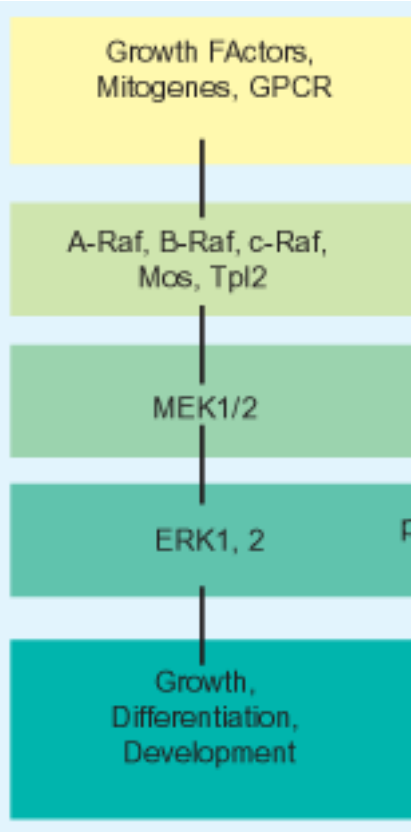
The Systems Biology Graphical Notation

Nicolas Le Novère, EMBL-EBI

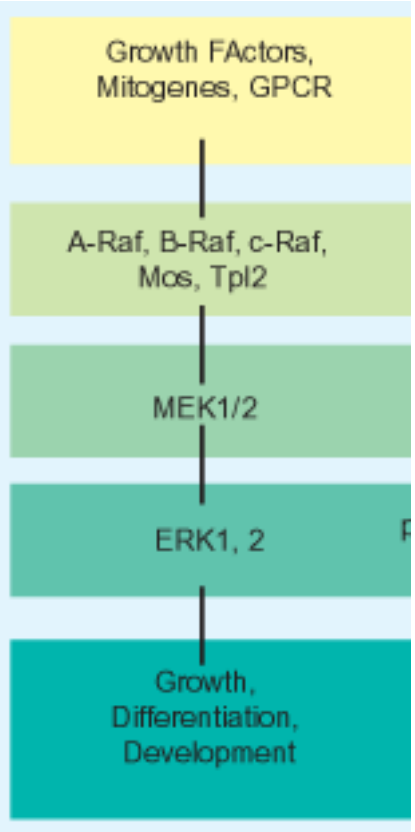
(on the behalf of SBGN editors, authors and contributors)

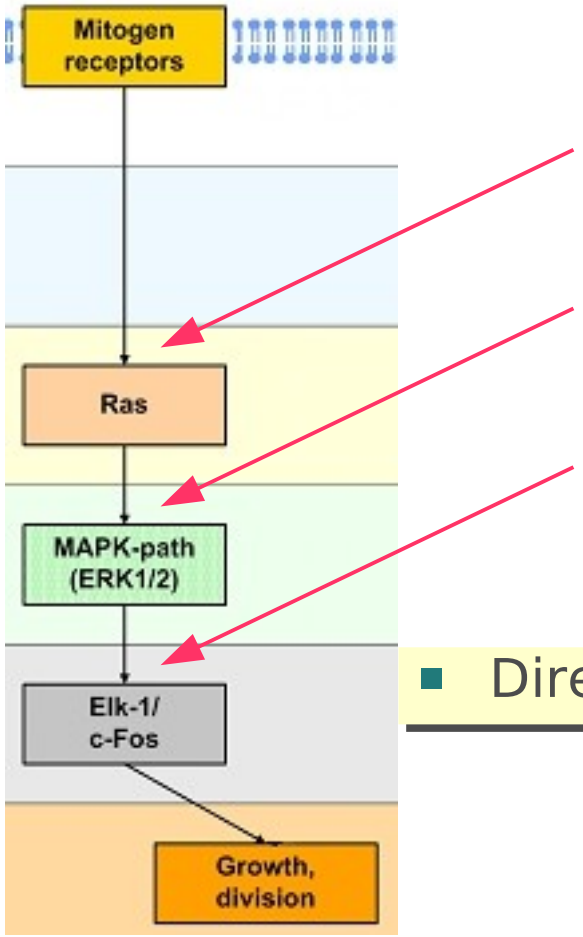
Different representations of a pathway



- No temporal sequence
- No directionality
- No biochemical effects
- No mechanistic descriptions

