# Modularisation & Normalisation of Ontologie

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with thanks to the protégé team

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# Why modularise an ontology?

- **Manageability**
  - **Independent development of modules**
- **Re-use**
  - **Most applications require only part of another ontology**
    - **How many applications need 65K anatomical entities**
- **Abstraction**
  - **Use only as much detail as is needed**
- **Evolution, Maintenance & tailoring**
  - **Controlled management of changes**
  - **Replace one variant with another**
    - **Hue-saturation-brightness vs Red-Blue-Green for colour**



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# Loosely coupled distributed ‘just in time’ ontology development

# Referencing, mapping & importing

- Mapping
  - Pointers via annotations only
- Referencing
  - Common identifiers only
    - OWL: URI as a unique reference
- Referencing with partial import
  - Upwards taxonomy?
- Importing
  - Inclusion of all information

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# Referencing

- **Common ID / Controlled vocabulary**
  - **Need the reference but not the structure**
    - **If everyone uses the same reference, we can know if we agree or disagree**
      - May not need to merge
      - Or may make later merging easier



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# Importing / Inclusion True modularisation:

- The rest of this talk
  - Important practicalities
  - Ontology structure and Normalisation

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# Important practicalities "Nonsemantic Identifiers"

- Lexical names make lousy identifiers
  - Spelling errors
  - Arguments over 'terms'
  - Changes in usage
  - Variation between sites
- Meaningless identifiers much safer
  - Almost impossible to edit a set of coherent modularised ontologies using names to link
    - Made particularly hard by the use of URIswww.



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# important practicalities

- Namespaces vs Base URIs/Modules
  - Namespaces are often used to indicate modules
    - … but do not depend on them
- Local copies vs web sources
  - Need local redirection and ‘repositories’
    - Still working on this in Protégé OWL
      - Let us know if it works well.
- Notion of a “package”
  - Still ill defined



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# Other work

- Swoop circle diagrams
- Oscar Corcho and KnowledgeWeb deliverables



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# Swoop - “Fly the mother ship”


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# Ontology Structure Assertion:

***The arrival of logic-based ontologies/OWL gives new opportunities to make ontologies more manageable and modular***

- **Let the ontology authors**
  - **create discrete modules**
  - **describe the links between modules**
- **Let the logic reasoner**
  - **Organise the result**



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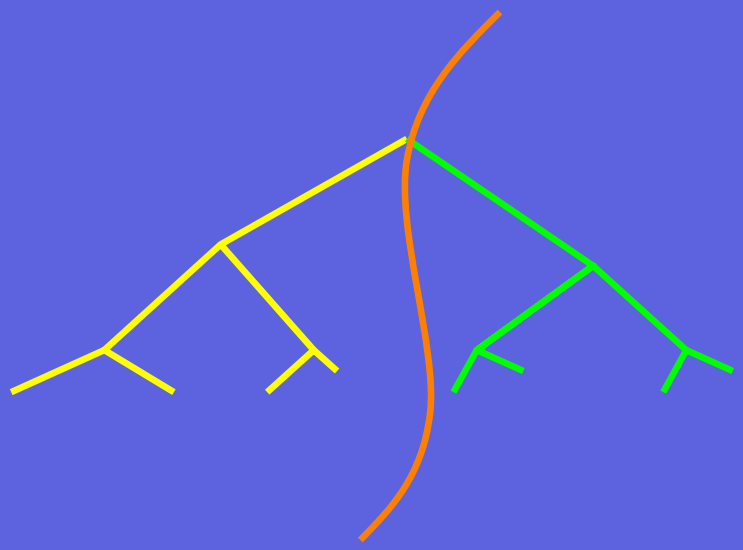
# Two dimensions for modularisation

- **Segmentation**
  - **Drugs, anatomy, diseases,**
  - **Micro and macro anatomy**
  - **…**





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# Some scenarios: Segmentation

- **Re-use of parts of a high level ontology**
  - **Self-standing vs modifiers**
    - **Continuants vs Occurrents**
      - Parts and whole - mereology
        - » Biology
          - * Core Anatomy
            - * Gross anatomy
              - * Organs
              - * Vessels
              - * Limbs
              - * Organs + vessels
              - * Limbs + vessels
              - ...
            - * Cellular



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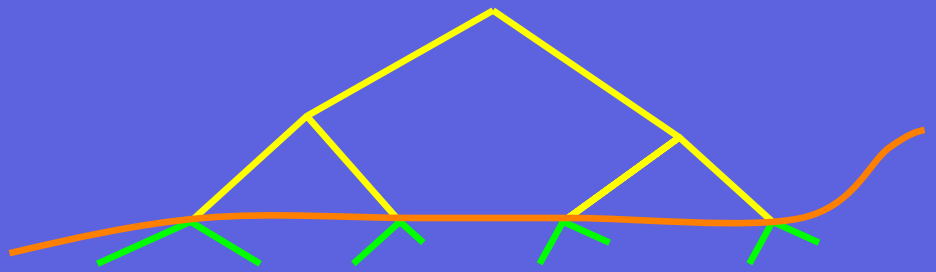
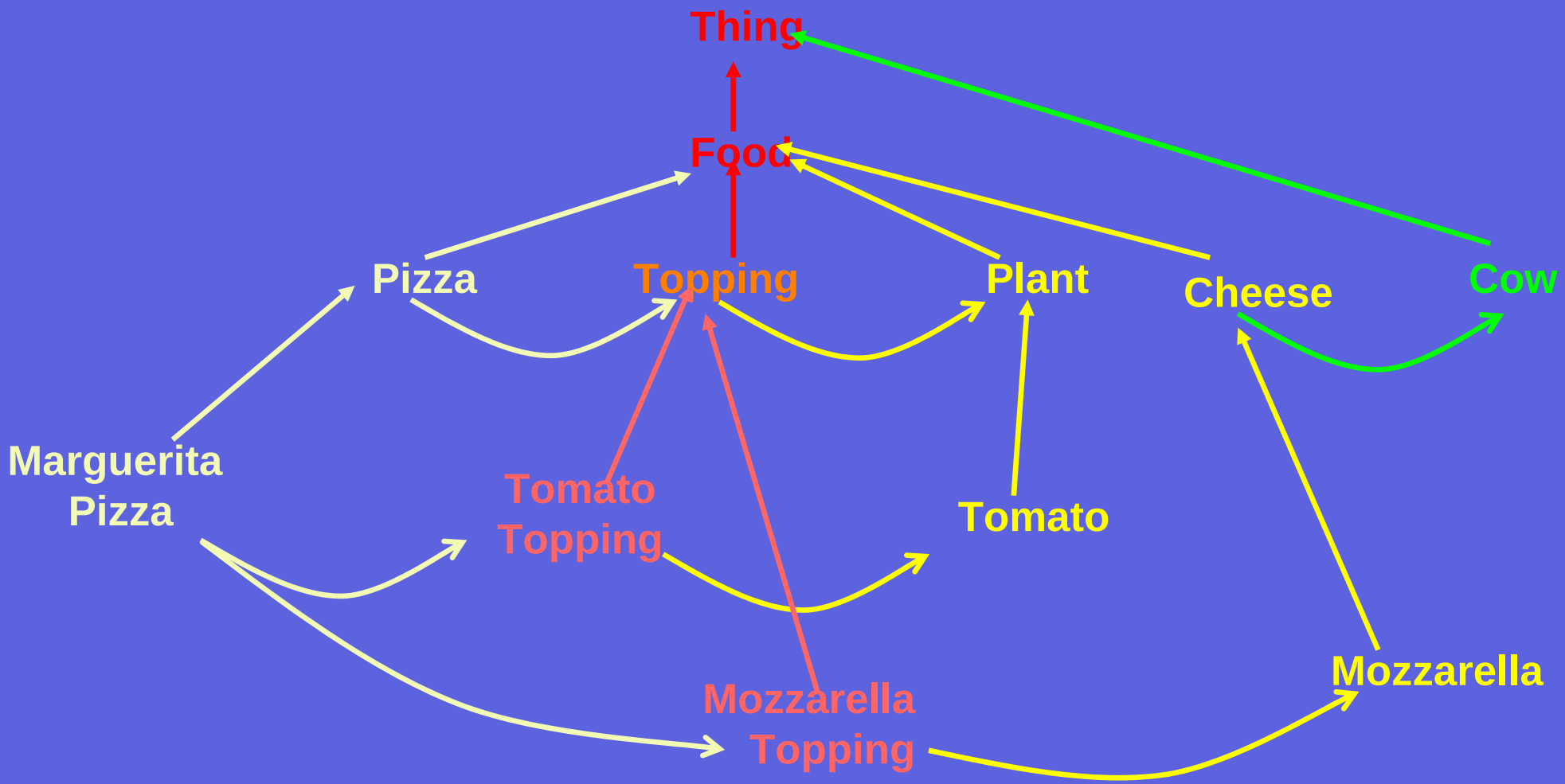
# Two dimensions for modularisation

