

Machine-Actionability and Interoperability





Collective Motion of Humans in Mosh and Circle Pits at Heavy Metal Concerts

Jesse L. Silverberg,* Matthew Bierbaum, James P. Sethna, and Itai Cohen

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(Received 13 February 2013; published 29 May 2013)

Human collective behavior can vary from calm to panicked depending on social context. Using videos publicly available online, we study the highly energized collective motion of attendees at heavy metal concerts. We find these extreme social gatherings generate similarly extreme behaviors: a disordered gaslike state called a *mosh pit* and an ordered vortexlike state called a *circle pit*. Both phenomena are reproduced in flocking simulations demonstrating that human collective behavior is consistent with the predictions of simplified models.

DOI: [10.1103/PhysRevLett.110.228701](https://doi.org/10.1103/PhysRevLett.110.228701)

PACS numbers: 89.65.Ef, 47.32.-y, 87.15.Zg, 87.23.Cc

Human collective behaviors vary considerably with social context. For example, lane formation in pedestrian traffic [1], jamming during escape panic [2], and Mexican waves at sporting events [3] are emergent phenomena that have been observed in specific social settings. Here, we study large crowds (10^2 – 10^5 attendees) of people under the extreme conditions typically found at heavy metal concerts [4]. Often resulting in injuries [5], the collective mood is influenced by the combination of loud (130 dB [6]), fast

Fig. 2, the decay length was 0.39 ± 0.03 m, which is approximately human shoulder width. Taken together, these findings offer strong support for the analogy between mosh pits and gases. As a further check, we examined the 2D speed distribution. Previous observations of human pedestrian traffic and escape panic led us to expect a broad distribution not well described by simple analytic expressions [2,13]. However, the measured speed distribution in mosh pits was well fit by the 2D Maxwell-Boltzmann



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Fig. 2, the decay length was 0.39 ± 0.02 times the approximately human shoulder width. These findings offer strong support for the analogy between mosh pits and gases. As a further check, we performed a 2D speed distribution. Previous observations of collective motion in pedestrian traffic and escape panic led us to expect a power-law-like distribution not well described by simple analytical models [2,13]. However, the measured speed distributions in mosh pits was well fit by the 2D Maxwell-Boltzmann distribution.





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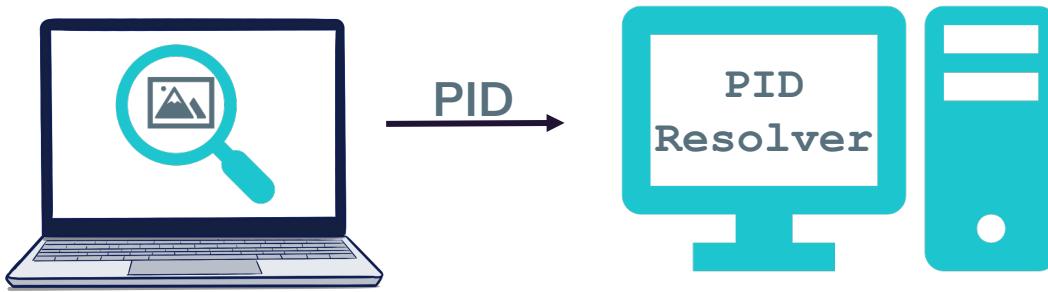
Human collective behaviors vary considerably with social context. For example, lane formation in pedestrian traffic [1], jamming during escape panic [2], and Mexican waves at sporting events [3] are emergent phenomena that have been observed in specific social settings. Here, we study large crowds (10^2 – 10^5 attendees) of people under the extreme conditions typically found at heavy metal concerts [4]. Often resulting in injuries [5], the collective mood is influenced by the combination of loud (130 dB [6]), fast

Fig. 2, the decay length was approximately human shoulder width. These findings offer strong support for the mosh pits and gases. As a function of speed, the 2D speed distribution. Previous work on pedestrian traffic and escape panic has shown the speed distribution not well described by the 2D Maxwell-Boltzmann distributions [2,13]. However, the measured speed distribution in mosh pits was well fit by the 2D Maxwell-Boltzmann