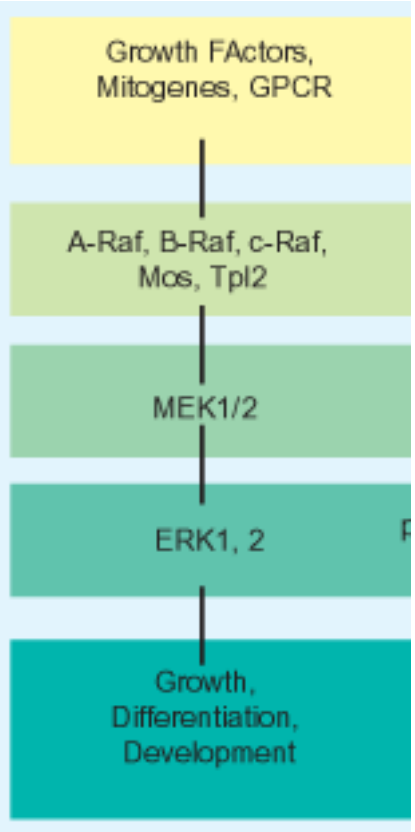
Different representations of a pathway

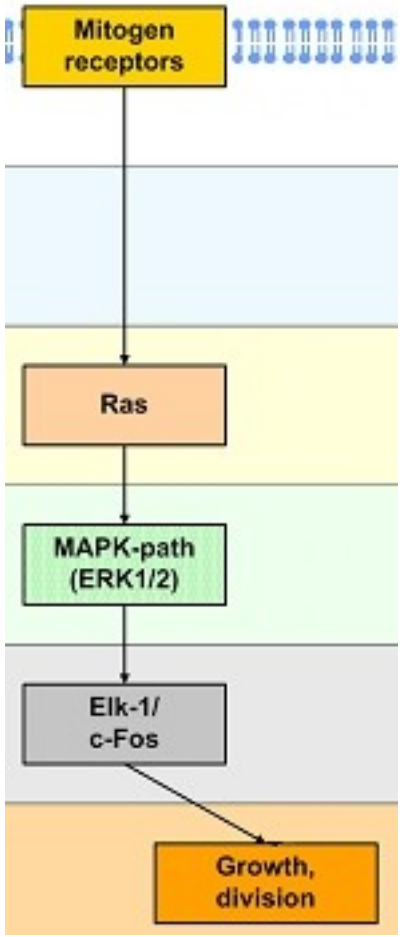


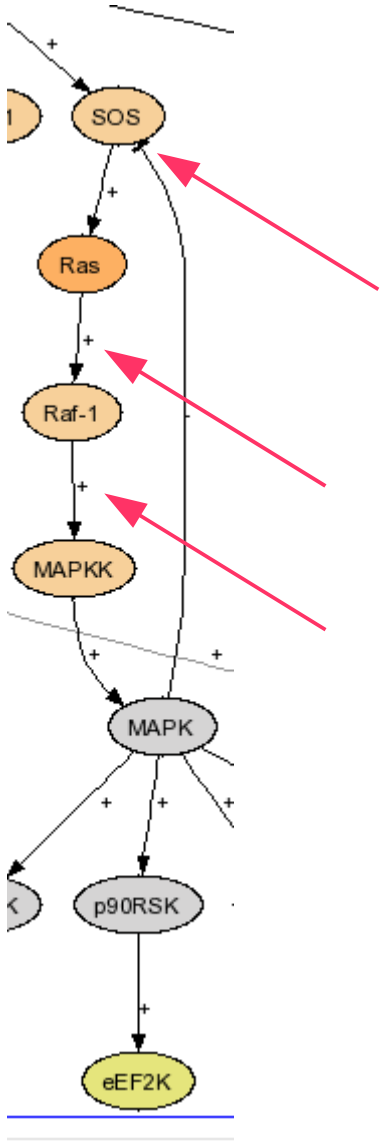


- Directionality of influence

Different representations of a pathway

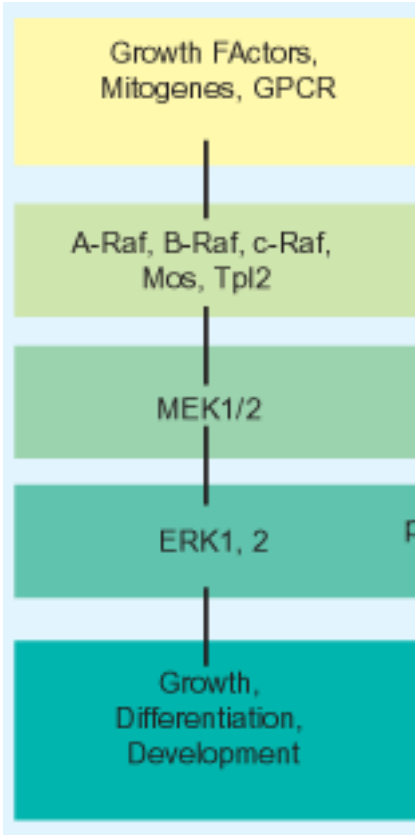


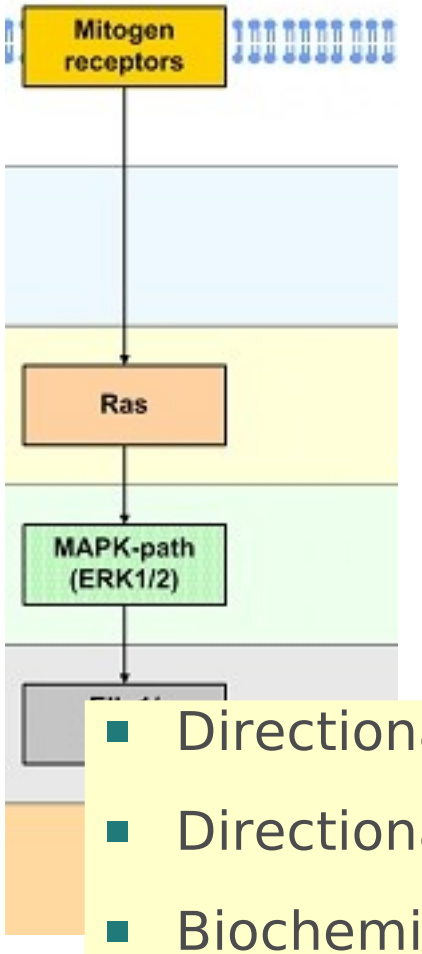


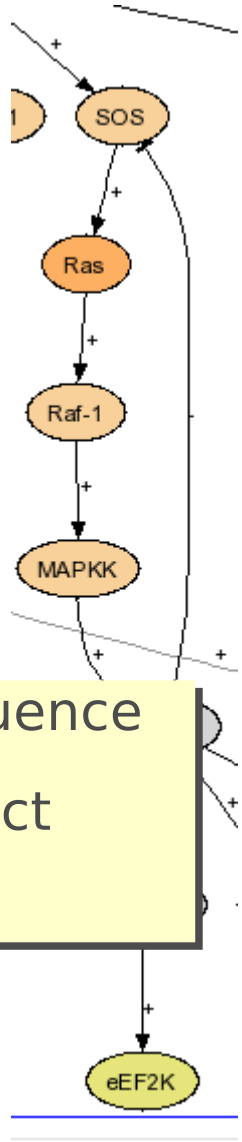


