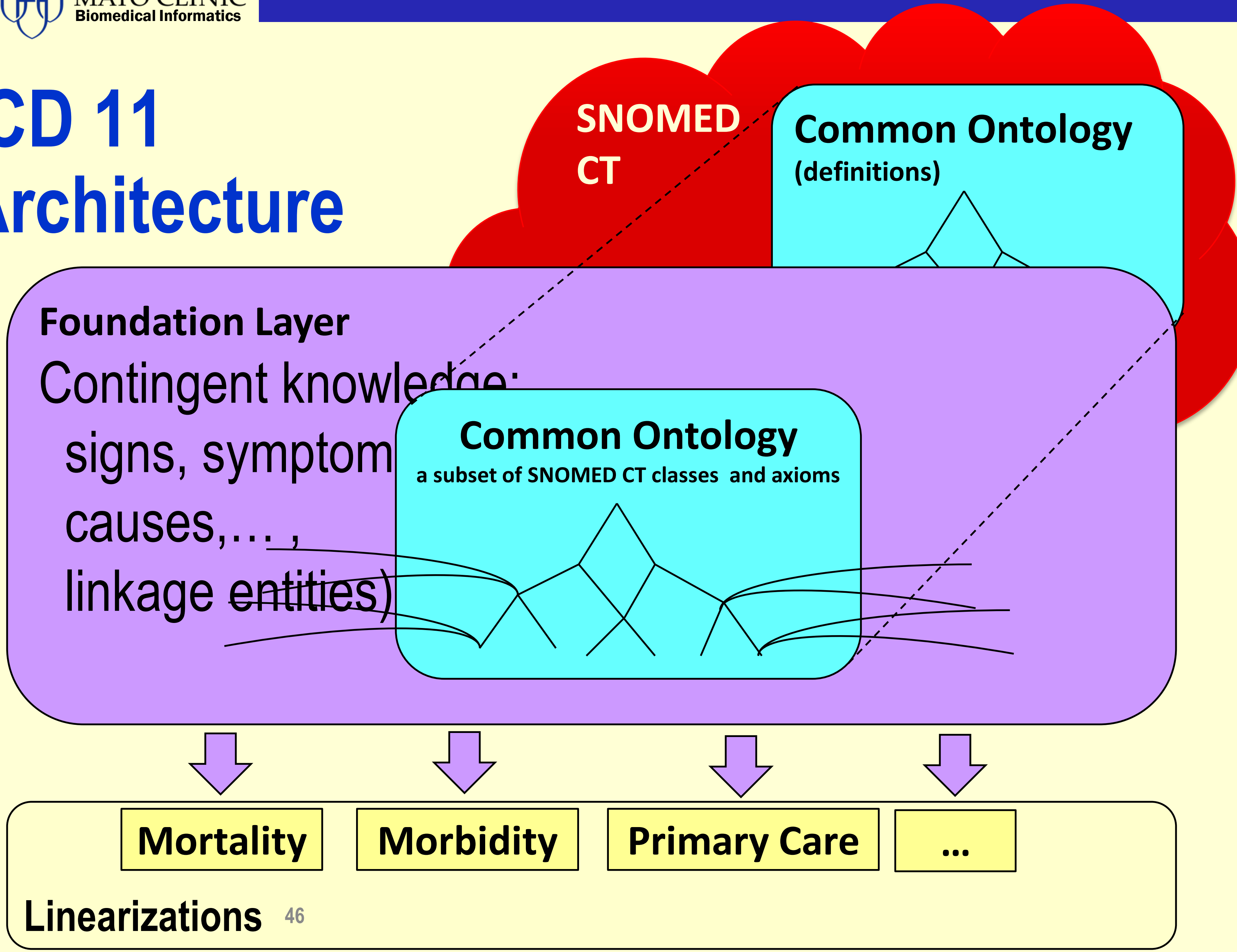
Gene ontology

HGVS grammar

….



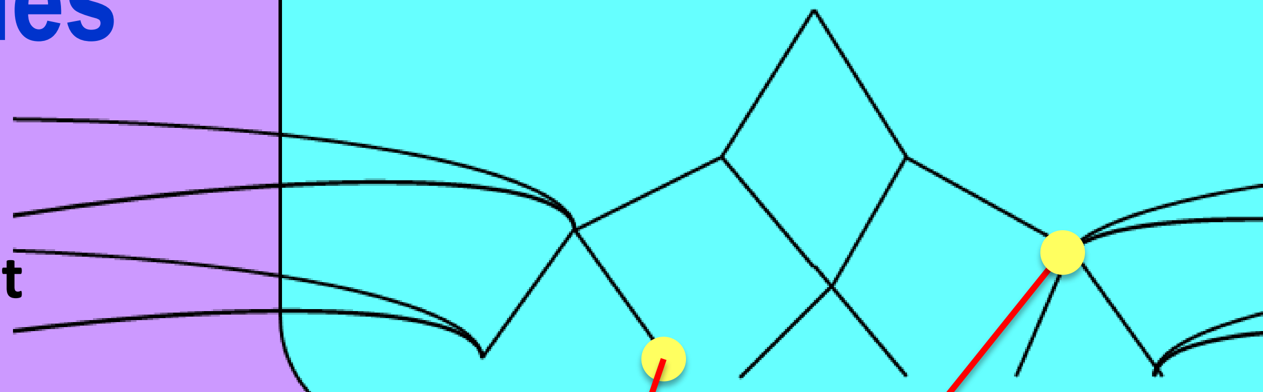
ICD 11 Architecture



ICD 11 Linkage Queries

Common Ontology
a subset of SNOMED CT

Links between Foundation Component and Linearizations



All linearization entities are represented as queries against Common Ontology

Morbidity Linearization

Residual Categories
NEC NOS

Morbidity
“Hypertension excluding Pregnancy”

SELECT ?CN WHERE
(?CN SubclassOf Hypertension)
MINUS
(?CN SubclassOf Disorders of Pregnancy)

Tough Love for SNOMED

- Clarify a "reference terminology"
  - Underpinning basis for all derivatives
  - Logical target for NLP, speech parsing
- Embrace genomic linkages (extramural?)
- Create "Linearizations" (not RefSets)
- Collaborate on Common Information Model (CIMI)
- Accommodate simple "value sets"
  - Simple enumerated lists, linked to reference
- Publish "usable" formats and REST services
  - Common Terminology Services – CTS2
  - Keep RFx for developers and researchers

Conclusion

- Terminology Is the Second Most Urgent Issue in Healthcare Information Today
- Problem Underlies Virtually All Machine-assisted Uses of Patient Data – 1° and 2°
- Convergence Toward Collaborating Systems is Critical and Occurring
- SNOMED's Future is Bright
  - Though strategic organization is required