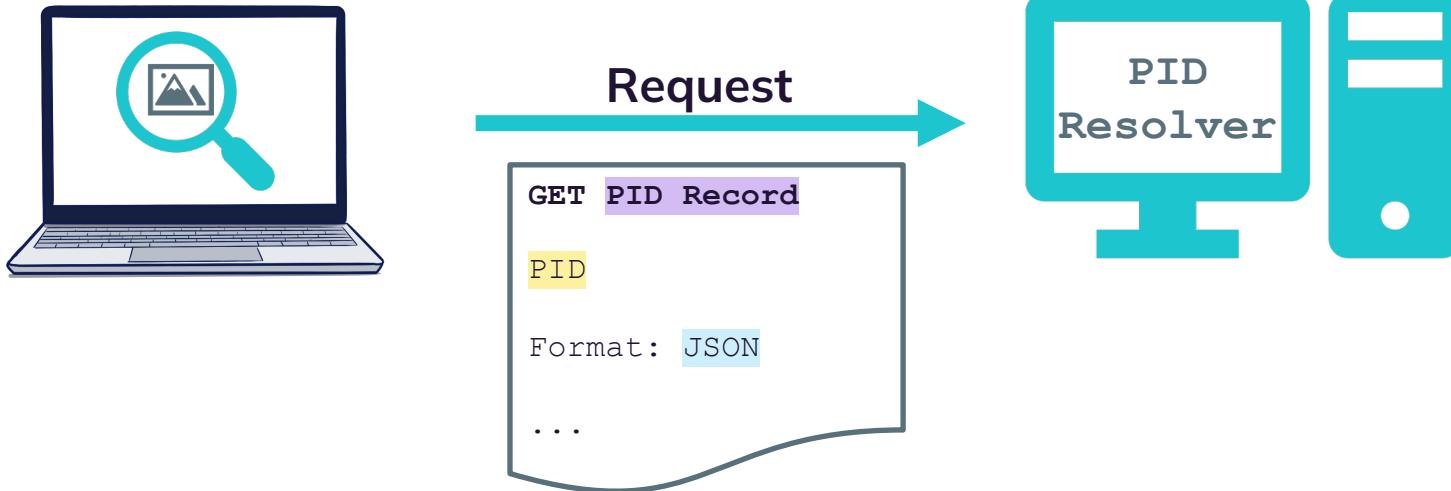


Client – PID Resolver Interaction



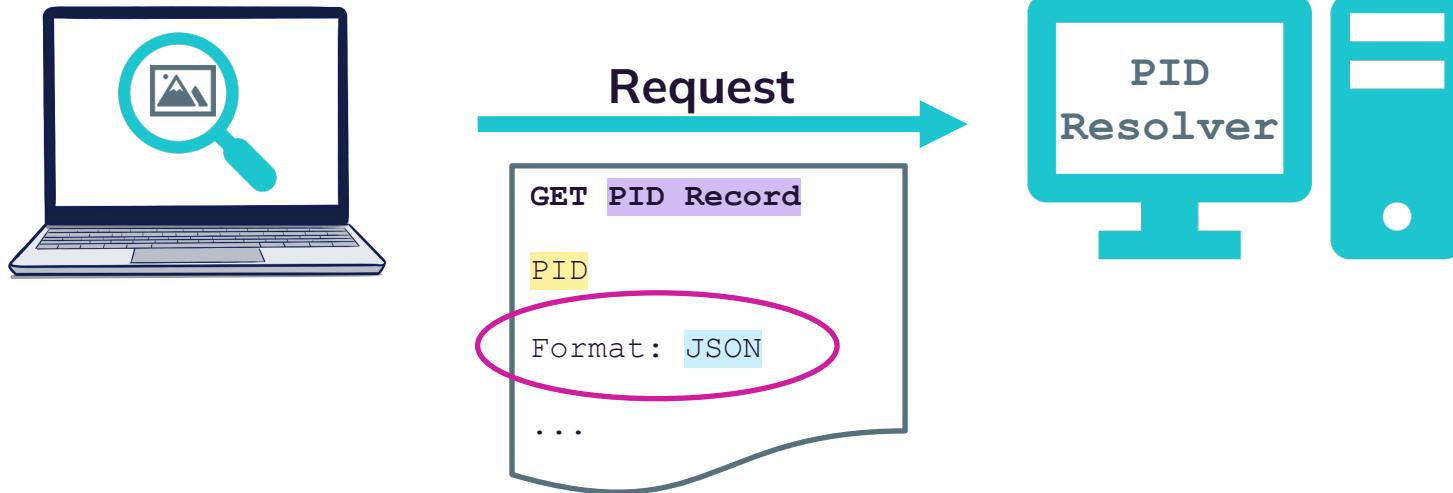


PID Record Request



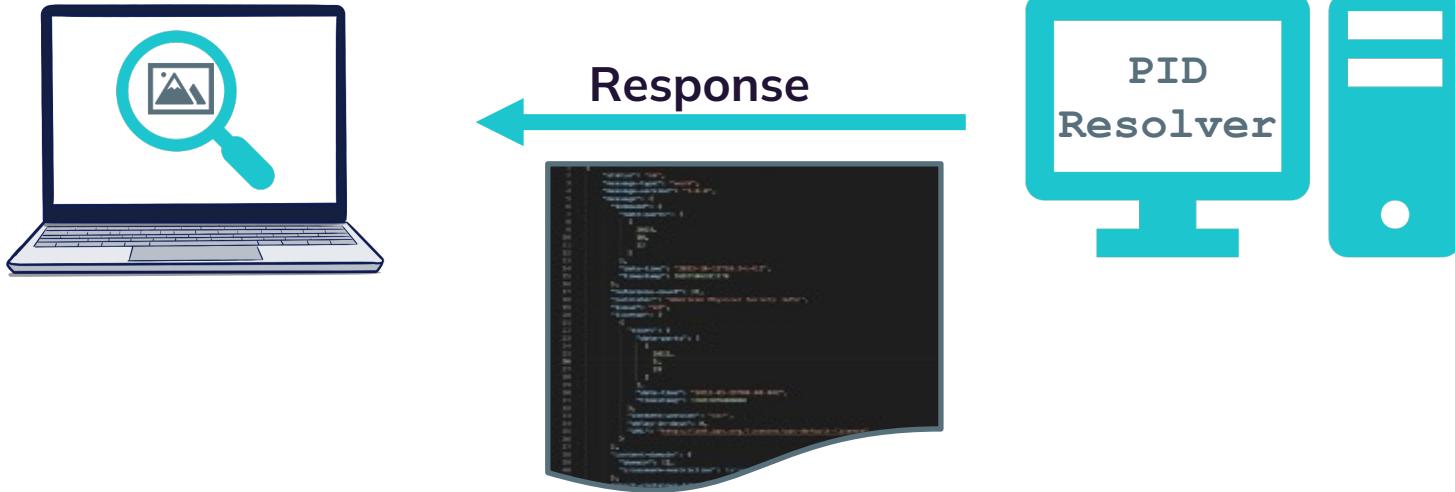


PID Record Request





PID Record Request





PID Record Schemas

```
<xsd:schema xmlns="http://www.crossref.org/schema/5.3.1" xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:fr="http://www.crossref.org/fundref.xsd" xmlns:ct="http://www.crossref.org/clinicaltrials.xsd" xmlns:rel="http://www.crossref.org/relations.xsd" xmlns:mml="http://www.w3.org/1998/Math/MathML" xmlns:jats="http://www.ncbi.nlm.nih.gov/JATS1" targetNamespace="http://www.crossref.org/schema/5.3.1">
  <!-- **** Crossref Metadata Input Schema v. 5.3.1 ****
  This is the latest iteration of the Crossref Metadata Input Schema, used to register metadata records with Crossref. This schema was originally developed for Crossref by Inera (http://www.inera.com)
  As of version 4.5.0 all changes are noted in the release notes for the schema repository in GitLab: https://gitlab.com/crossref/schema/-/releases
  Prior updates are noted as comments within previous schema versions. -->
  <!-- include common schema -->
  <xsd:include schemaLocation="common5.3.1.xsd"/>
  <!-- imported schema -->
  <xsd:import namespace="http://www.ncbi.nlm.nih.gov/JATS1" schemaLocation="JATS-journalpublishing1-3d2-mathml3.xsd"/>
  <xsd:import namespace="http://www.w3.org/1998/Math/MathML" schemaLocation="http://www.w3.org/Math/XMLSchema/mathml3/mathml3.xsd"/>
  <xsd:import namespace="http://www.crossref.org/fundref.xsd" schemaLocation="fundref.xsd"/>
  <xsd:import namespace="http://www.crossref.org/clinicaltrials.xsd" schemaLocation="clinicaltrials.xsd"/>
  <xsd:import namespace="http://www.crossref.org/AccessIndicators.xsd" schemaLocation="AccessIndicators.xsd"/>
  <xsd:import namespace="http://www.crossref.org/relations.xsd" schemaLocation="relations.xsd"/>
  <!-- *** Head elements (used when processing submission XML) -->
  <xsd:element name="doi_batch">
    <xsd:annotation>
      <xsd:documentation>Top level element for a metadata record submission. This element indicates the start and end of the XML file. The version number is fixed to the version of the schema.
    </xsd:annotation>