- Directionality of influence
- Directionality of effect

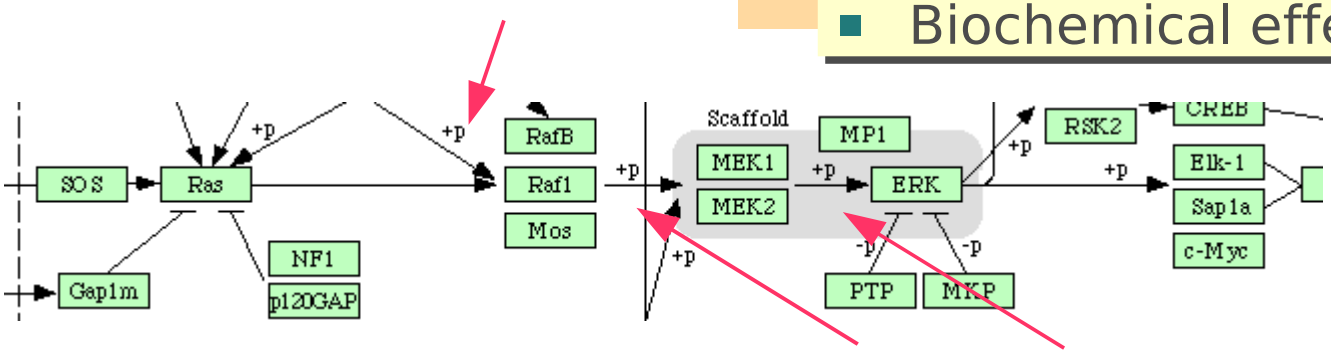
Different representations of a pathway



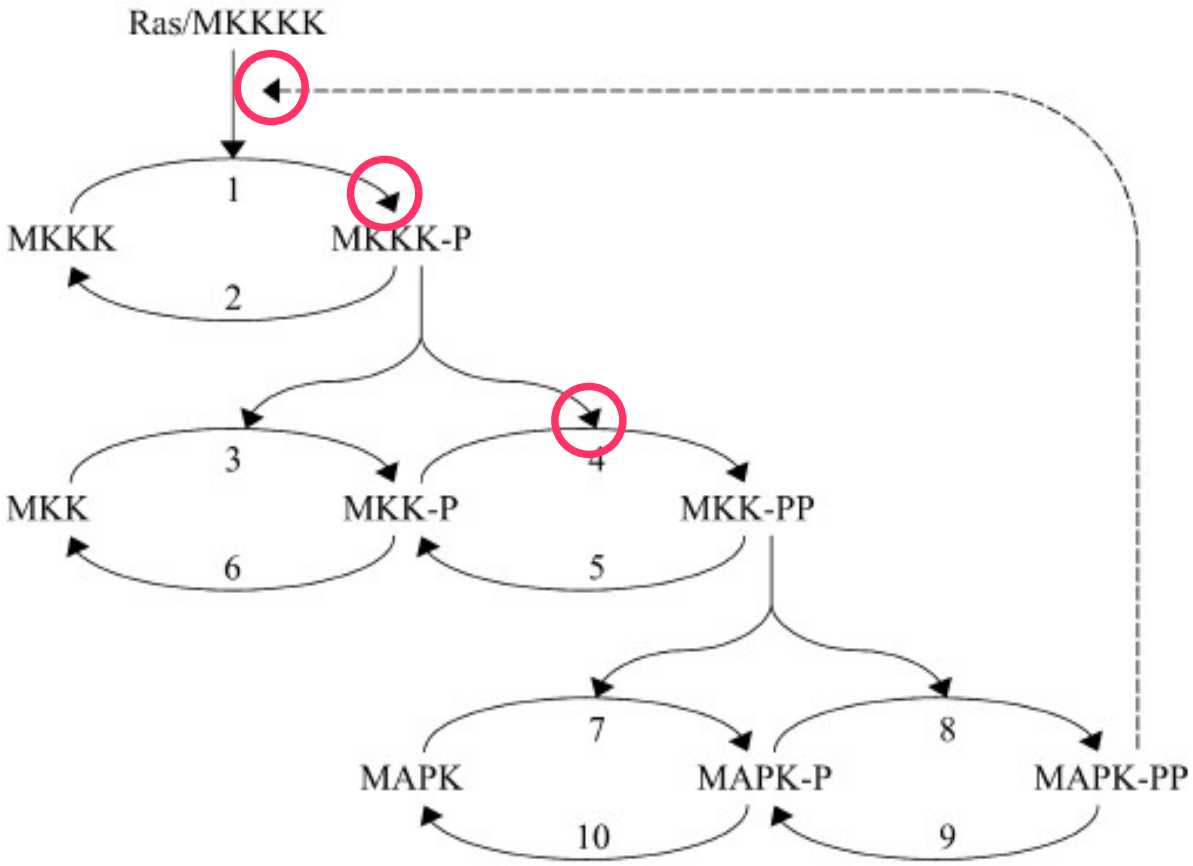




- Directionality of influence
- Directionality of effect
- Biochemical effect



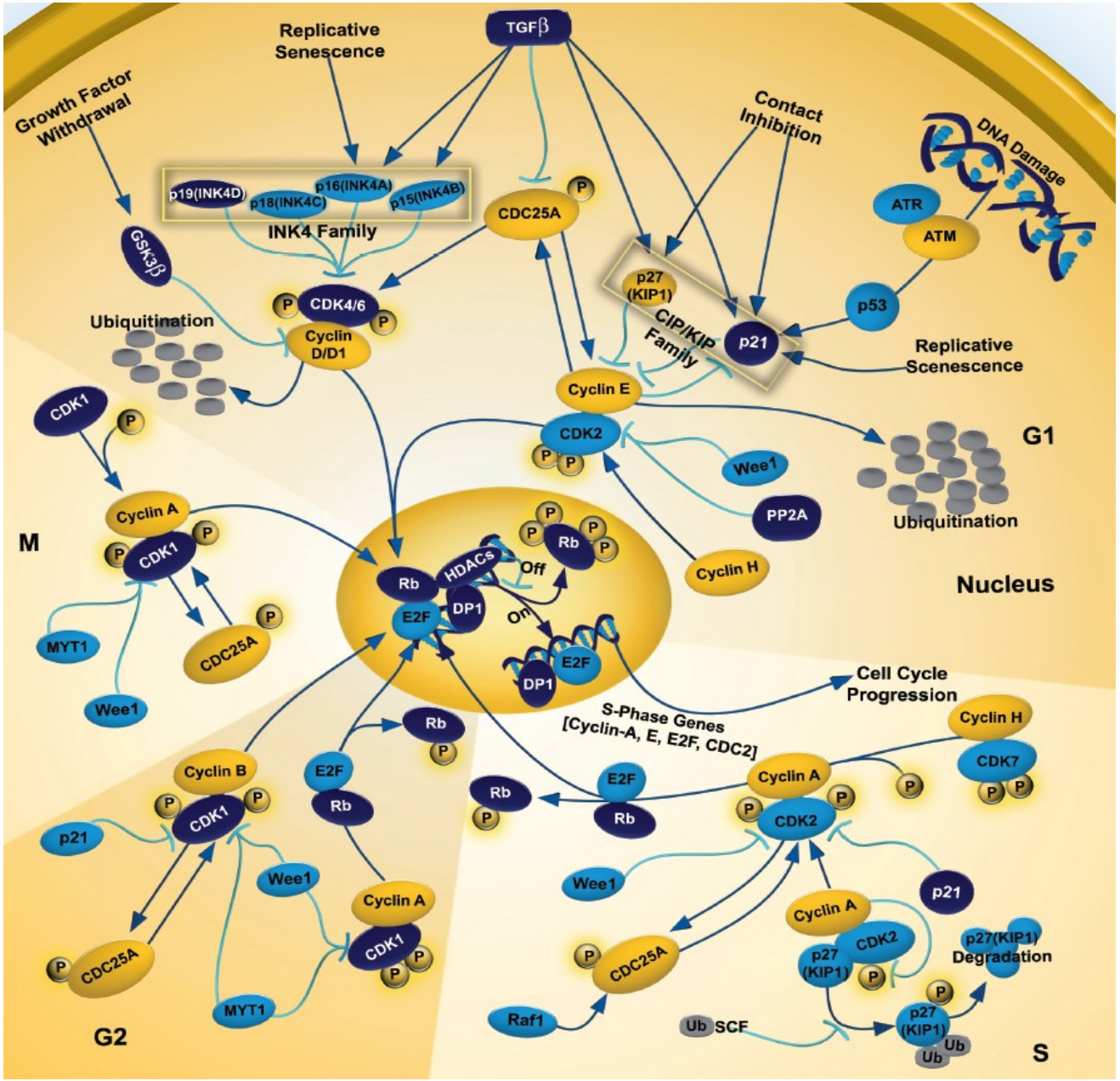
Different representations of a pathway



THREE *different* meanings for ONE symbol!

