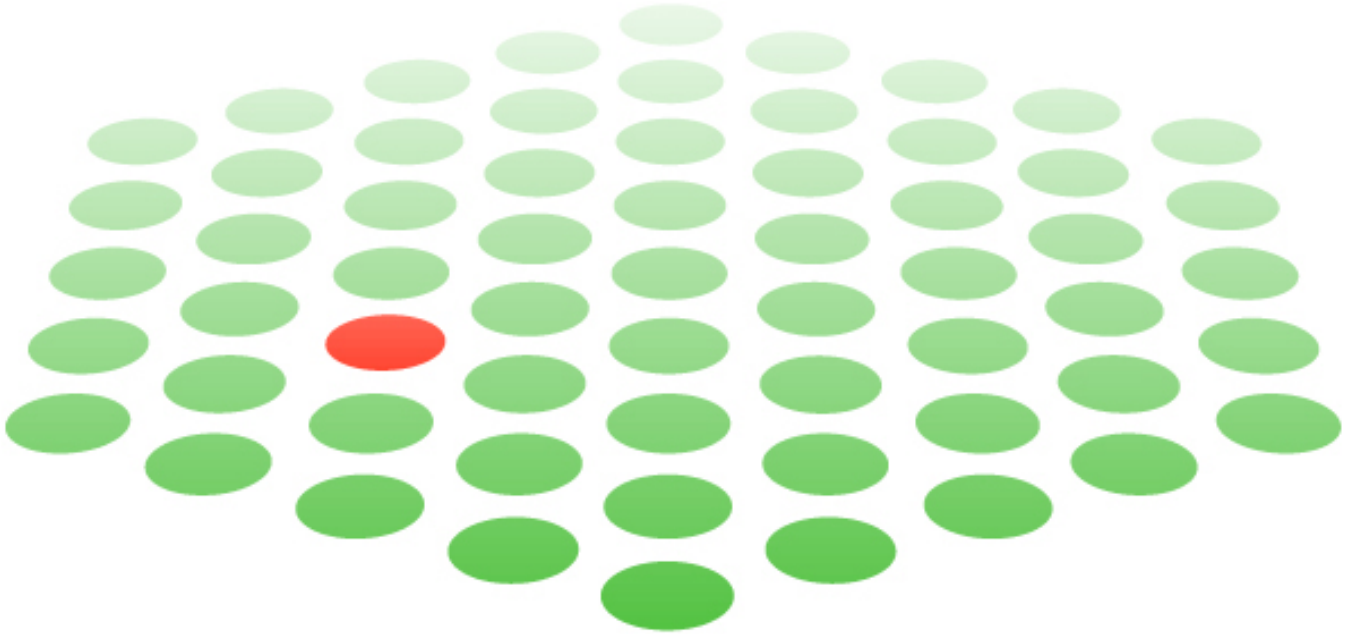
Biomedical literature mining

(and why we *really* need Open Access)



Lars Juhl Jensen
EMBL Heidelberg

why biomedicine?

why literature mining?

why open access?

MEDLINE

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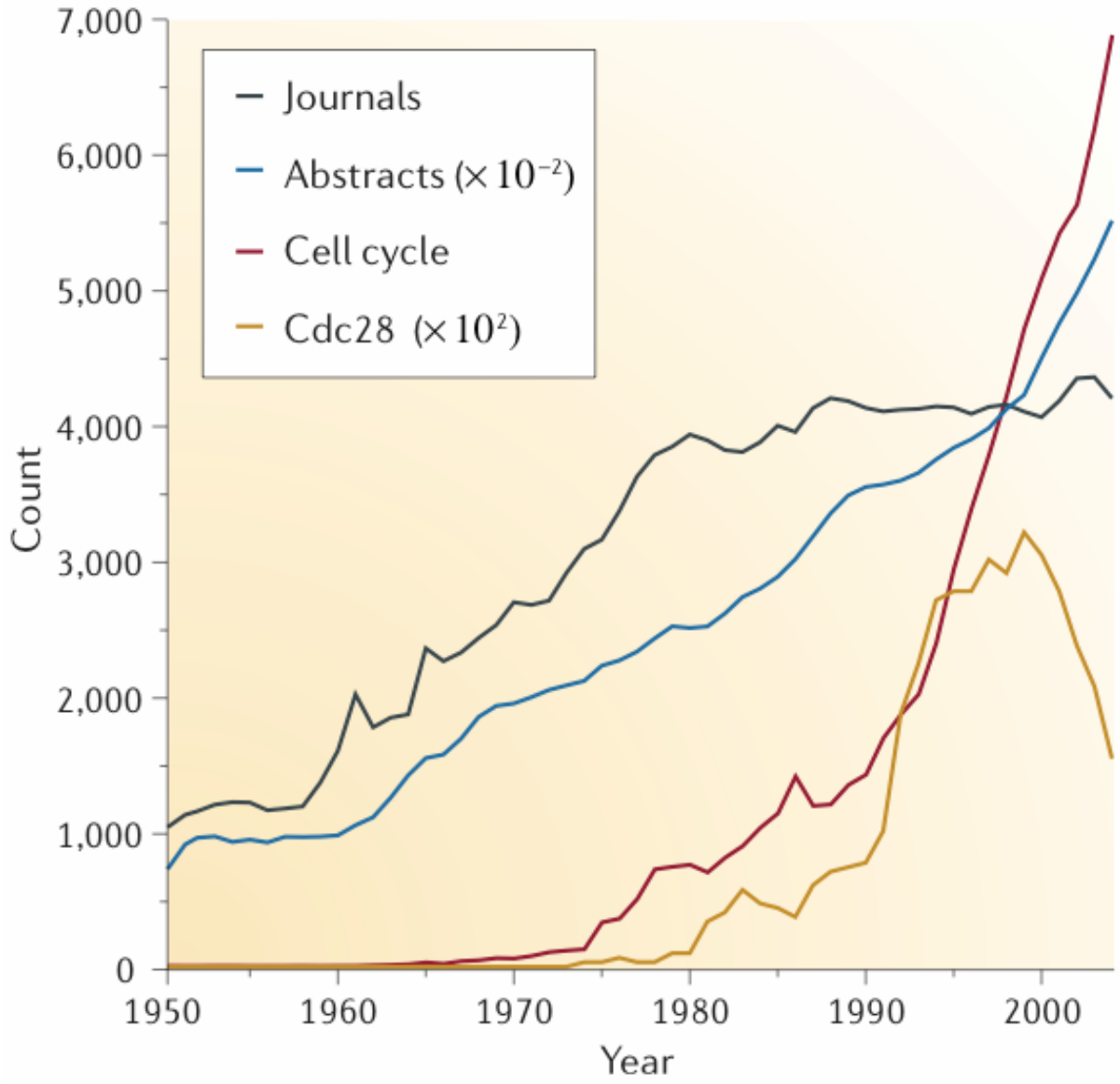