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref="head"/>
        <xsd:element ref="body"/>
      </xsd:sequence>
      <xsd:attribute name="version" type="xsd:string" fixed="5.3.1"/>
    </xsd:complexType>
  </xsd:element>
  <xsd:element name="head">
    <xsd:annotation>
      <xsd:documentation>Container for information related to the DOI batch submission. This element uniquely identifies the batch deposit to Crossref and contains information that will be used during processing. </xsd:documentation>
    </xsd:annotation>
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref="doi_batch_id"/>
        <xsd:element ref="timestamp"/>
        <xsd:element ref="depositor"/>
        <xsd:element ref="registrant"/>
      </xsd:sequence>
    </xsd:complexType>
  </xsd:element>
  <xsd:element name="body">
    <xsd:annotation>
```



PID Record Schemas

```
<xsd:schema xmlns="http://www.crossref.org/schema/5.3.1" xmlns:xsd="http://www.w3.org/2001/XMLSchema" xmlns:fr="http://www.crossref.org/fundref.xsd" xmlns:ct="http://www.crossref.org/clinicaltrials.xsd" xmlns:rel="http://www.crossref.org/relations.xsd" xmlns:mml="http://www.w3.org/1998/Math/MathML" xmlns:jats="http://www.ncbi.nlm.nih.gov/JATS1" targetNamespace="http://www.crossref.org/schema/5.3.1" xmlns="http://www.crossref.org/schema/5.3.1">
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  <xsd:import namespace="http://www.ncbi.nlm.nih.gov/JATS1" schemaLocation="JATS-journalpublishing1-3d2-mathml3.xsd"/>
  <xsd:import namespace="http://www.w3.org/1998/Math/MathML" schemaLocation="http://www.w3.org/Math/XMLSchema/mathml3/mathml3.xsd"/>
  <xsd:import namespace="http://www.crossref.org/fundref.xsd" schemaLocation="fundref.xsd"/>
  <xsd:import namespace="http://www.crossref.org/clinicaltrials.xsd" schemaLocation="clinicaltrials.xsd"/>
  <xsd:import namespace="http://www.crossref.org/AccessIndicators.xsd" schemaLocation="AccessIndicators.xsd"/>
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  <!-- *** Head elements (used when processing submission XML) -->
  <xsd:element name="doi_batch">
    <xsd:annotation>
      <xsd:documentation>Top level element for a metadata record submission. This element indicates the start and end of the XML file. The version number is fixed to the version of the schema.
```