- **Abstraction - specialisation**
  - **Vertebrate anatomy, mammalian anatomy, human anatomy**
    - **What is common?**
  - **hand**
    - **left, right hand**
  - **Vertebra**
    - **cervical (neck…)**
      - 2nd, 3rd, 4th..
    - **thoracic (chest)**
      - 8th, 9th, 10th…
  - **Specialisation of guideline for my hospital**



# Segmentation & locking



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# Primitive & defined classes

- **Primitive classes**
  - **Cheese, Mozarella, Pizza,**
    - **Cannot be split**
      - Must be in one module
- **Defined classes**
  - **Cheesy Pizza, Vegetarian Pizza**
    - **Span modules**
      - Glue modules together
      - "Come apart" when classes are split
        - » Often collapse logically
        - » Can't tell them apart without the ontology referenced
  - **But need to know which module**
    - **Therefore want them to have just one primitive parent**
- **Additional descriptions**
  - **References between classes**
    - **Cheese comes from Milk**
      - Milk is new extra information



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# Reasons normalise an ontology?

- **Modularisation, Evolution and Maintenance**
  - **The general modularisation problem for expressive ontologies is intractable**
    - **Need additional constraints**
    - **Ease of defining mutually exclusive segments**
  - **Ease maintenance behaviour**
    - **1 change in one place**
      - No “side effects” or “update anomalies”
- **Defeat combinatorial explosions**
  - **Reduce an exponential structure to two linear structures**
    - **“Just in time” ontologies**
- **A first step towards comprehensive meta models and ontology schemas**



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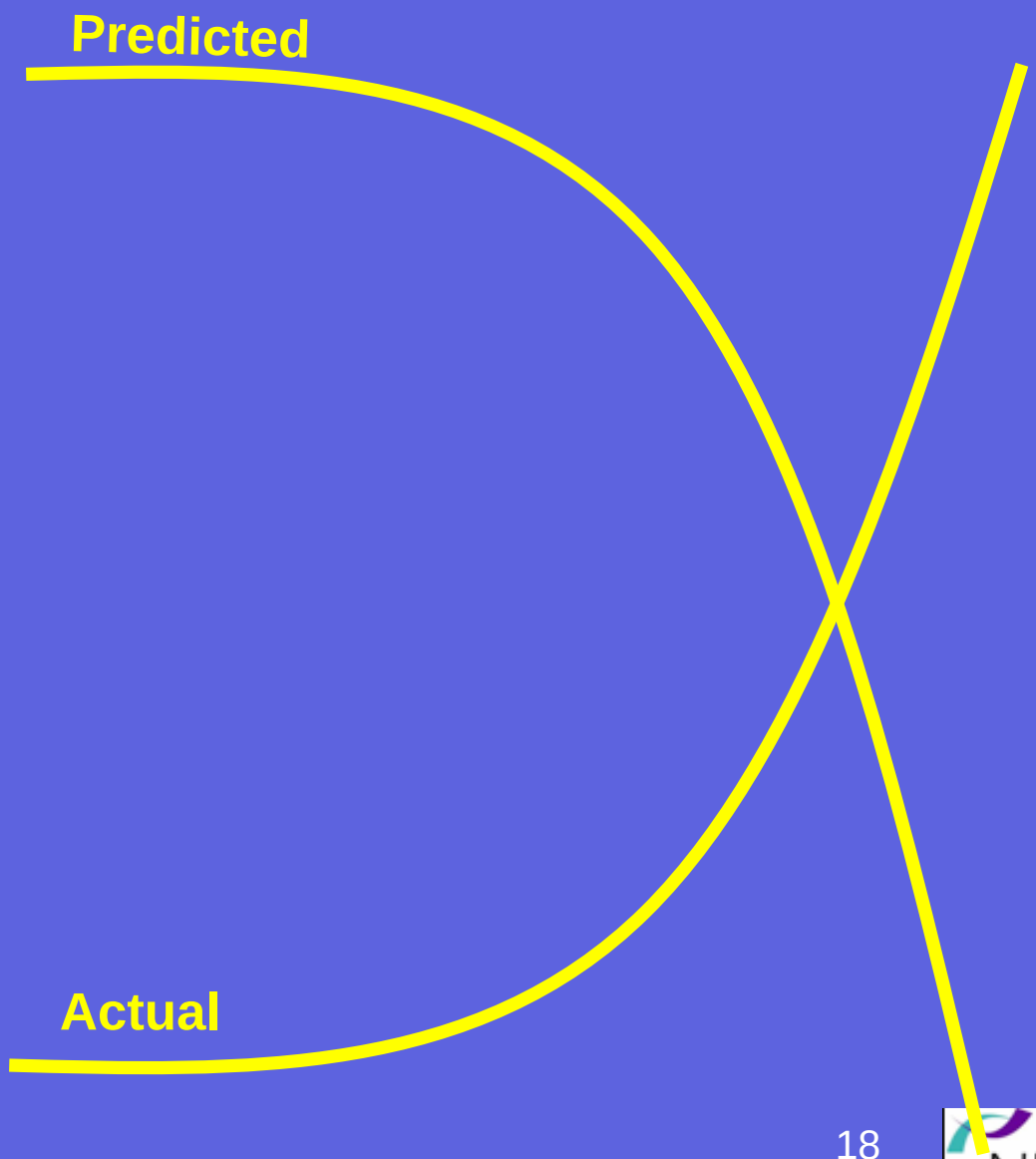
# The scaling problem: The combinatorial explosion