Jensen et al., Nature Reviews Genetics, 2006

too much to read

literature mining

open access

information retrieval

finding the papers

ad hoc retrieval

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users-specified query

“yeast AND cell cycle”

stemming

yeast / yeasts

dynamic query expansion

yeast / *S. cerevisiae*

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1: Homma MK, Wada I, Suzuki T, Yamaki J, Krebs EG, Homma Y. — Links

CK2 phosphorylation of eukaryotic translation initiation factor 5 potentiates cell cycle progression.
Proc Natl Acad Sci U S A. 2005 Oct 14; [Epub ahead of print]
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2: Leevers SJ, McNeill H. — Links

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3: Wu JQ, Pollard TD. — Related Articles, Links

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MEDLINE

abstracts

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Mitotic cyclin (Clb2)-bound Cdc28 (Cdk1 homolog) directly phosphorylated Swe1 and this modification served as a priming step to promote subsequent Cdc5-dependent Swe1 hyperphosphorylation and degradation

yeast?

cell cycle?

entity recognition

identifying the substance(s)

Mitotic cyclin (Clb2)-bound Cdc28 (Cdk1 homolog) directly phosphorylated Swe1 and this modification served as a priming step to promote subsequent Cdc5-dependent Swe1 hyperphosphorylation and degradation

Cdc28 $\Rightarrow$ yeast

Cdc28 $\Rightarrow$ cell cycle

good synonyms list

manual curation

orthographic variation

CDC28

Cdc28p

disambiguation

hairy

SDS

Cdc2

iHOP

information hyperlinked over proteins

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COCOON

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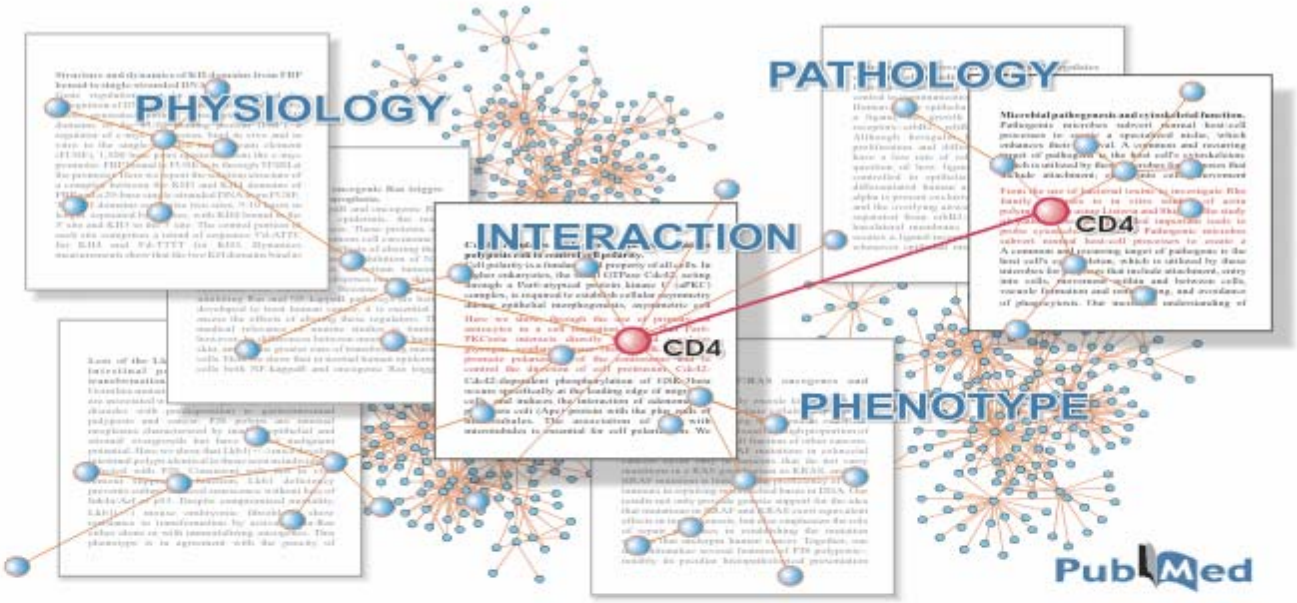
Concept & Implementation
by Robert Hoffmann



Hoffmann, R., Valencia, A. A Gene Network for Navigating the Literature. Nature Genetics 36, 664 (2004)

Search for a gene *synonym* or *accession number*... (Click here for an example: SNF1)

all fields in all organism

[SEARCH]

Symbol	Name	Synonyms	Organism
CDC28	Cell division control protein 28	CDK1, HSL5, SRM5, YBR1211, YBR160W	Saccharomyces cerevisiae

UniProt	P00546
IntAct	P00546
NCBI Gene	852457
NCBI RefSeq	NP_009718
NCBI Accession	CAA25065, CAA56509, CAA85119

Homologues of CDC28 ... new

Definitions for CDC28 ...

Enhanced PubMed/Google query ... new

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Furthermore, SW14 associates with CLB2 protein and is a substrate for the CLB2-**associated** CDC28 kinase in vitro.

Furthermore, the Cks1 protein was shown to be physically **associated** with active forms of the Cdc28 protein kinase.

The cyclin-dependent kinase Cdc28p **associates** with the cyclin Clb2p to induce mitosis in the yeast Saccharomyces cerevisiae.

We find that G1 arrest in the cdc37-1 mutant is accompanied by a decrease in the Cdc28 activity **associated** with the G1 cyclin Cln2.

We found that Hct1 was **phosphorylated** in vivo at multiple CDK consensus sites during cell cycle stages when activity of the cyclin-dependent kinase Cdc28 is high and APC activity is low.

It is likely, therefore, that Cks1 mediates a more specialized **function** of the Cdc28 kinase such as its ability to form specific multimeric complexes or to localize properly in cellular compartments.