PID Record Schemas

are also called

Kernel Information Profiles

Identifies the batch deposit to Crossref and contains information that will be used to process.

```
<xsd:element name="doi_batch">
  <xsd:annotation>
    <xsd:documentation>Top level element for a metadata record submission. This element indicates the start and end of the XML file. The version number is fixed to the version of the schema.
```

One Last Thing about PIDs...
PIDs in Schemas, Vocabularies and Ontologies



allosteric molecule

 http://purl.obolibrary.org/obo/MI_1159 

A molecule whose binding or catalytic properties at one site are altered by allosteric post-translational modification or binding of an allosteric effector at a distinct site. An allosteric molecule is identified by referring to its participant id. 

Search

Exact match Include obsolete terms Include imported terms

 Tree 

- ↳ molecular interaction (1,454)
 - ↳ attribute name (139)
 - ↳ interaction attribute name (38)
 - 3d-r-factors
 - 3d-resolution
 - 3d-structure
 - affected interaction
 - agonist
 - allosteric change in dynamics
 - allosteric change in structure
 - allosteric effector
 - allosteric k-type response
 - allosteric molecule**
 - allosteric post-translational modification
 - allosteric v-type response
 - allostery
 - altered physicochemical compatibility
 - antagonist
 - author-confidence
 - binding site hiding
 - caution
 - comment
 - complex-properties
 - composite binding site formation
 - configurational pre-organization
 - cooperative effectvalue

- Show counts
 Show obsolete terms
 Show all siblings

▼ Class Information

- created_by**
orchard

creation_date
2012-06-07T12:55:09Z

has_obo_namespace
PSI-MI

in_subset
PSI-MI_slim

▼ Class Relations

- Subclass of**
- [biological role](#)
 - [interaction attribute name](#)
 - [cooperative interaction](#)

Ontologies > MI > Classes > MI:1159  en 

Identifier

allosteric molecule http://purl.obolibrary.org/obo/MI_1159 

Purl

A molecule whose binding or catalytic properties at one site are altered by allosteric post-translational modification or binding of an allosteric effector at a distinct site. An allosteric molecule is identified by referring to its participant id. 

Search MI...

Search

 Exact match Include obsolete terms Include imported terms Tree  Graph

molecular interaction (1,454)

attribute name (139)

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3d-r-factors

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creation_date

2012-06-07T12:55:09Z

has_obo_namespace

PSI-MI

in_subset

PSI-MI_slim

▼ Class Relations**Subclass of**

- biological role
- interaction attribute name
- cooperative interaction



Persistent URLs (PURLs) are a form of PIDs. A PURL Resolver redirects HTTP requests to the current URL of a resource.

- ↳ molecular interaction (1,454)
- ↳ attribute name (139)
- ↳ interaction attribute name (38)
 - 3d-r-factors
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 - author-confidence
 - binding site hiding
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 - complex-properties
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 - cooperative effector

- Show counts
- Show obsolete terms
- Show all siblings

allosteric effector at a distinct site. An allosteric molecule is

 Search

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Ontologies > MI > Classes > MI:1159 

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▼ Class Relations

Subclass of

- [biological role](#)
- [interaction attribute name](#)
- [cooperative interaction](#)

Molecular Interactions Controlled Vocabulary

Keywords: Search terms

Class: allosteric molecule

Term IRI: http://purl.obolibrary.org/obo/MI_1159

Definition: A molecule whose binding or catalytic properties at one site are altered by allosteric post-translational modification or binding of an allosteric effector at a distinct site. An allosteric molecule is identified by referring to its participant id. [database_cross_reference: PMID:18706817]

Annotations

- has_obo_namespace: PSI-MI
- http://www.geneontology.org/formats/obolOwl#created_by: orchard
- http://www.geneontology.org/formats/obolOwl#creation_date: 2012-06-07T12:55:09Z
- http://www.geneontology.org/formats/obolOwl#id: MI:1159
- in_subset: http://purl.obolibrary.org/obo/mi#PSI-MI_slim

Class Hierarchy

Thing

- + [molecular interaction](#)
 - + [attribute name](#)
 - + [interaction_attribute_name](#)
 - [figure legend](#)
 - [comment](#)
 - [function](#)
 - [url](#)
 - [disease](#)
 - [caution](#)
 - [pathway](#)
 - [author-confidence](#)
 - [inhibition](#)
 - [stimulant](#)
 - [agonist](#)
 - [more...](#)
 - [allosteric molecule](#)

Superclasses & Asserted Axioms

- [interaction_attribute_name](#)
- [biological role](#)
- [cooperative interaction](#)

Molecular Interactions Controlled Vocabulary

Keywords: [Search terms](#)

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- [http://www.geneontology.org/formats/obolOwl#id: MI:1159](#)
- [in_subset: http://purl.obolibrary.org/obo/mi#PSI-MI_slim](#)

Class Hierarchy

Thing

- + [molecular interaction](#)
 - + [attribute name](#)
 - + [interaction_attribute_name](#)
 - [figure legend](#)
 - [comment](#)
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 - [pathway](#)
 - [author-confidence](#)
 - [inhibition](#)
 - [stimulant](#)
 - [agonist](#)
 - [more...](#)
 - [allosteric molecule](#)