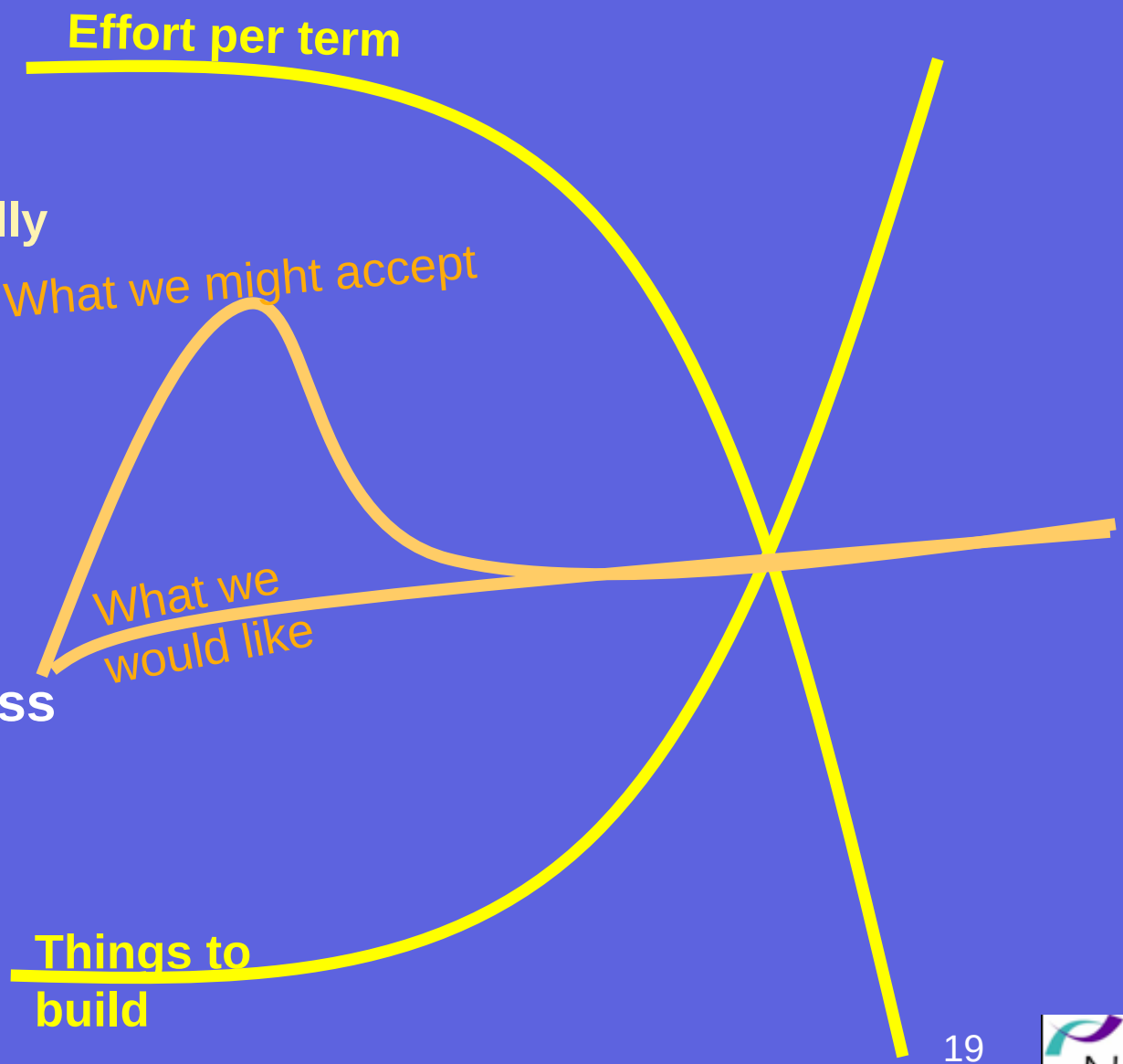
- **It keeps happening!**
  - **"Simple" brute force solutions do not scale up!**

- **Conditions x sites x modifiers x activity x context→**
  - ***Huge number of terms to author***
  - ***Software CHAOS***



# Combination of things to be done & time to do each thing

- Terms and forms needed
  - Increases exponentially
- Effort per term or form
  - Must decrease to compensate
- To give the effectiveness we want
  - Or might accept



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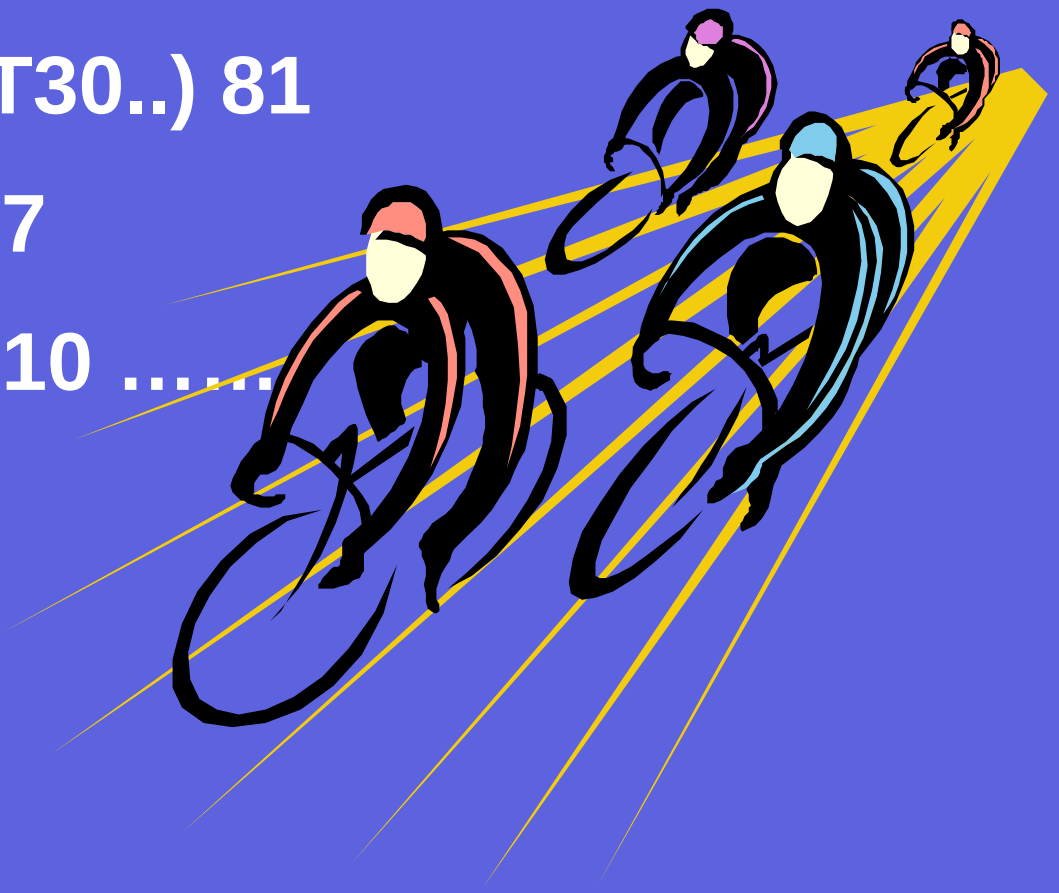
# The exploding bicycle