- Transition
- catalysis
- inhibition

Can-this be understood by biologists?



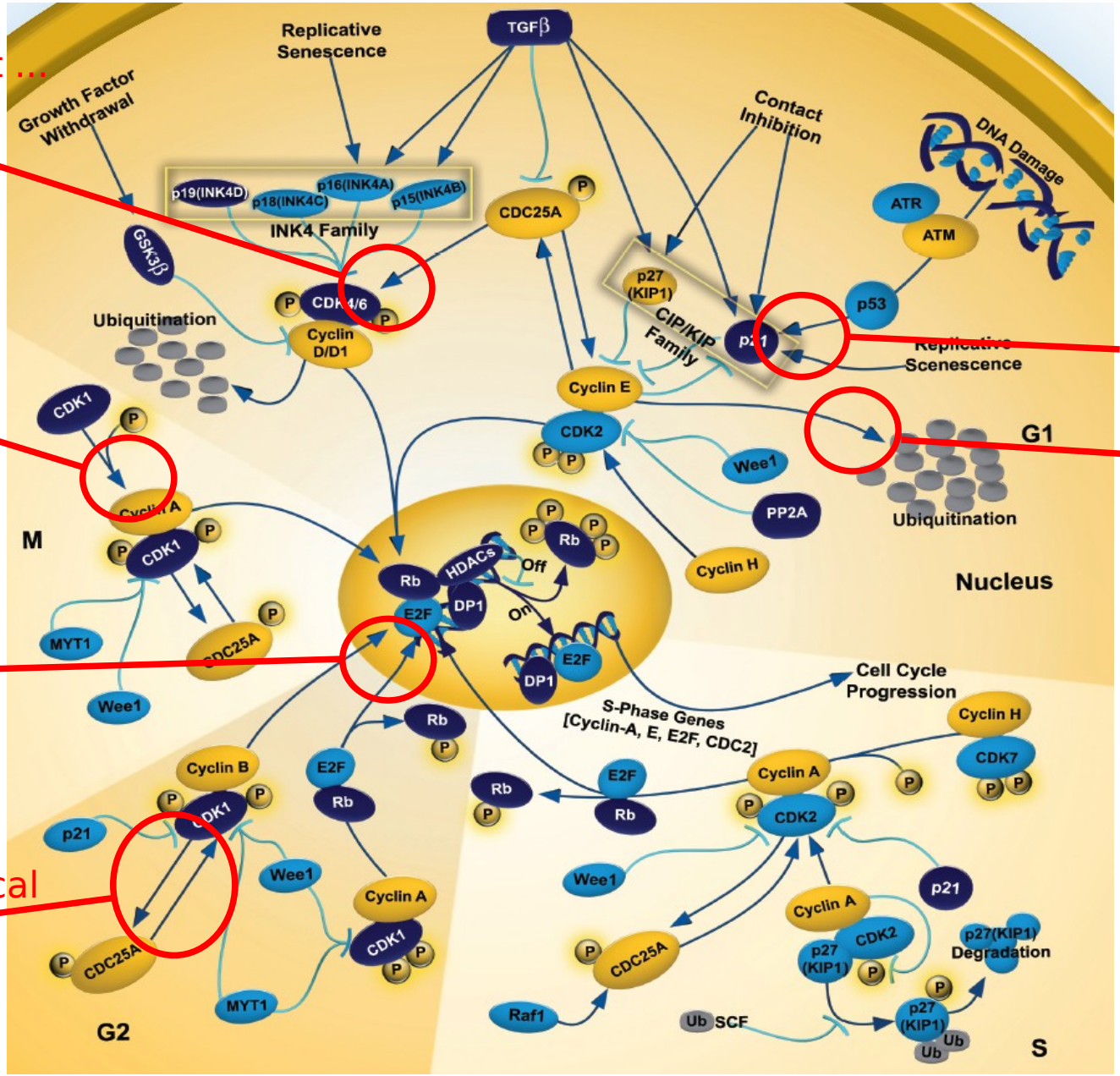
Can-this be understood by biologists?

Stimulates? but … what exactly?

Associates into?

Translocates?

No idea. Reciprocal stimulation?