Cdc37 **promotes** the stability of protein kinases Cdc28 and Cak1.

In addition, Cdc37 **promotes** the production of Cak1, but not that of Cdc28, when coexpressed in insect cells.

The B-type cyclins Clb5 and Clb6 are the primary activators of the S phase **function** of the budding yeast CDK Cdc28.

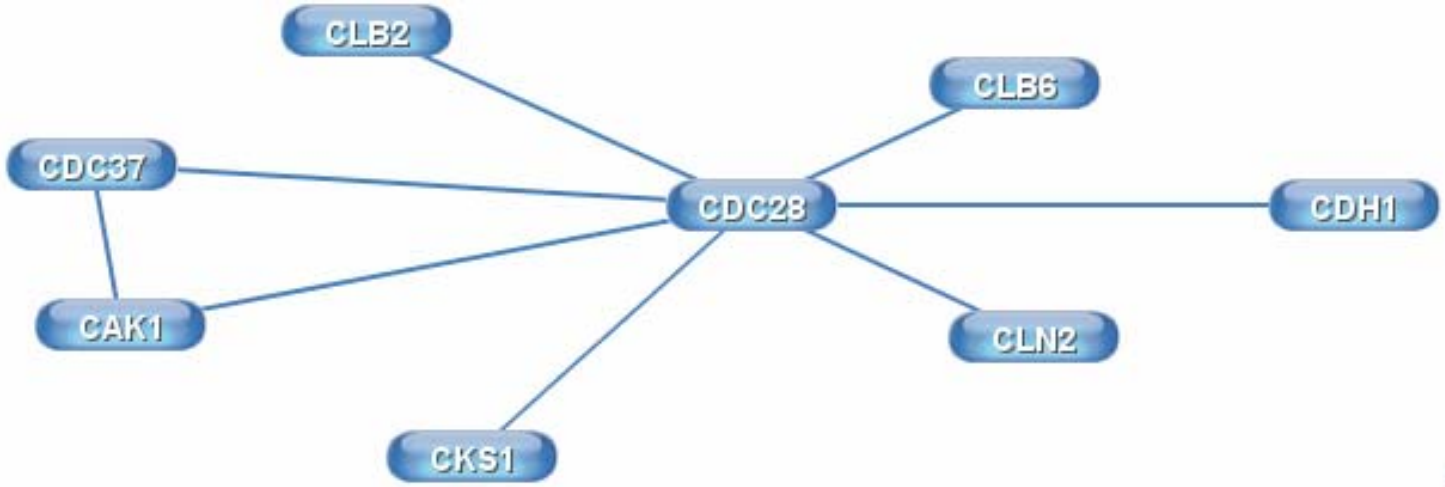
All three cak1 mutants displayed significant synthetic interactions with loss-of-**function** mutations in CDC28 and KIN28.

abstracts

complete papers

information extraction

formalizing the facts



[Redo graph layout]

The B-type cyclins Clb5 [CLB5] and Clb6 [CLB6] are the primary activators of the S phase **function** of the budding yeast CDK Cdc28 [CDC28].

Furthermore, SW14 associates with CLB2 [CLB2] protein and is a substrate for the CLB2-**associated** CDC28 [CDC28] kinase in vitro.

The cyclin-dependent kinase Cdc28 [CDC28]p **associates** with the cyclin Clb2 [CLB2]p to induce mitosis in the yeast Saccharomyces cerevisiae.

In addition, Cdc37 [CDC37] **promotes** the production of Cak1 [CAK1], but not that of Cdc28 [CDC28], when coexpressed in insect cells.

We found that Hct1 [CDH1] was **phosphorylated** in vivo at multiple CDK consensus sites during cell cycle stages when activity of the cyclin-dependent kinase Cdc28 [CDC28] is high and APC activity is low.

All three cak1 [CAK1] mutants displayed significant synthetic interactions with loss-of-**function** mutations in CDC28 [CDC28] and KIN28 [KIN28].

Cdc37 [CDC37] **promotes** the stability of protein kinases Cdc28 [CDC28] and Cak1 [CAK1].

Furthermore, the Cks1 [CKS1] protein was shown to be physically **associated** with active forms of the Cdc28 [CDC28] protein kinase.

We find that G1 arrest in the cdc37-1 mutant is accompanied by a decrease in the Cdc28 [CDC28] activity **associated** with the G1 cyclin Cln2 [CLN2].

It is likely, therefore, that Cks1 [CKS1] mediates a more specialized **function** of the Cdc28 [CDC28] kinase such as its ability to form specific multimeric complexes or to localize properly in cellular compartments.