- 1972 ICD-9 (E826) 8
- READ-2 (T30..) 81
- READ-3 87
- 1999 ICD-10 ……





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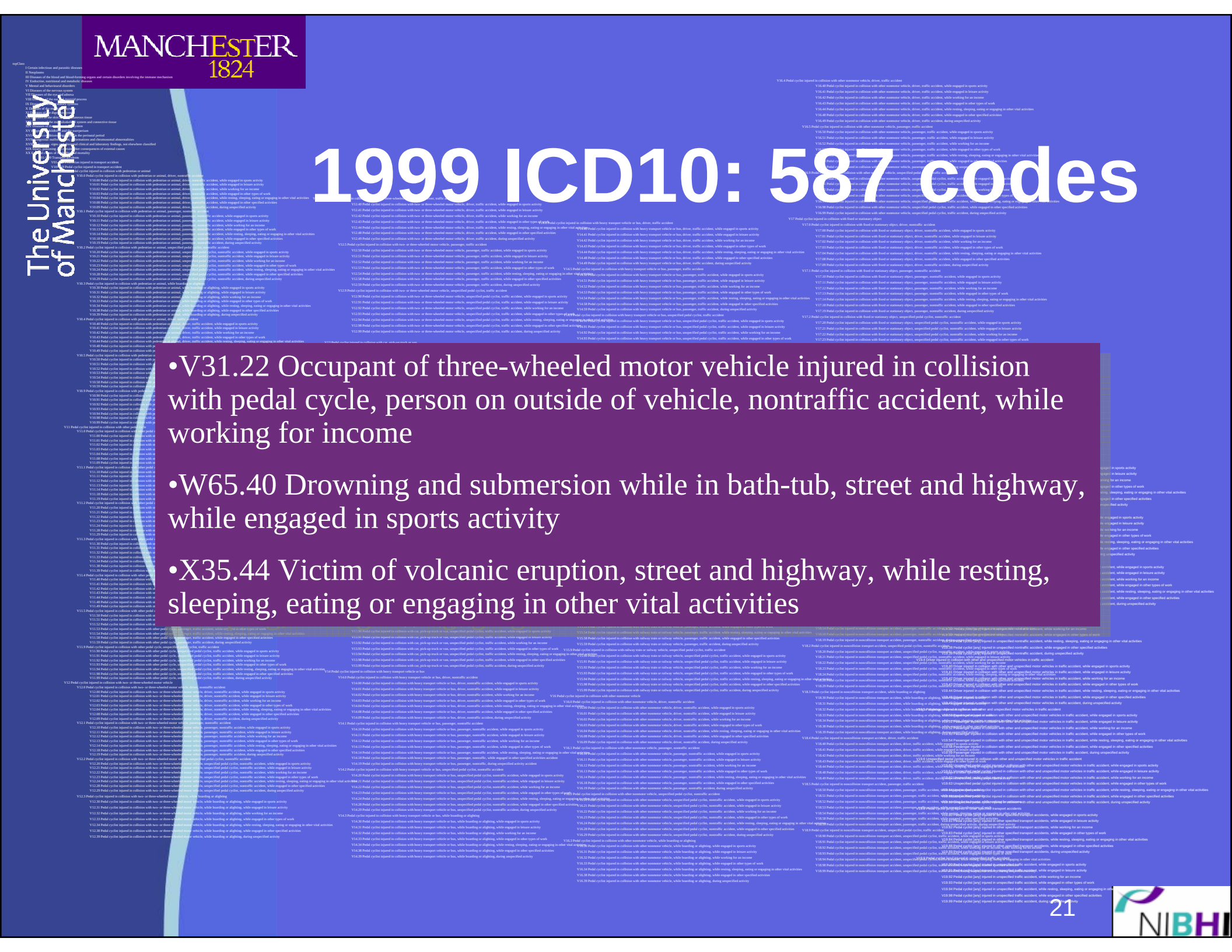
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1999 ICD10: 587 codes
•V31.22 Occupant of three-wheeled motor vehicle injured in collision with pedal cycle, person on outside of vehicle, nontraffic accident, while working for income
•W65.40 Drowning and submersion while in bath-tub, street and highway, while engaged in sports activity
•X35.44 Victim of volcanic eruption, street and highway, while resting, sleeping, eating or engaging in other vital activities

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# Evolution Maintenance & tailoring

- What might a change affect?
  - What needs to be locked?
- What has to be changed to make a variation?
  - What can be “swapped out” and replaced?



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# Logic-based Ontologies: Conceptual Lego

hand

extremity

body

gene

protein

cell

expression

chronic

acute

Lung inflammation

infection

abnormal

normal

bacterial

deletion

polymorphism

ischaemic



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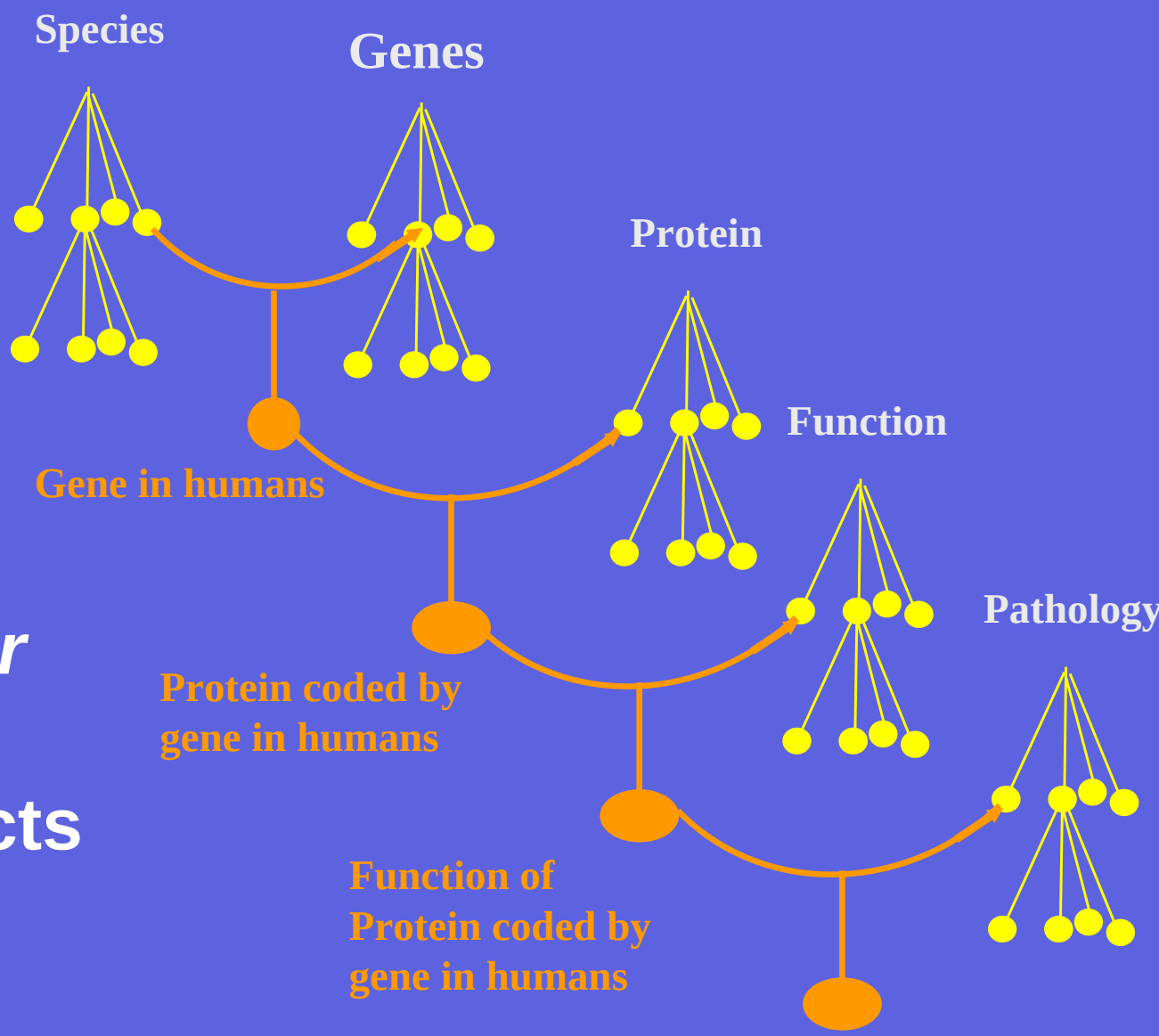
# Logic-based Ontologies: Conceptual Lego