Superclasses & Asserted Axioms

- [interaction_attribute_name](#)
- [biological role](#)
- [cooperative interaction](#)

[Show RDF Source](#)

Molecular Interactions Controlled Vocabulary

Keywords:

Search terms

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- <http://www.geneontology.org/formats/obolOwl#id>: MI:1159
- in_subset: http://purl.obolibrary.org/obo/mi#PSI-MI_slim

Class Hierarchy

Thing

- + molecular interaction
 - + attribute name
 - figure legend
 - comment
 - function
 - url
 - disease
 - caution
 - pathway
 - author-confidence
 - inhibition
 - stimulant
 - agonist
 - [more...](#)
 - allosteric molecule



Internationalized Resource Identifier (IRI) is extending the URI, allowing for a greater set of characters.

Superclasses & Asserted Axioms

- [interaction attribute name](#)
- [biological role](#)
- [cooperative interaction](#)

allosteric molecule

http://purl.obolibrary.org/obo/MI_1159 ⚒ Copy

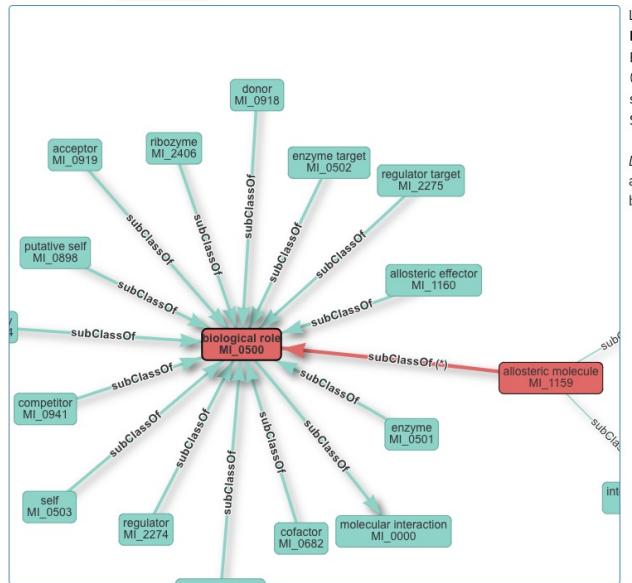
A molecule whose binding or catalytic properties at one site are altered by allosteric post-translational modification or binding of an allosteric effector at a distinct site. An allosteric molecule is identified by referring to its participant id. ⓘ

Search MI...

Search

Exact match Include obsolete terms Include imported terms

Tree Graph



Search node

Search Node

▼ Class Information

created_by

orchard

creation_date

2012-06-07T12:55:09Z

has_obo_namespace

PSI-MI

in_subset

PSI-MI_slim

▼ Class Relations

Subclass of

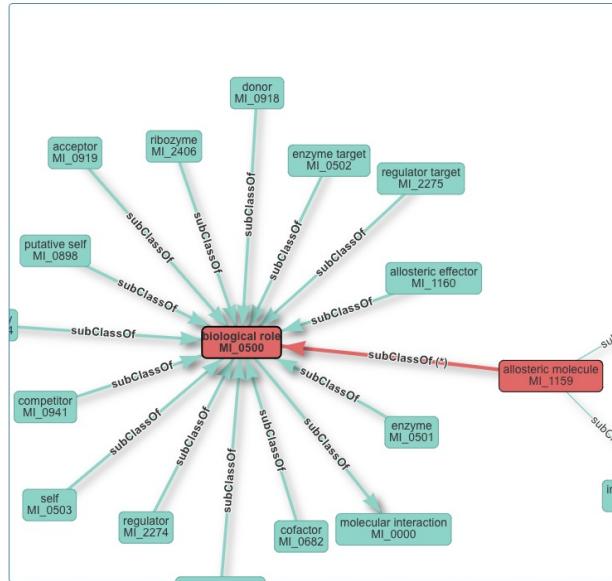
- biological role
- interaction attribute name
- cooperative interaction

allosteric molecule[http://purl.obolibrary.org/obo/MI_1159](#) ⚏ Copy

A molecule whose binding or catalytic properties at one site are altered by allosteric post-translational modification or binding of an allosteric effector at a distinct site. An allosteric molecule is identified by referring to its participant id. ⓘ

Search MI...

Search

 Exact match Include obsolete terms Include imported terms**Tree** **Graph**

Legend

Relationship

Extended nodes (*)