co-mentioning

statistical methods

NLP

Natural Language Processing

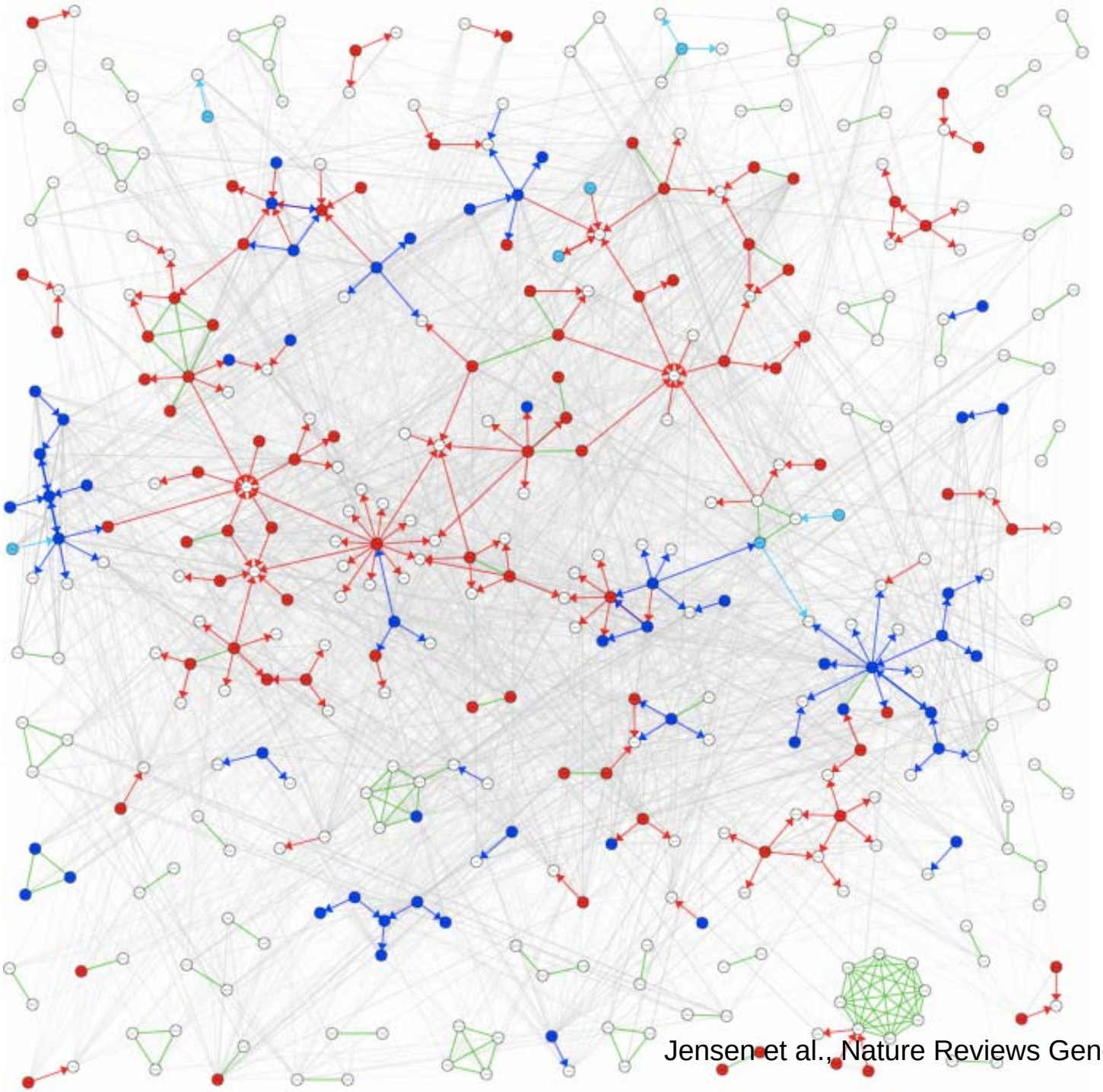
Gene and protein names

Cue words for entity recognition

Verbs for relation extraction

[nxexpr The expression of
[nxgene the cytochrome
genes
[nxpg CYC1 and CYC7]]]
is controlled by
[nxpg HAP1]

Mitotic cyclin (Clb2)-bound Cdc28 (Cdk1 homolog) directly phosphorylated Swe1 and this modification served as a priming step to promote subsequent Cdc5-dependent Swe1 hyperphosphorylation and degradation



Jensen et al., Nature Reviews Genetics, 2006

new discoveries

text mining

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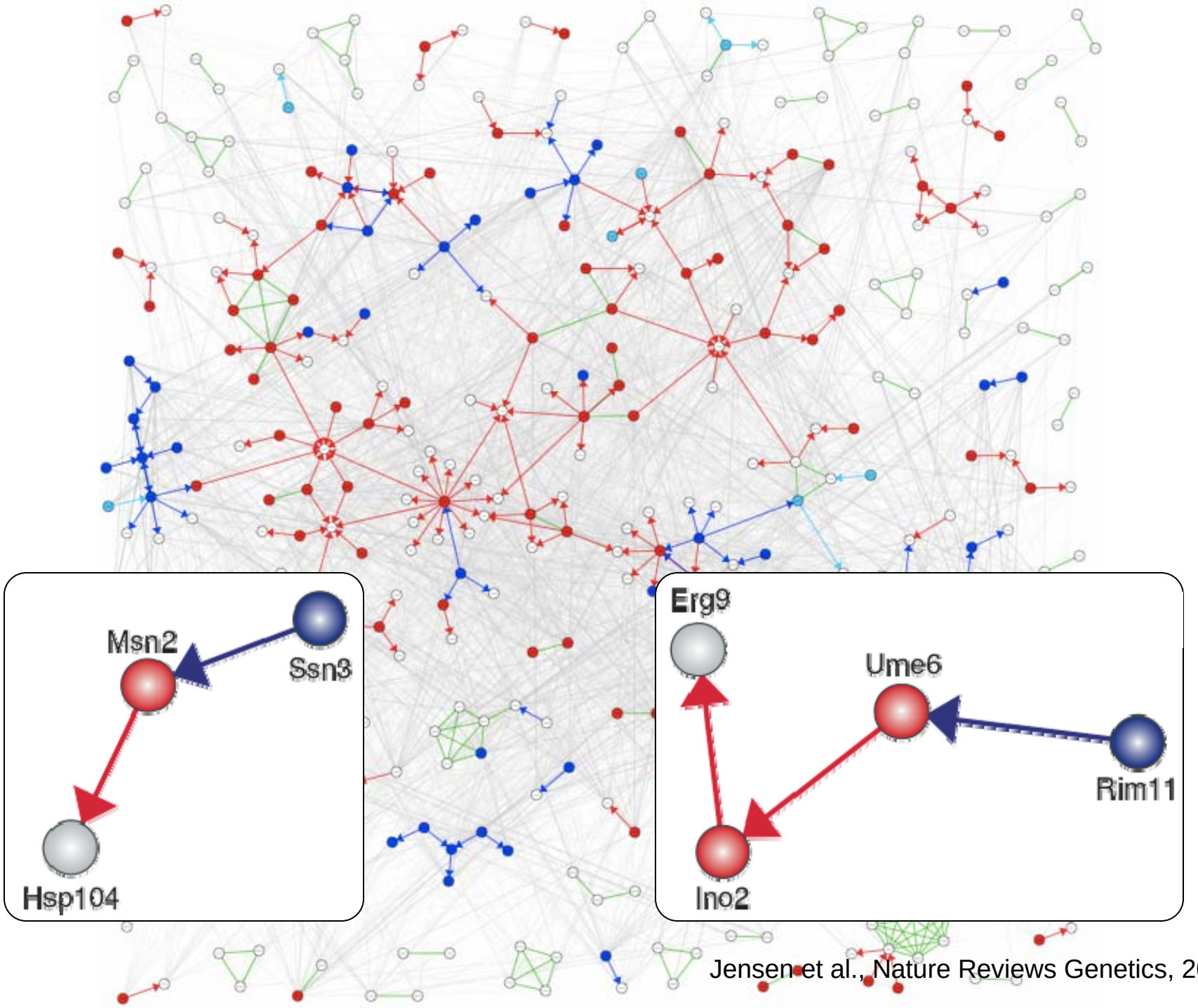