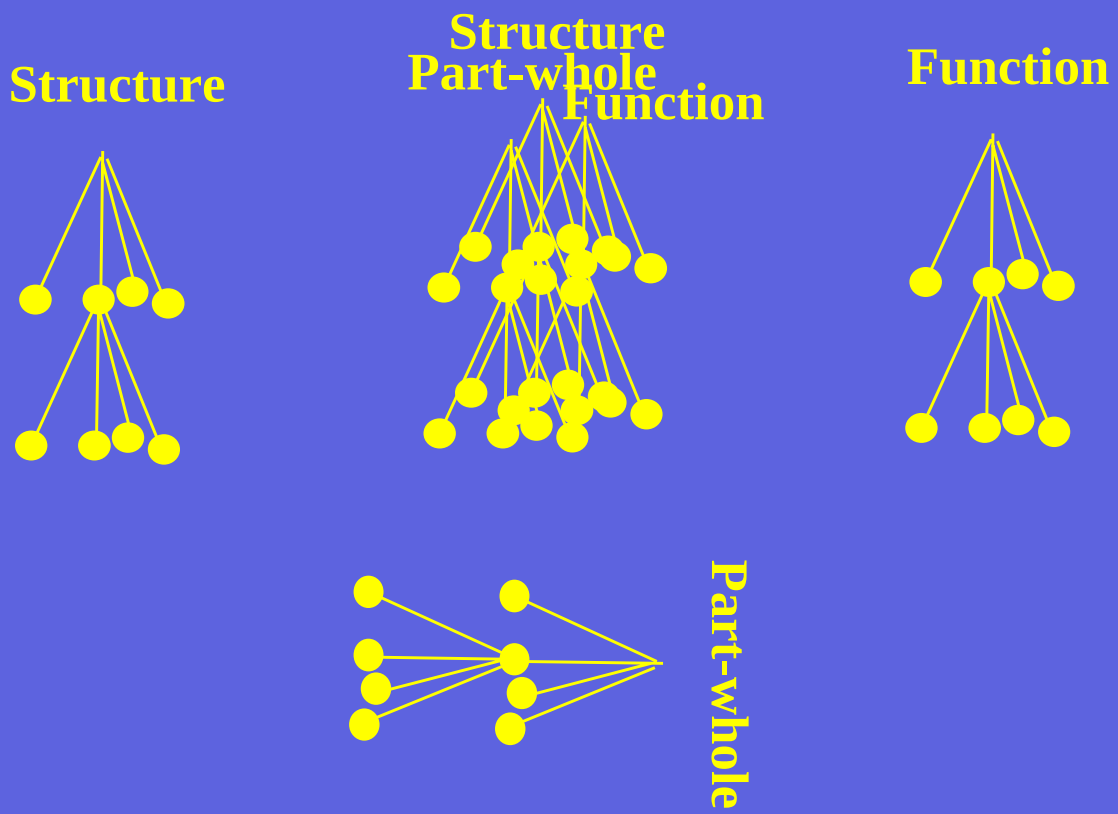
"***SNPolymorphism*** of ***CFTRGene*** causing ***Defect in MembraneTransport*** of ***Chloride Ion*** causing ***Increase*** in ***Viscosity*** of ***Mucus*** in ***CysticFibrosis***…"

"***Hand*** which is ***anatomically normal***"

***Normalisation for Segmentation:***
**Logical Constructs build complex concepts from modularised primitives**



# Normalising (untangling) Ontologies



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# Normalisation and Untangling

**Let the reasoner do multiple classification**

- **Tree**
  - **Everything has just one parent**
    - **A ‘strict hierarchy’**
- **Directed Acyclic Graph (DAG)**
  - **Things can have multiple parents**
    - **A ‘Polyhierarchy’**
- **Normalisation**
  - **Separate primitives into disjoint trees**
  - **Link the trees with restrictions**
    - **Fill in the values**



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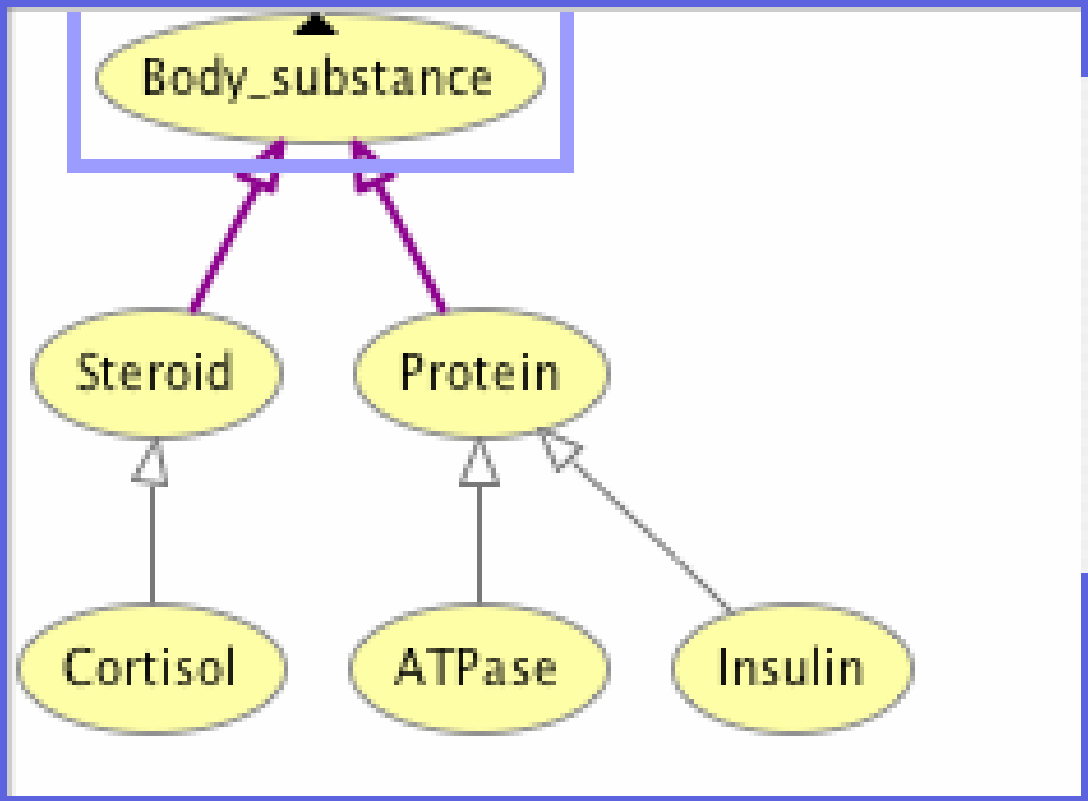
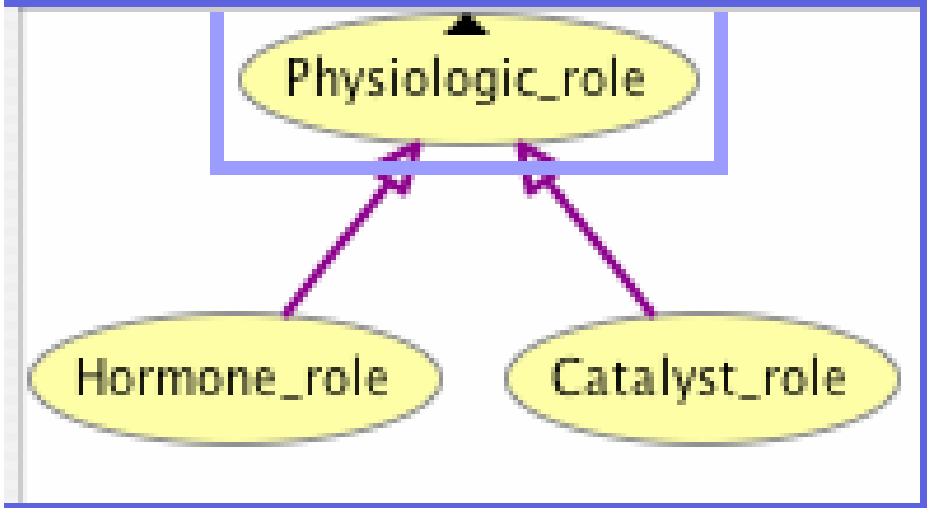
# Untangling and Enrichment