subClassOf

Select/Deselect all

Color Visibility



▼ Class Information

created_by

orchard

creation_date

2012-06-07T12:55:09Z

has_obo_namespace

PSI-MI

in_subset

PSI-MI_slim

▼ Class Relations

Subclass of

- biological role
- interaction attribute name
- cooperative interaction

Create clusters Open all clusters Auto rearrange ⌘ Hierarchical layout

Search node

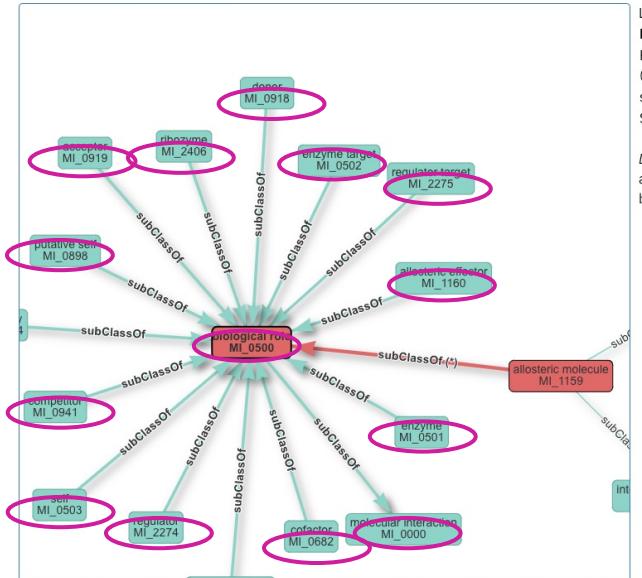
Search Node

allosteric molecule http://purl.obolibrary.org/obo/MI_1159 ⚏ Copy

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Search MI...

Search

 Exact match Include obsolete terms Include imported terms**Tree** ⚏ **Graph**

▼ Class Information

created_by

orchard

creation_date

2012-06-07T12:55:09Z

has_obo_namespace

PSI-MI

in_subset

PSI-MI_slim

▼ Class Relations

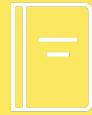
Subclass of

- biological role
- interaction attribute name
- cooperative interaction

[Create clusters](#) [Open all clusters](#) [Auto rearrange](#) [Hierarchical layout](#)

Search node

Search Node



The study of meaning, reference, or truth is called **Semantics**.

Exact match Include obsolete terms Include imported terms

Search



Formally describing **concepts**, **relationships** between (meta)data entities, and **categories**, encodes semantics with the data.

This technology is known as the **Semantic Web**.