Jensen et al., Nature Reviews Genetics, 2006

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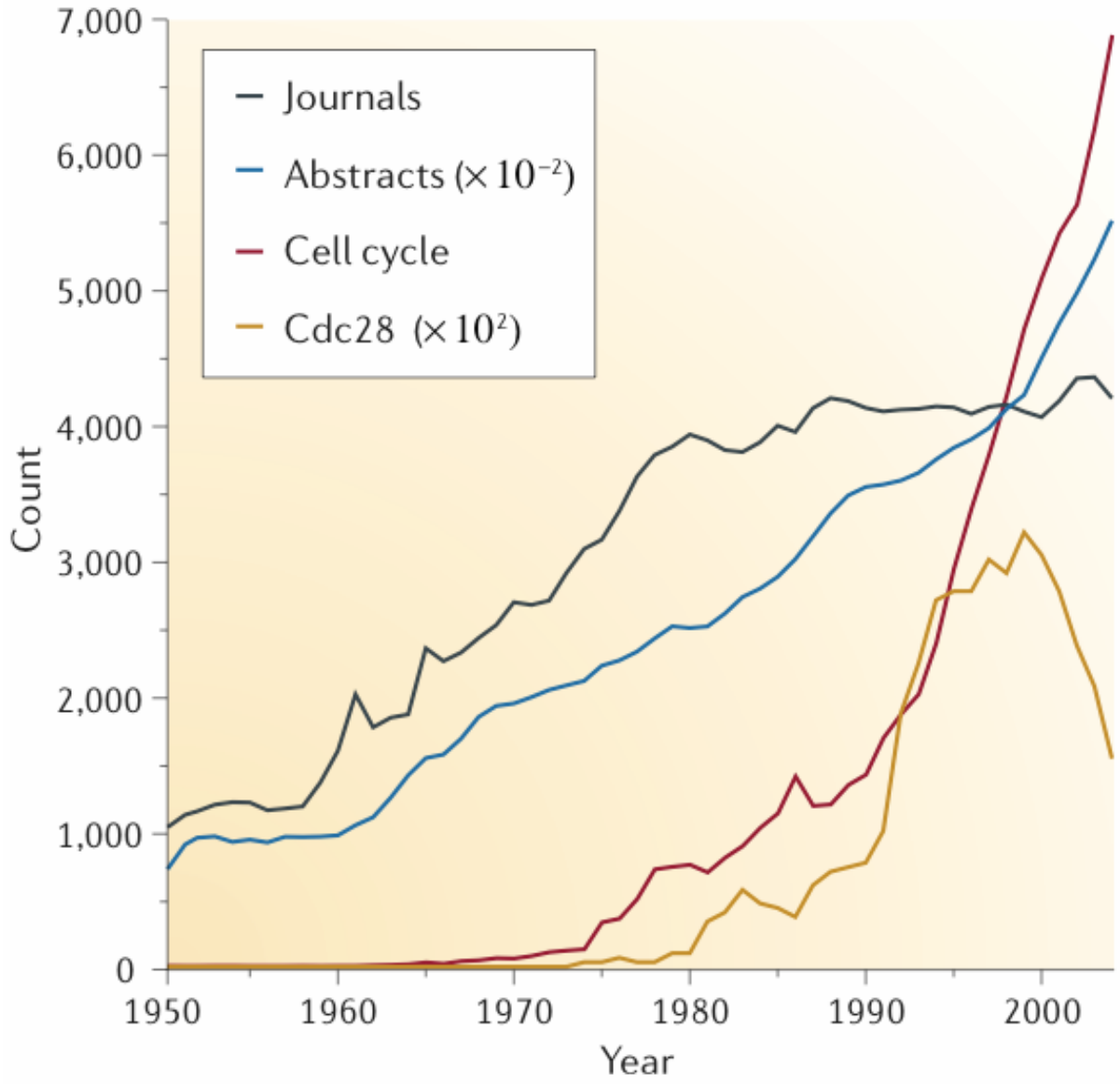

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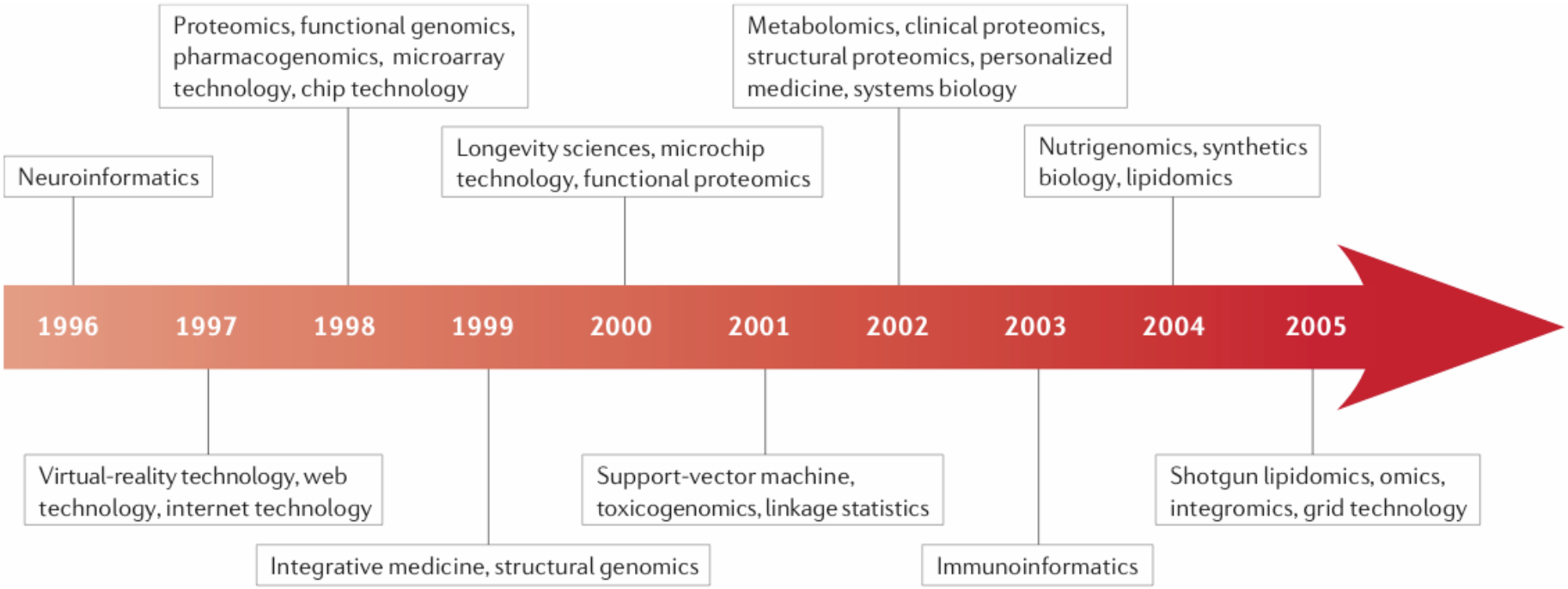
buzzwords