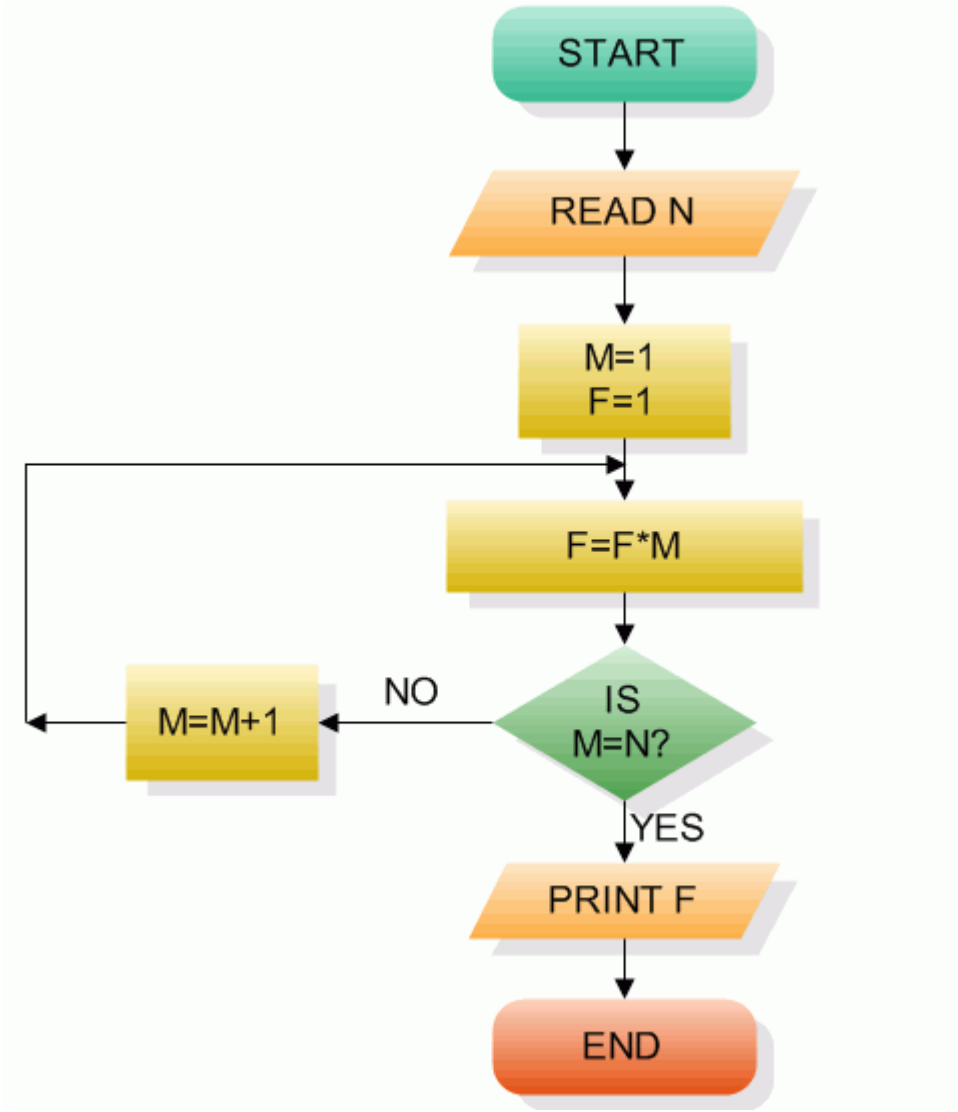


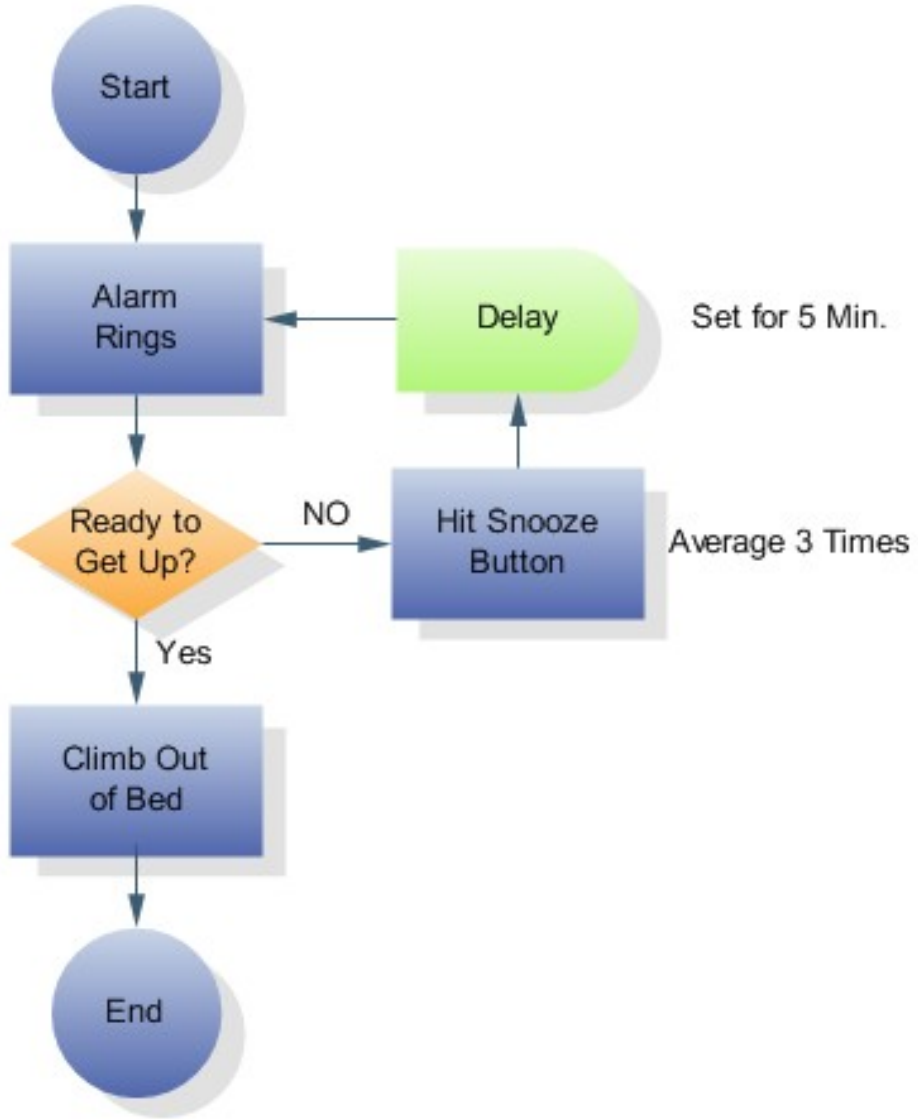
Associates into?

Stimulates gene transcription?

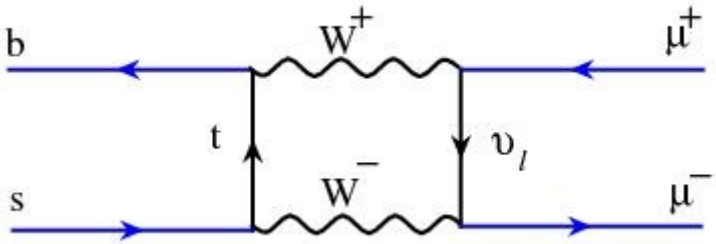
Is degraded?

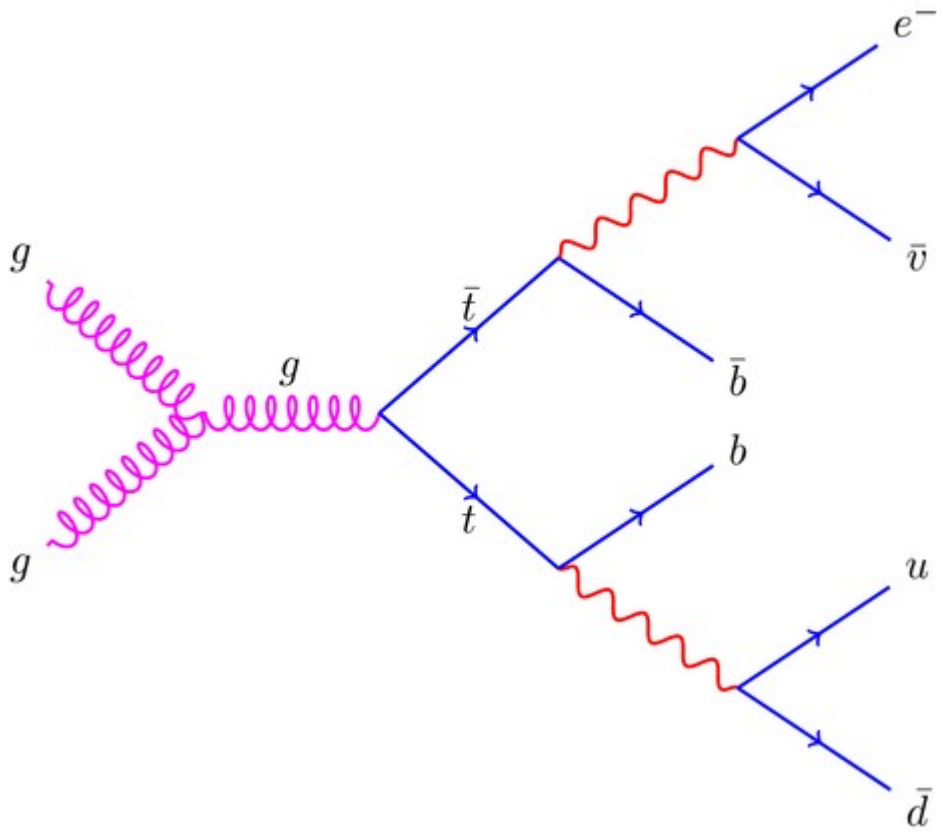
Every computer scientist understands those