## Using a classifier to make life easier

Substance
- Protein
- - ProteinHormone
- - - Insulin
- Steroid
- - SteroidHormone
- - - Cortisol
- Hormone
- -ProteinHormone
- - - Insulin
- - SteroidHormone
- - - Cortisol
- Catalyst
- - Enzyme
- - - ATPase

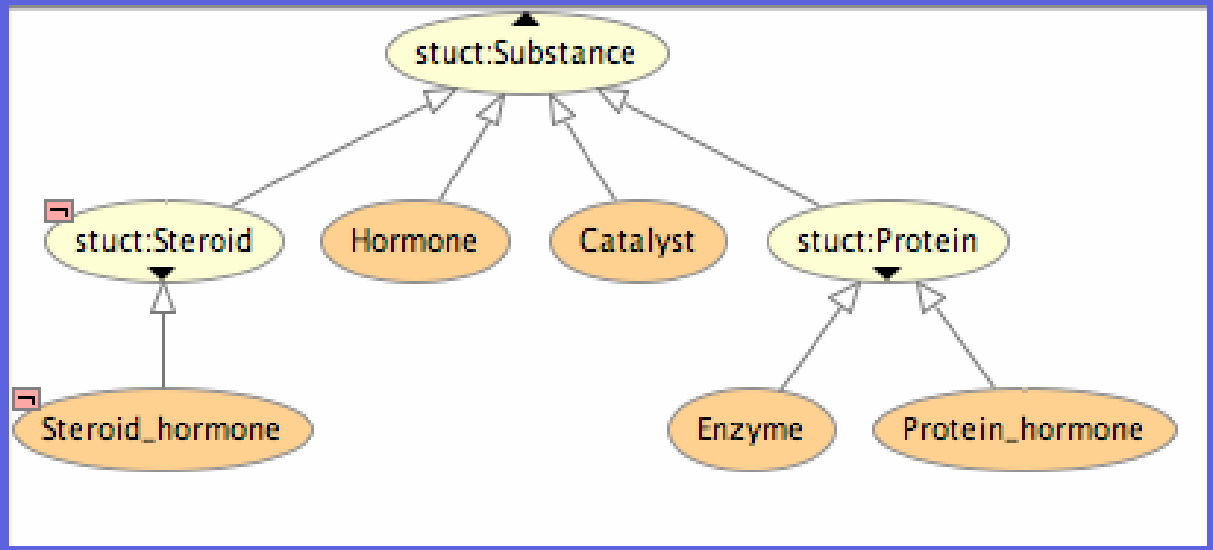
# Most normalisation results in three potential modules: *two primitive skeletons*