Create clusters Open all clusters Auto rearrange Hierarchical layout

Search mode

Search Node

an allosteric effector at a distinct site. An allosteric molecule is

▼ Class Information

created_by
orchard

creation_date
2012-06-07T12:55:09Z

has_obo_namespace
PSI-MI

in_subset
PSI-MI, slim

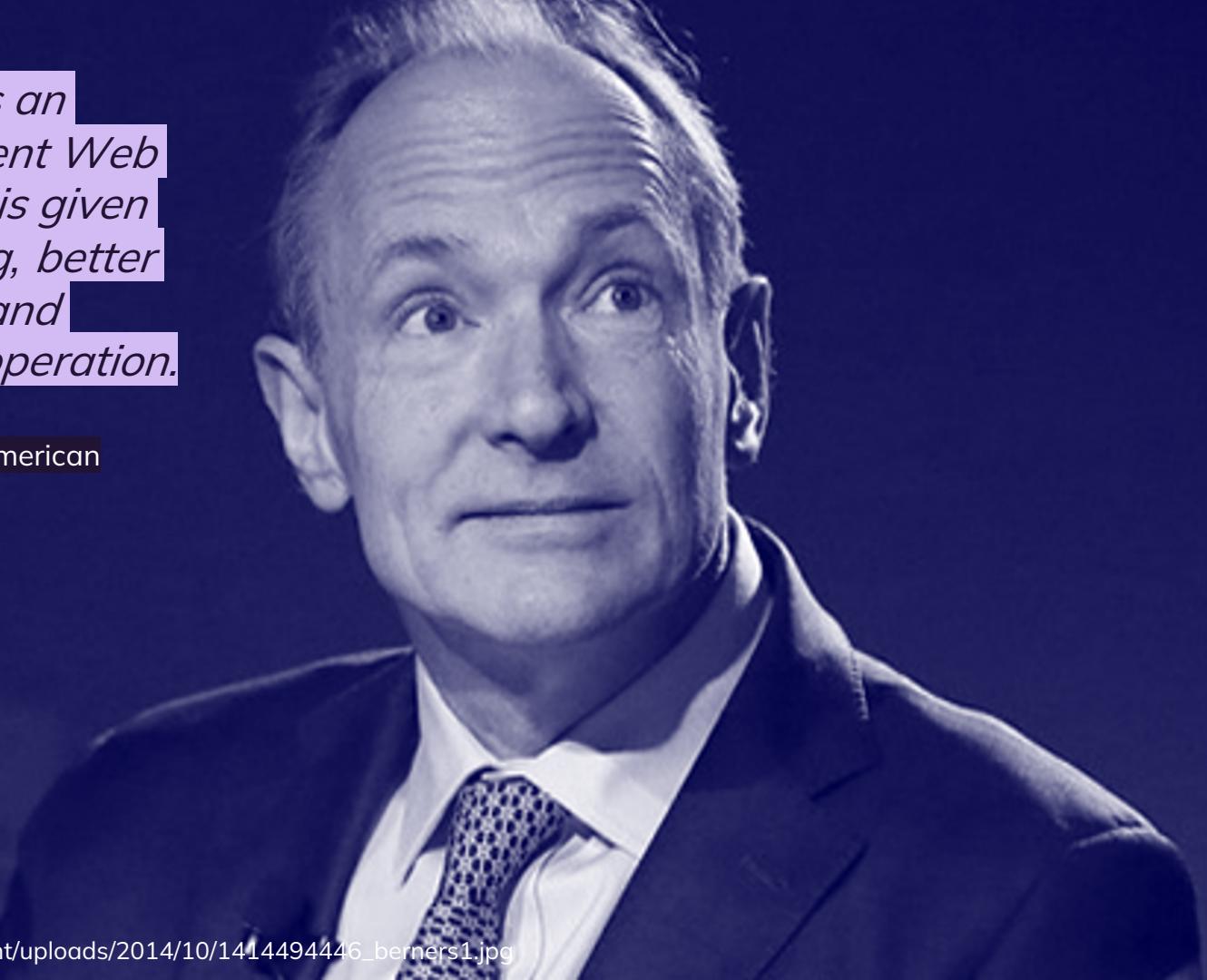
▼ Class Relations

Subclass of

- biological role
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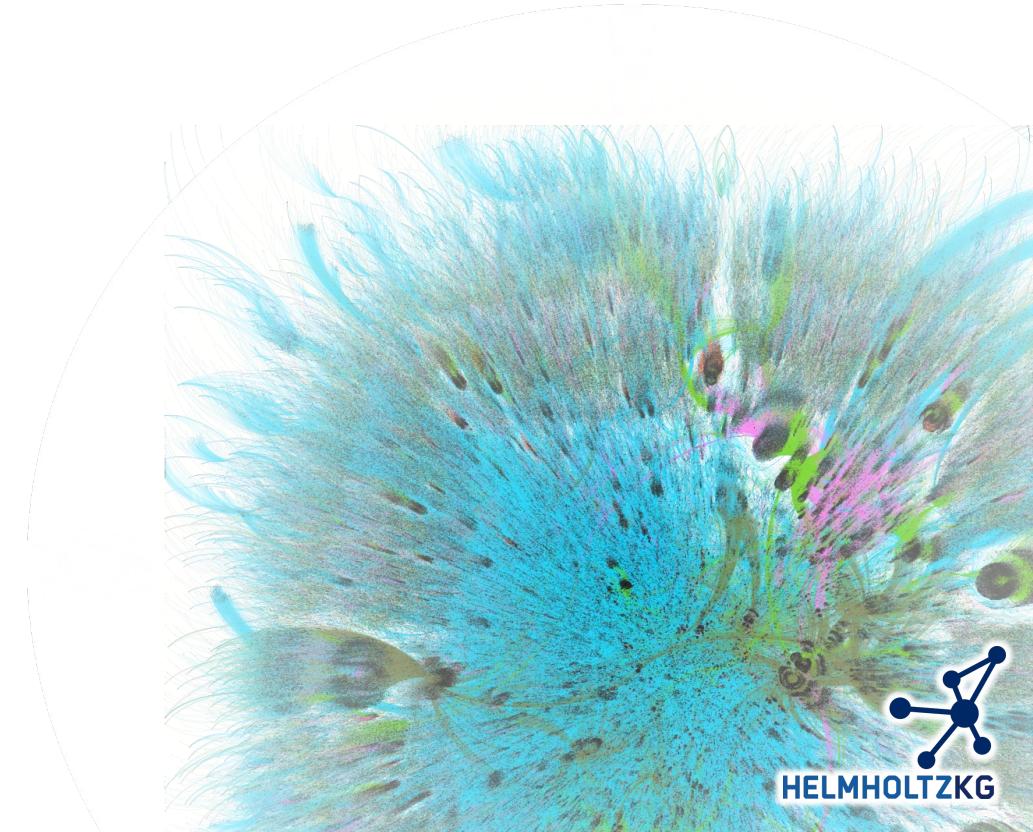
The Semantic Web is an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation.

Berners-Lee et al. (2001),
The Semantic Web, Scientific American





Semantic Web Technologies



```
<!-- http://purl.obolibrary.org/obo/IAO_0100001 -->
```

```
<owl:AnnotationProperty rdf:about="http://purl.obolibrary.org/obo/IAO_0100001">
  <obo:IAO_0000111 xml:lang="en">term replaced by</obo:IAO_0000111>
  <obo:IAO_0000114 rdf:resource="http://purl.obolibrary.org/obo/IAO_0000125"/>
  <obo:IAO_0000115 xml:lang="en">Use on obsolete terms, relating the term to another term that can be used as a substitute</obo:IAO_0000115>
  <obo:IAO_0000117 xml:lang="en">Person:Alan Ruttenerberg</obo:IAO_0000117>
  <obo:IAO_0000119 xml:lang="en">Person:Alan Ruttenerberg</obo:IAO_0000119>
  <rdfs:comment xml:lang="en">Add as annotation triples in the granting ontology</rdfs:comment>
  <rdfs:label>term replaced by</rdfs:label>
  <rdfs:label xml:lang="en">term replaced by</rdfs:label>
</owl:AnnotationProperty>
```

```
<!-- http://purl.obolibrary.org/obo/NCIT_C42610 -->
```

```
<owl:AnnotationProperty rdf:about="http://purl.obolibrary.org/obo/NCIT_C42610">
  <obo:IAO_0000115>A shortened form of a word or phrase. [Definition Source: NCI]</obo:IAO_0000115>
  <rdfs:label xml:lang="en">abbreviation</rdfs:label>
  <rdfs:subPropertyOf rdf:resource="http://www.w3.org/2004/02/skos/core#altLabel"/>
</owl:AnnotationProperty>
```

```
<!-- http://purl.obolibrary.org/obo/NCIT_C93495 -->
```

```
<owl:AnnotationProperty rdf:about="http://purl.obolibrary.org/obo/NCIT_C93495">
  <obo:IAO_0000115>The non-unique initials or abbreviated name used for identification. [Definition Source: NCI]</obo:IAO_0000115>
  <rdfs:label xml:lang="en">acronym</rdfs:label>
  <rdfs:subPropertyOf rdf:resource="http://www.w3.org/2004/02/skos/core#altLabel"/>
</owl:AnnotationProperty>
```

```
<!-- http://purl.obolibrary.org/obo/RD_0001900 -->
```

```
<owl:AnnotationProperty rdf:about="http://purl.obolibrary.org/obo/RD_0001900"/>
```