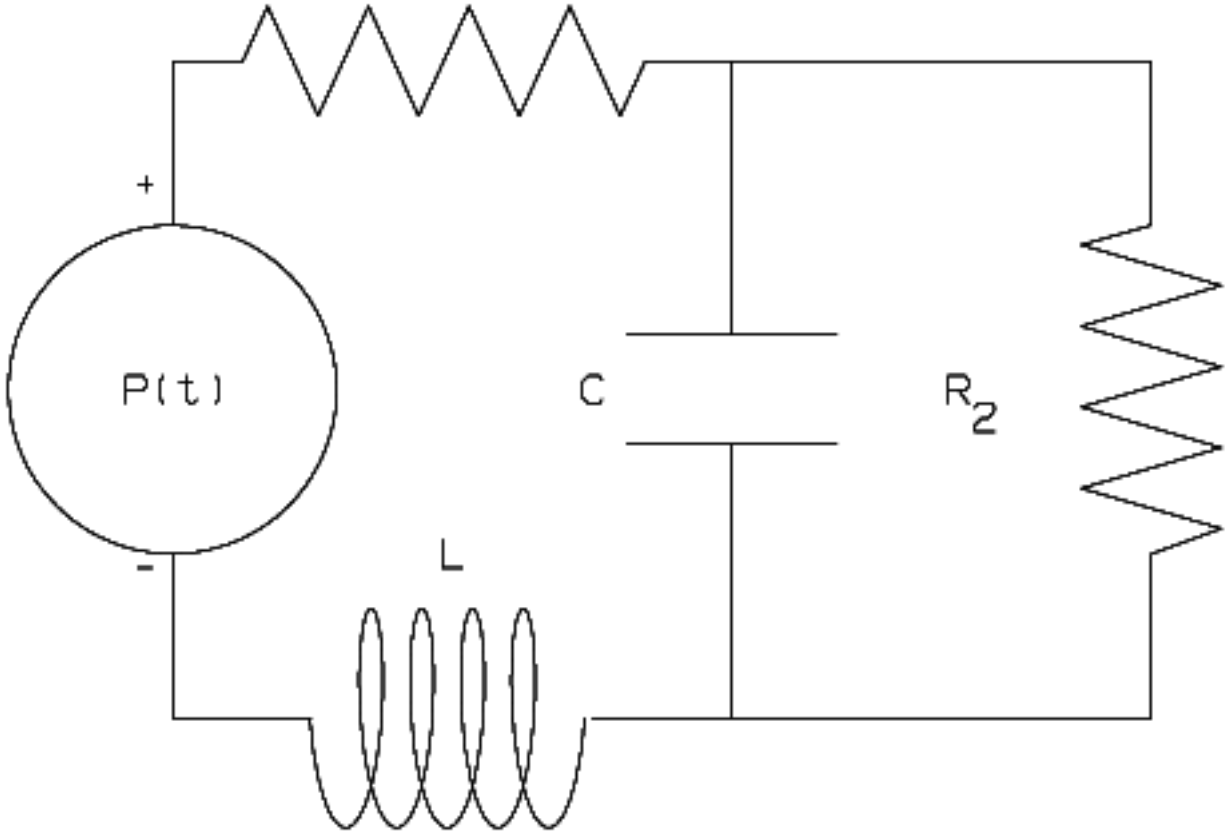


Every physicist understands those

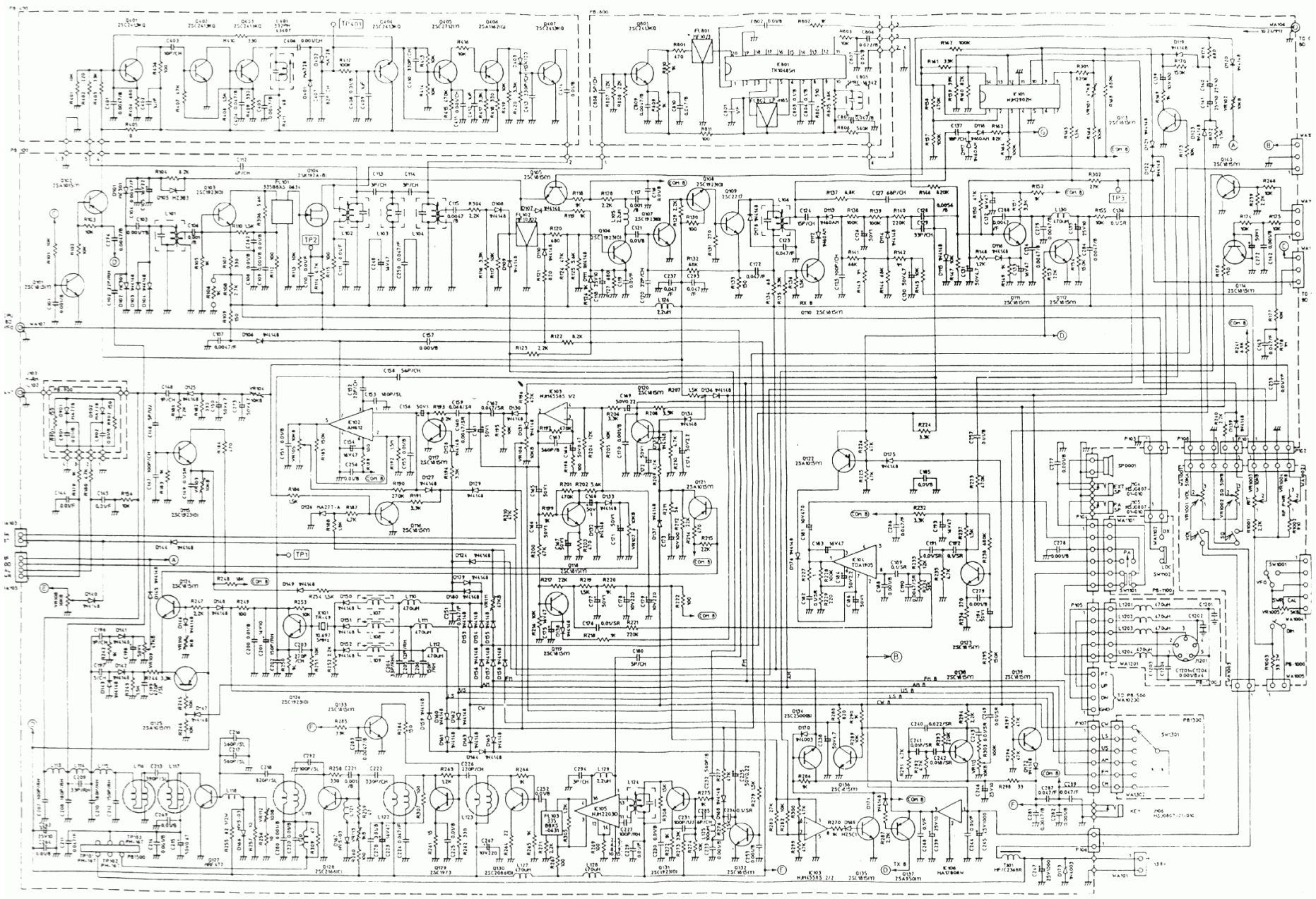




Every engineer understands that



Or that