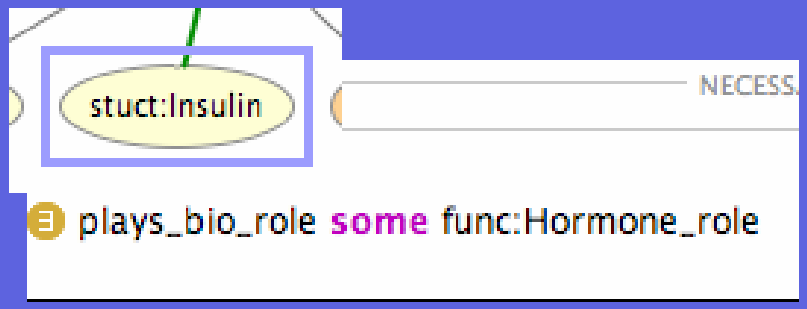



# And an interface

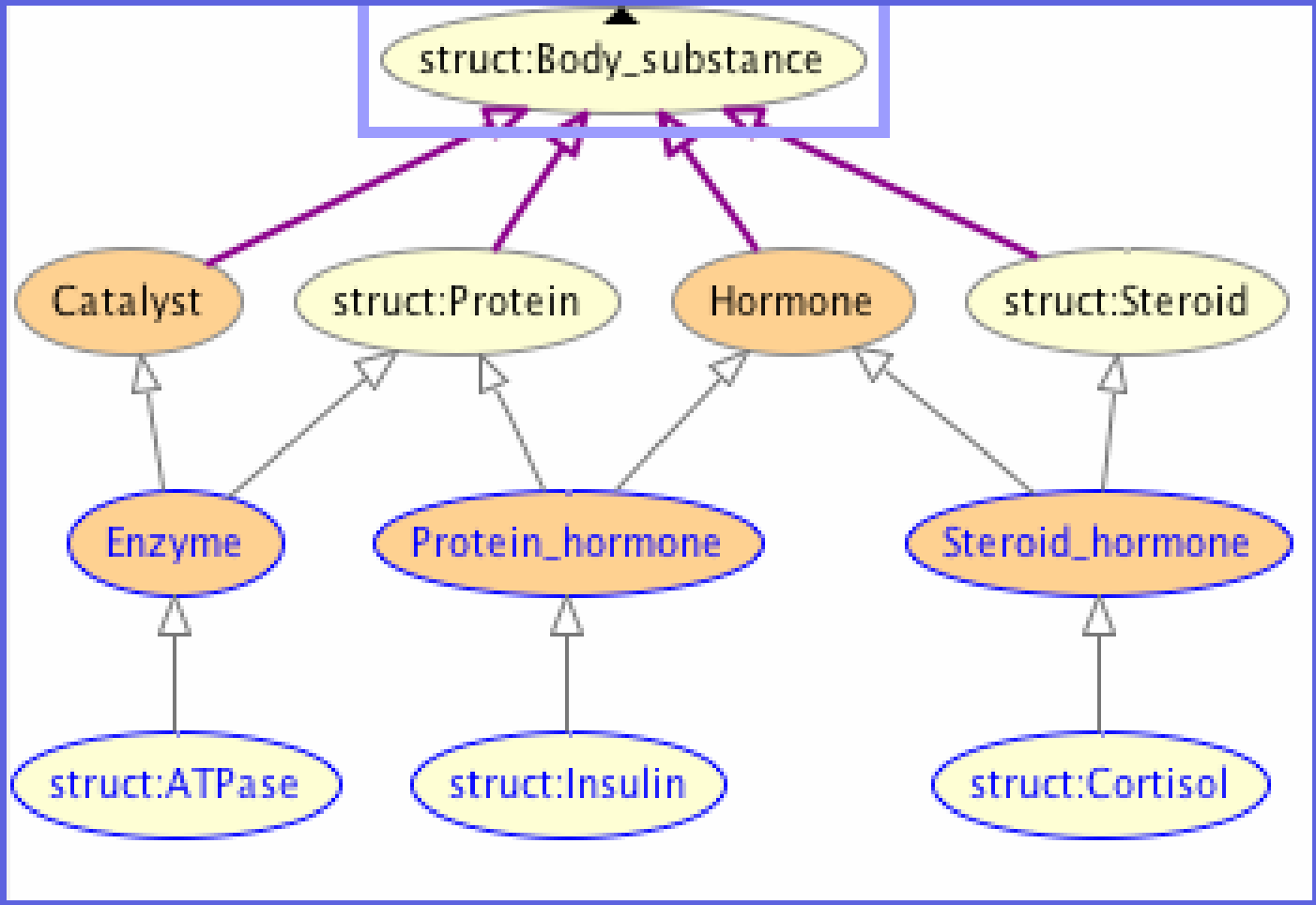
Definitions




Plus extra description



# Unified ontology after classification



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# Consider the steps to make a change

- What do we have to do to organise hormones as metabolic hormones and sex hormones and stress hormones and add in testosterone?



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# A Few of the changes the hard way

Substance
- Protein
- - ProteinHormone
- - - Insulin
- Steroid
- - SteroidHormone
- - - Cortisol
- Hormone
- - Sex Hormone
- - - ProteinSexHrmn - ProteinHormone
- - - ProteinMetabolicHrmn
- - - - Insulin
- - - ProteinSexHormone
- - SteroidHormone
- - - Cortisol
- Catalyst
- - Enzyme
- - - ATPase

# The easy way - and only create the ones I need

-Substance
- - Protein
- - - Insulin
- - - ATPase
- Steroid
- - Cortisol
- - Testosterone- -

- PhsioloicRole
- - HormoneRole
- - - SexHR
- - - MetabolicHR
- - - StressHR
- - CatalystRole

SexHR ≡ Substance & *playsRole-someValuesFrom* SexHR

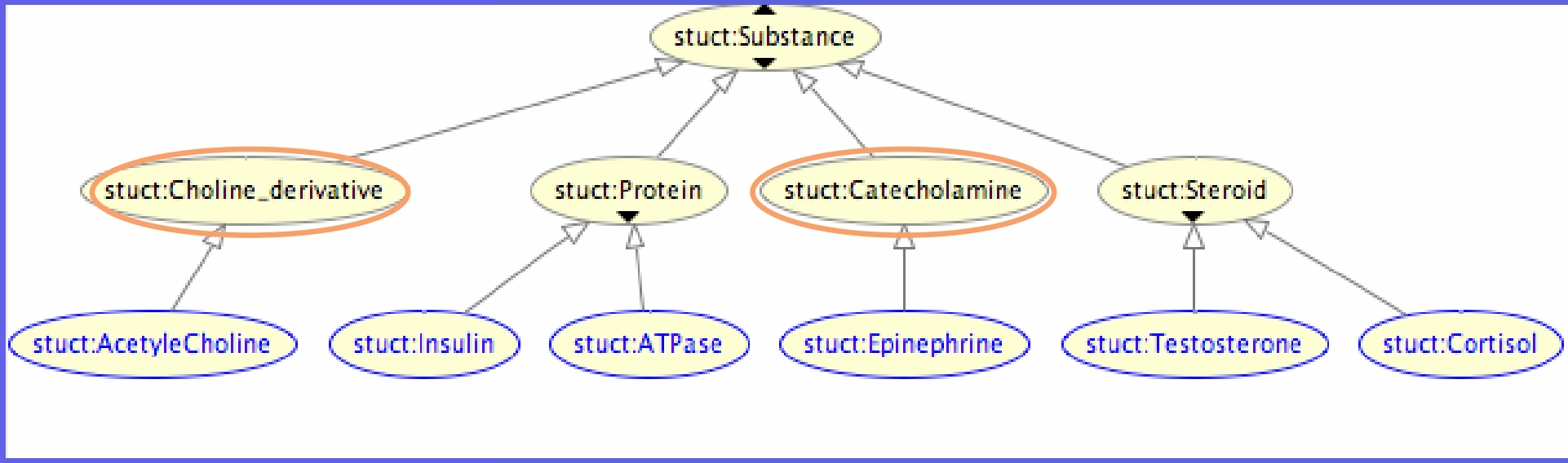
MetabolicHrmn ≡ Substance & *playsRole someValuesFrom* MetabolicHR

Testosterone→ *playsRole someValuesFrom* SexHR

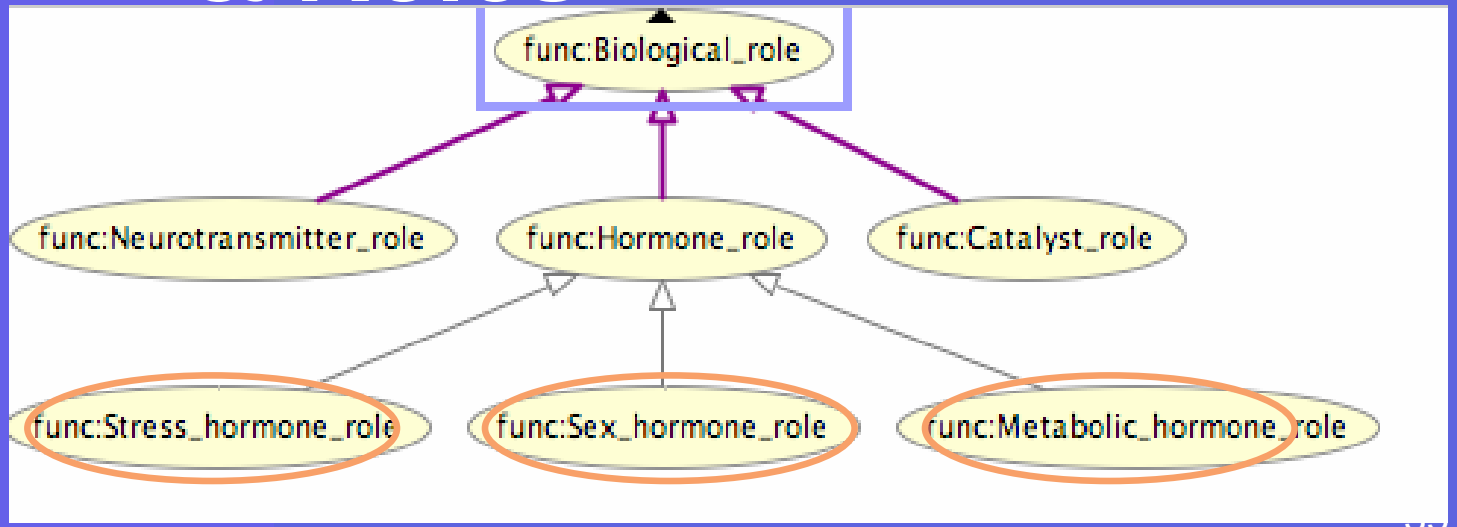
Cortisol→ *playsRole someValuesFrom* StressHr