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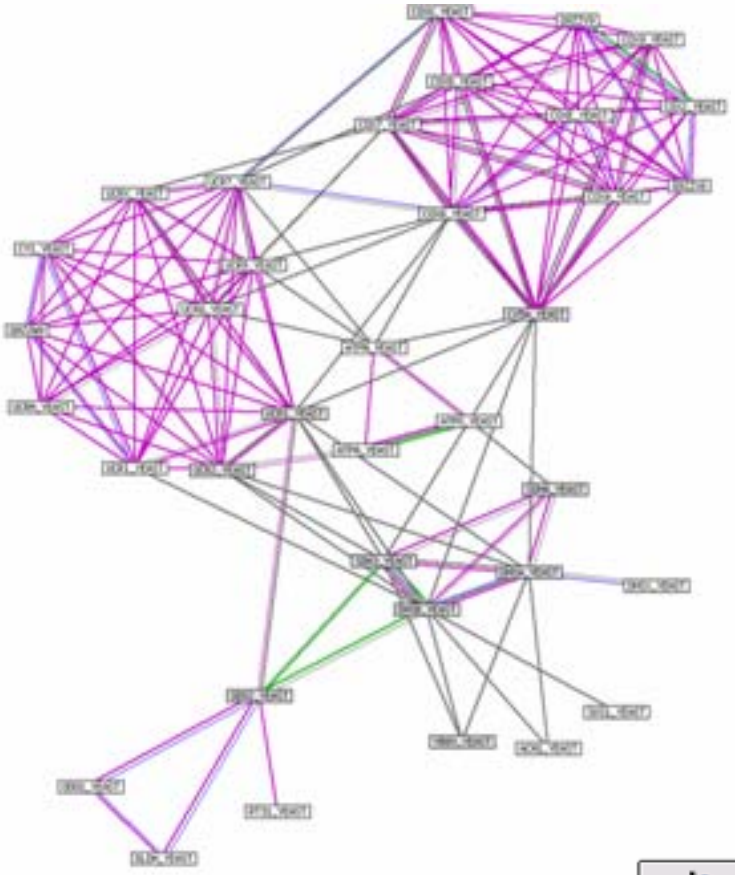