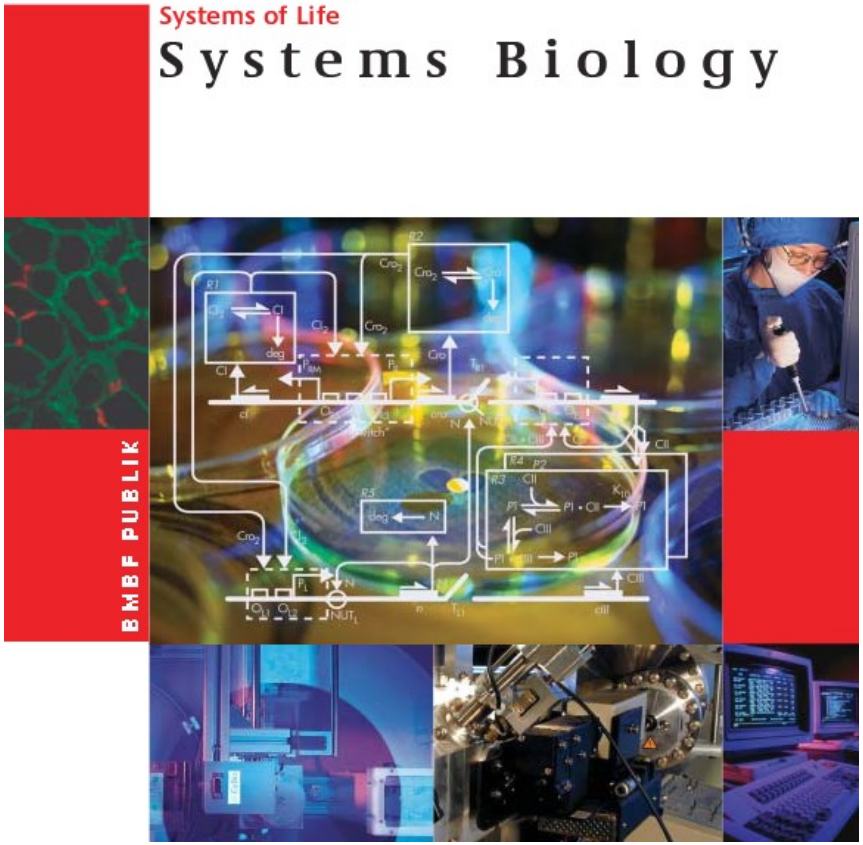


What did-those diagram bring?

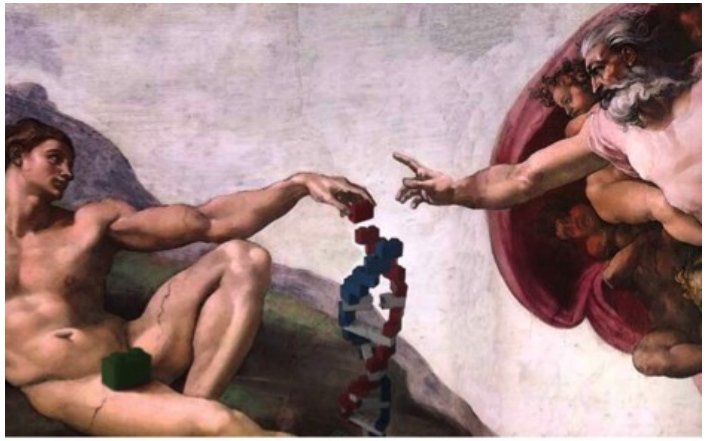
What do-we expect in modern (future) life science