Substance
- Protein
- - ProteinHormone
- - - Insulin
- - Enzyme
- - - ATPase
- Steroid
- - SteroidHomone^
- - - Cortisol
-Hormone
- - ProteinHormone^
- - - Insulin^
- - SteroidHormone^
- - SexHR
- - - Testosterone
- - StressHormone
- - - Cortisol^
- - MetabolicHrmn
- Catalyst
- - Enzyme^
- - - ATPase^

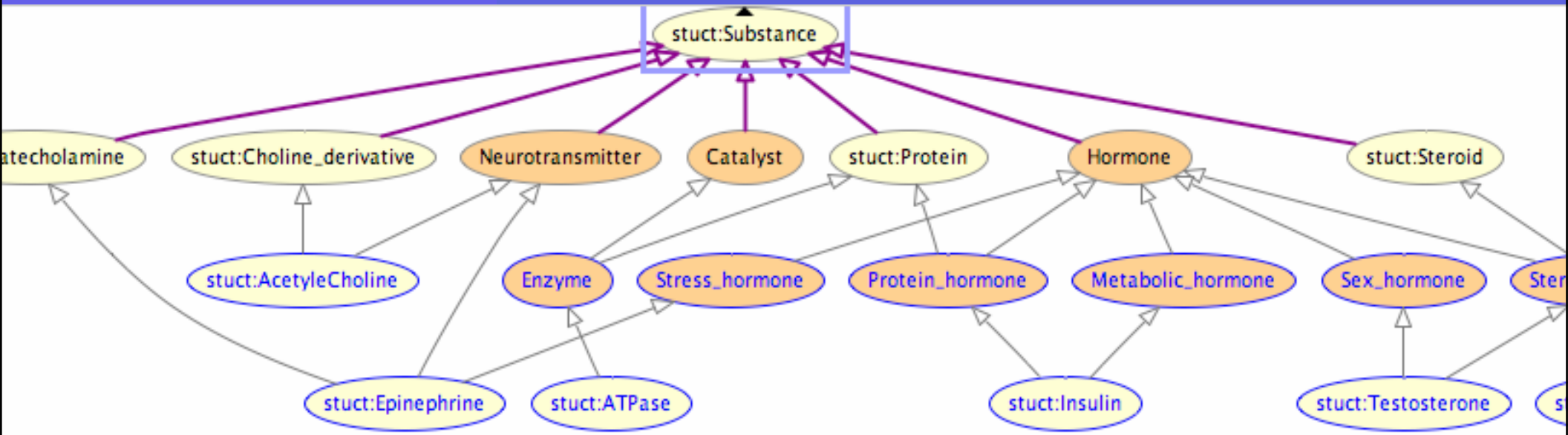
# Changes to Structure



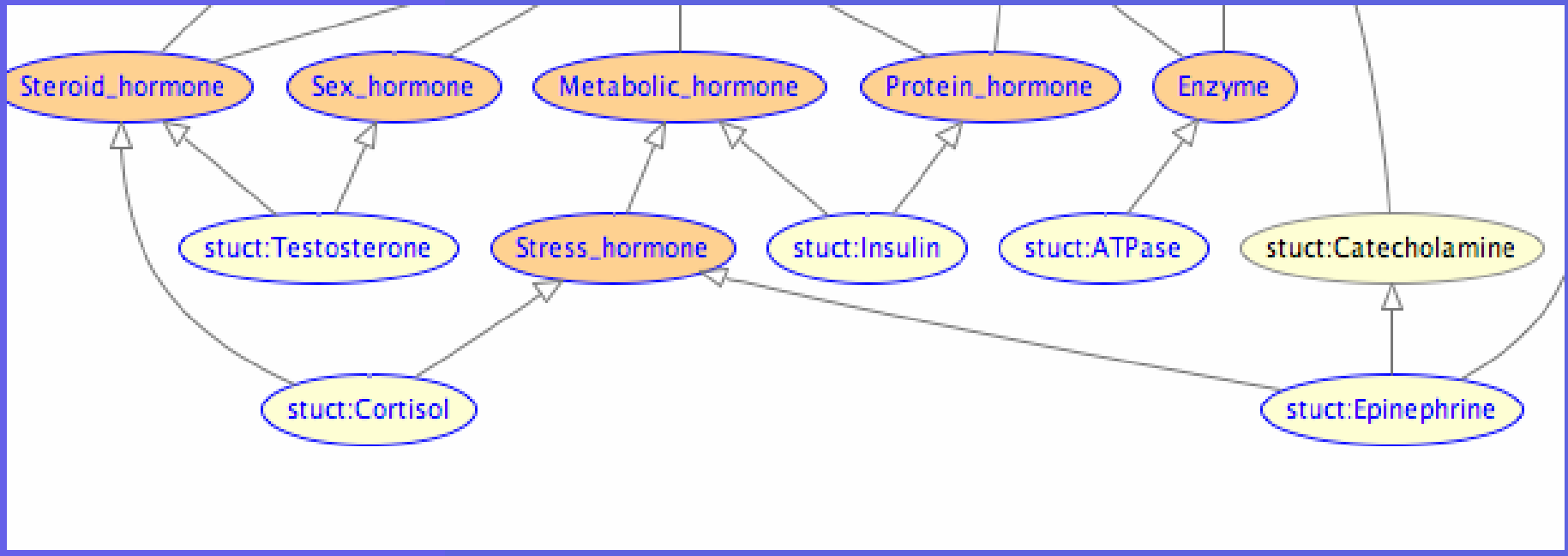

# & Roles



# Update the overall structure



# stress roles are metabolic roles: One change



# Another Example

**From**

Diameter
- Large_diameter
  - Large_increasing_diameter
  - Large_decreasing_diameter
- Small_diameter
  - Small_increasing_diameter
  - Small_decreasing_diameter

**to add regular/irregular we get**

Diameter
- Large_diameter
  - Large_increasing_diameter
    - Large_increasing_regular_diameter
    - Large_increasing_irregular_diameter
  - Large decreasing_diameter
    - Large_decreasing_regular_diameter
    - Large_decreasing_irregular_diameter
- Small_diameter
  - Small_increasing_diameter
    - Small_increasing_regular_diameter
    - Small_increasing_irregular_diameter
  - Small_decreasing_diameter
    - Small_decreasing_regular_diameter
    - Small_decreasing_irregular_diameter

# Instead of

Level
- Large
- Small

Trend
- Increasing
- Decreasing

Regularity
- Regular
- Irregular

# Which would you rather maintain?

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# Summary

- Modularisation for
  - Manageability
  - Locking and collaborative development
  - Adaptation and Localisation
- Two dimensions:
  - Abstraction & Segmentation
- Normalisation
  - Clean modularisation
  - Control the combinatorial explosion
  - Support smooth evolution
    - Changes only in one place



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