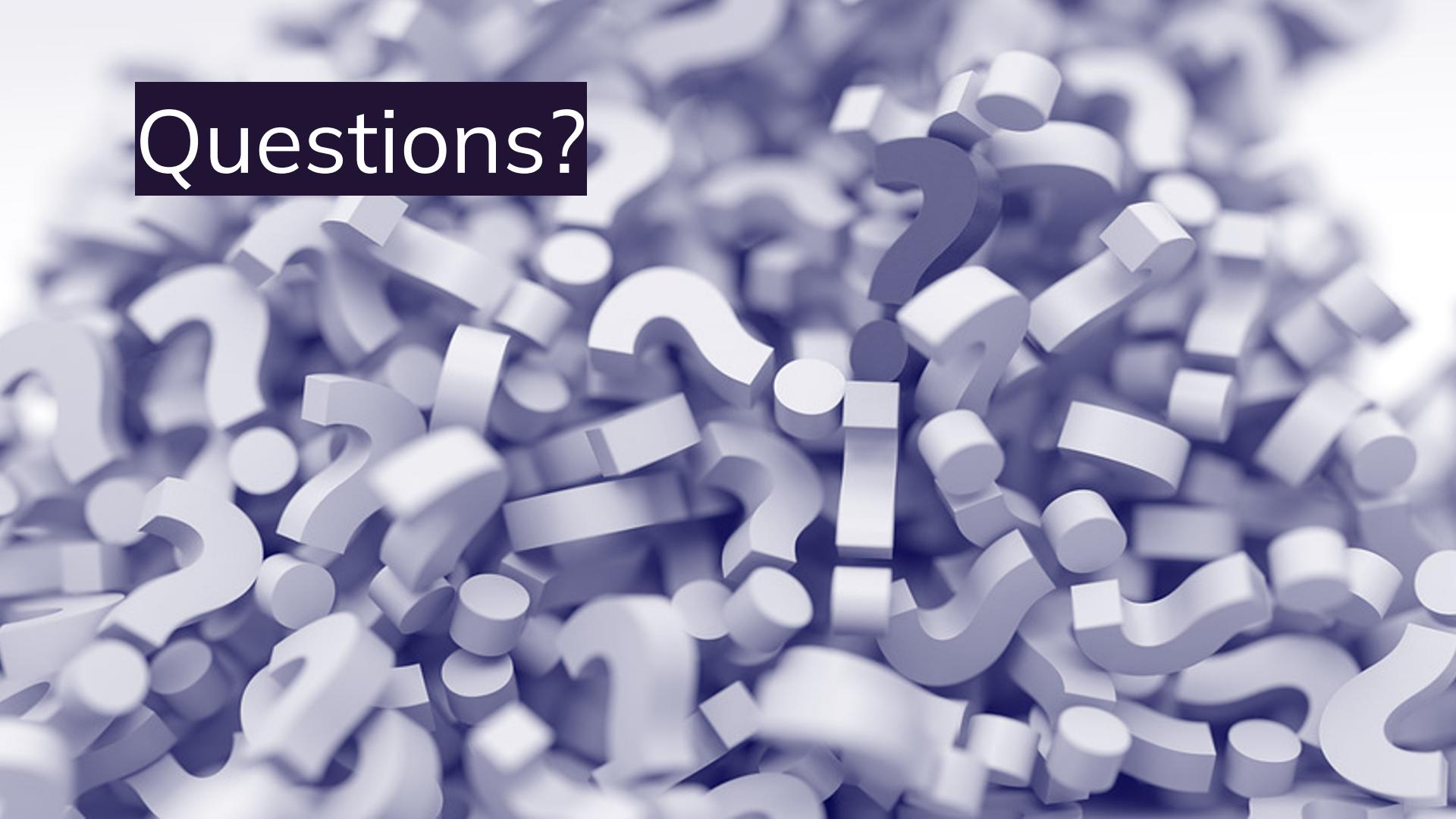
```
<!-- http://purl.obolibrary.org/obo/RD_0002259 -->
```

```
<owl:AnnotationProperty rdf:about="http://purl.obolibrary.org/obo/RD_0002259">
  <rdfs:subPropertyOf rdf:resource="http://www.geneontology.org/formats/oboInOwl#SubsetProperty"/>
</owl:AnnotationProperty>
```

„But this is another story and
shall be told another time.“

Michael Ende, The Neverending Story (1979)

Questions?



DISCLAIMER

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