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Gene fusions

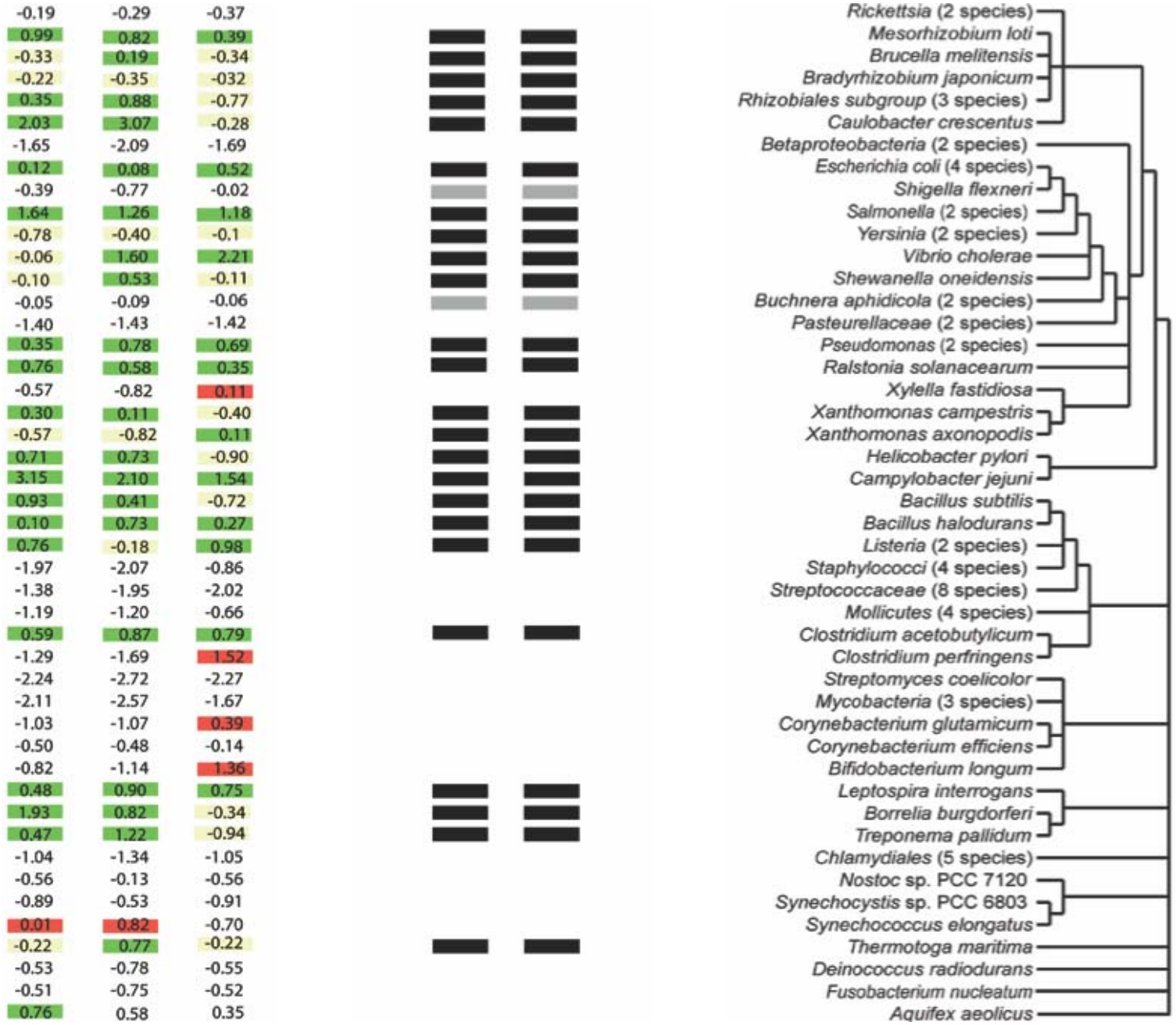
Experimental interaction data

Microarray expression data

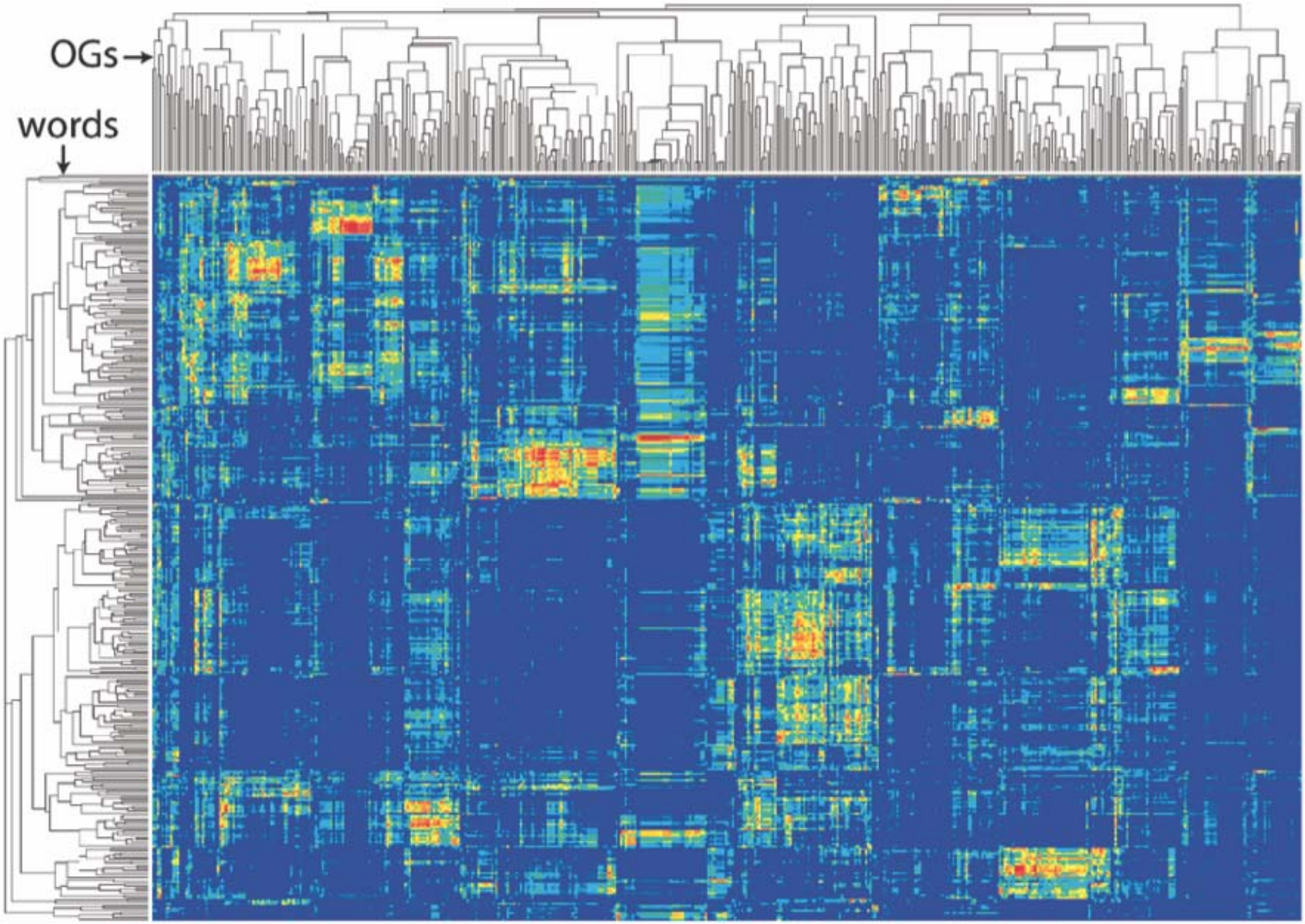
Database imports

Literature mining

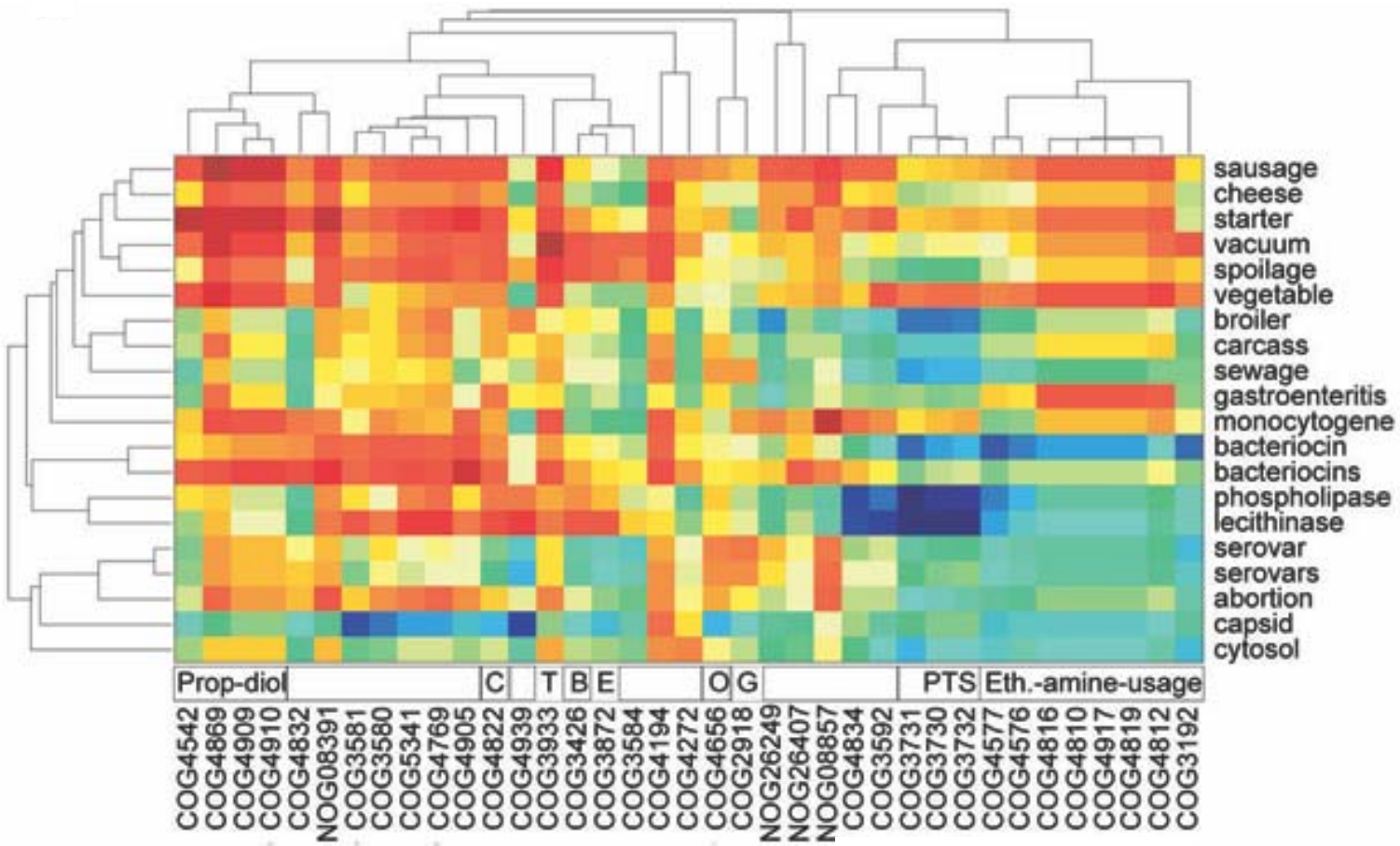
genotype to phenotype



Korbel et al., PLoS Biology, 2005

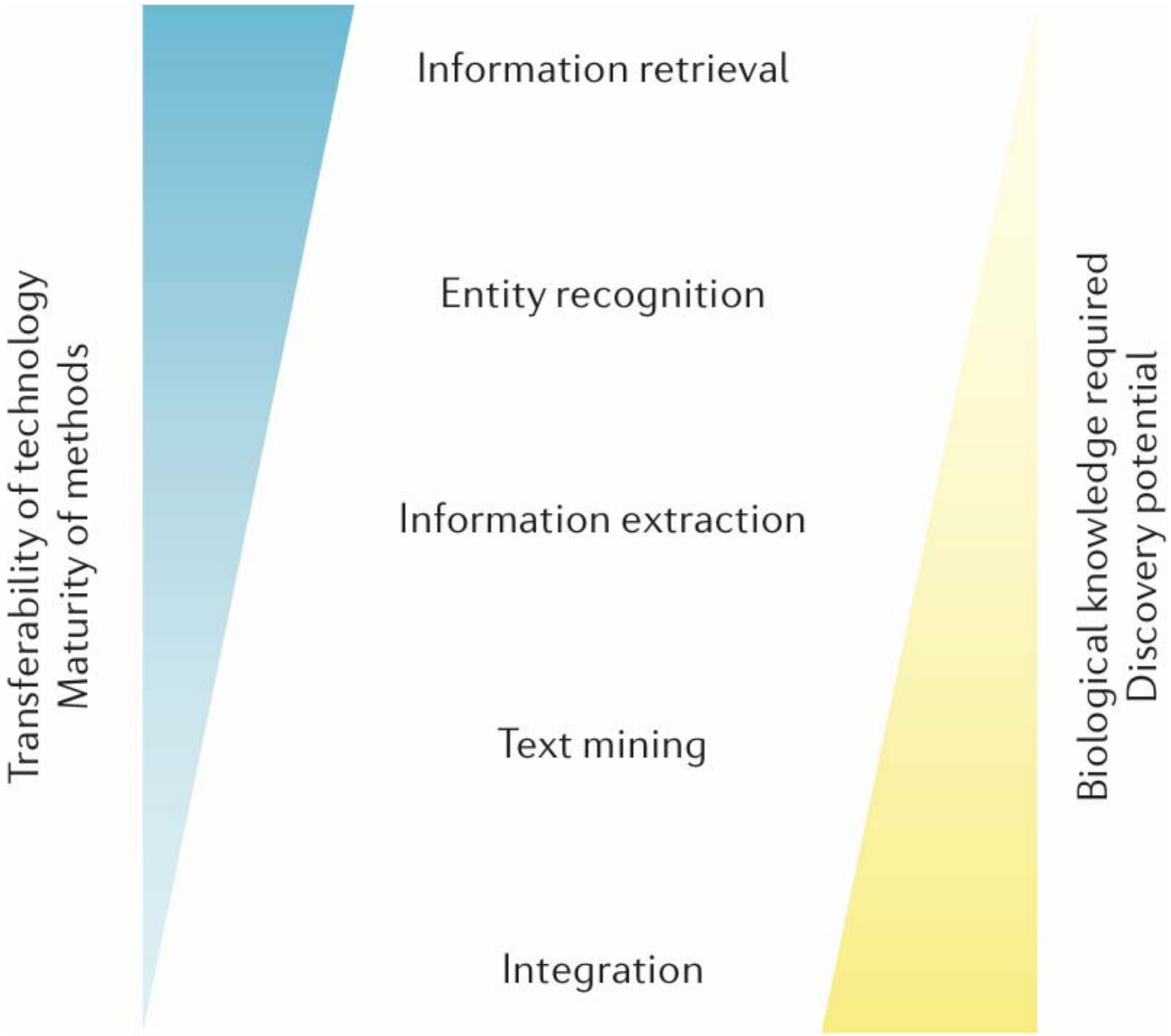


Korbel et al., PLoS Biology, 2005



Korbel et al., PLoS Biology, 2005

where are we now?



Jensen et al., Nature Reviews Genetics, 2006

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restricted access

open access

the tools are there

now we need the text!

Acknowledgments

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Miguel Andrade
Peer Bork