Federal Ministry
of Education
and Research

Basic science



Technology



EXTREME GENETIC ENGINEERING

An Introduction to Synthetic Biology

etc group

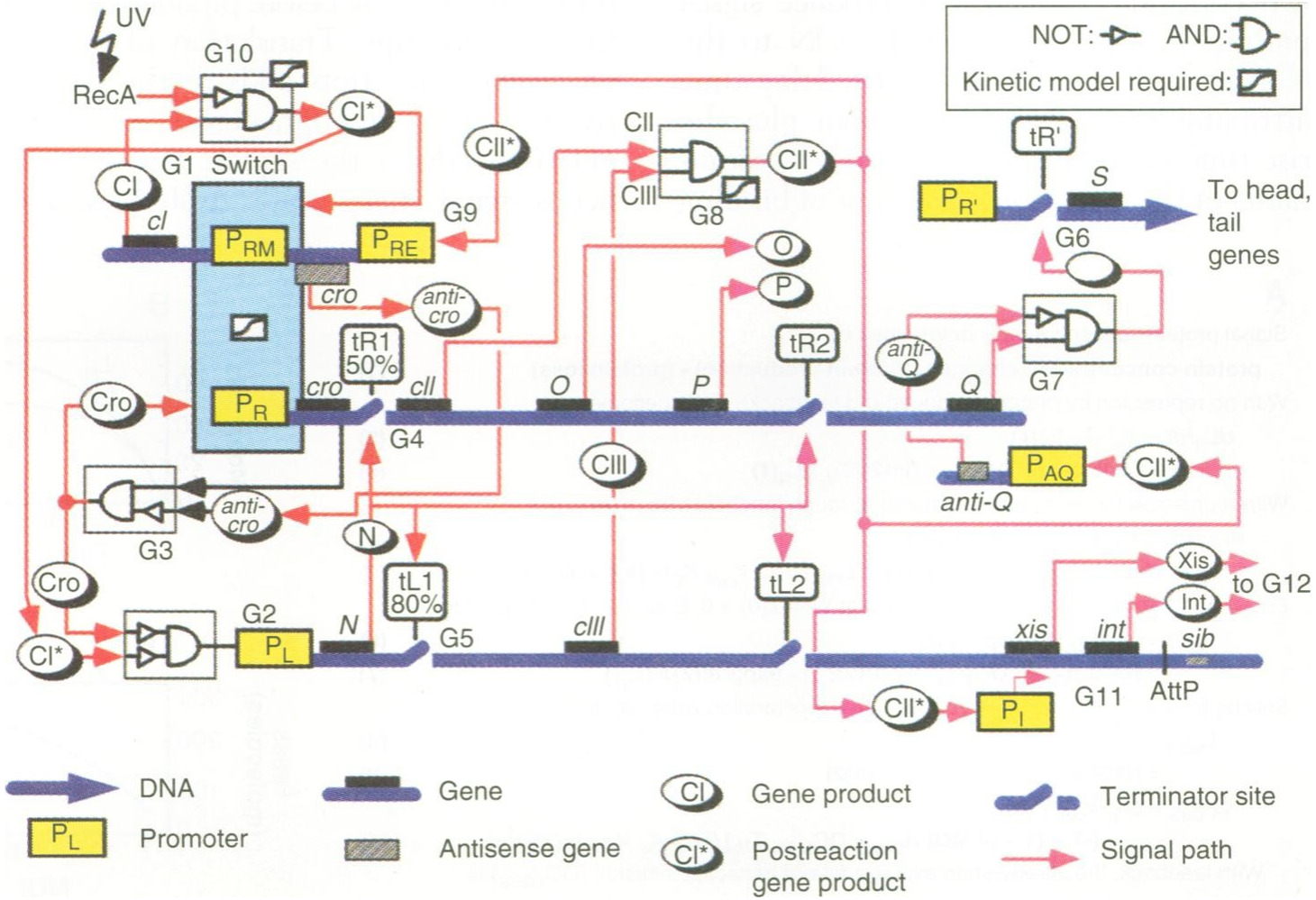
January 2007

GN

Why can-we understand electric diagrams?

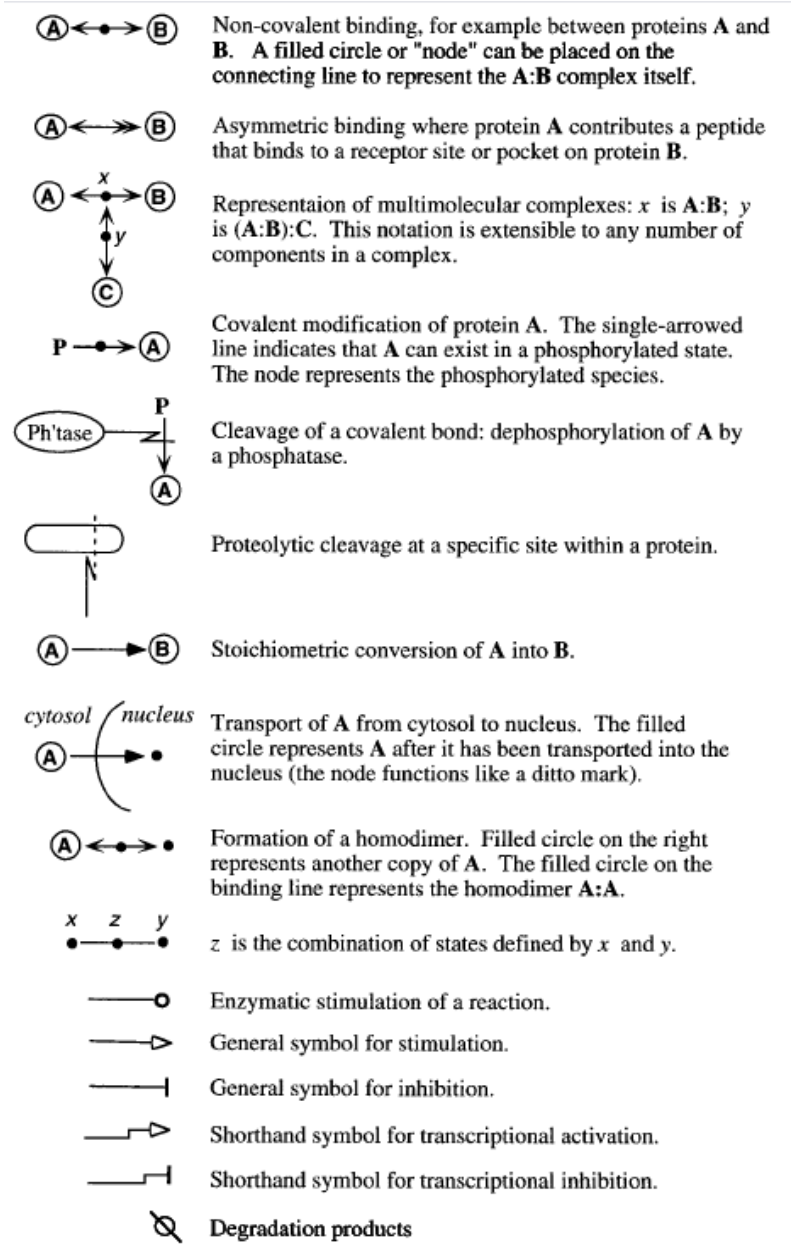
- Standard symbols
  - Simple shapes, easily recognisable
  - Limited number of basic symbols (<70)
  - Similarity of shapes reflects similarity of functions
- Unambiguous interpretation of the circuits
- Endorsed by the community for practical reasons
  - End-users: manufacturers
  - Tool developers
  - Publishing industry
  - Teaching communities

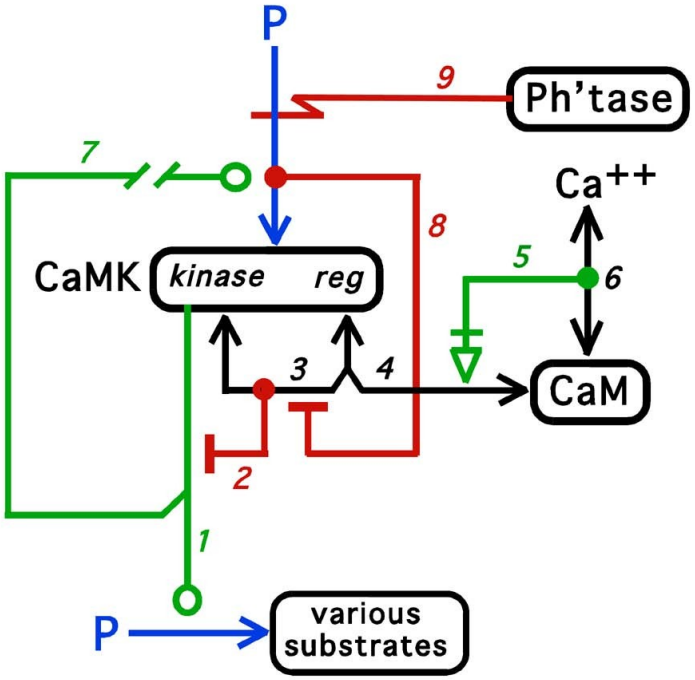
Using electrical diagrams



- McAdams and Shapiro (1995) Science, 269: 650-657

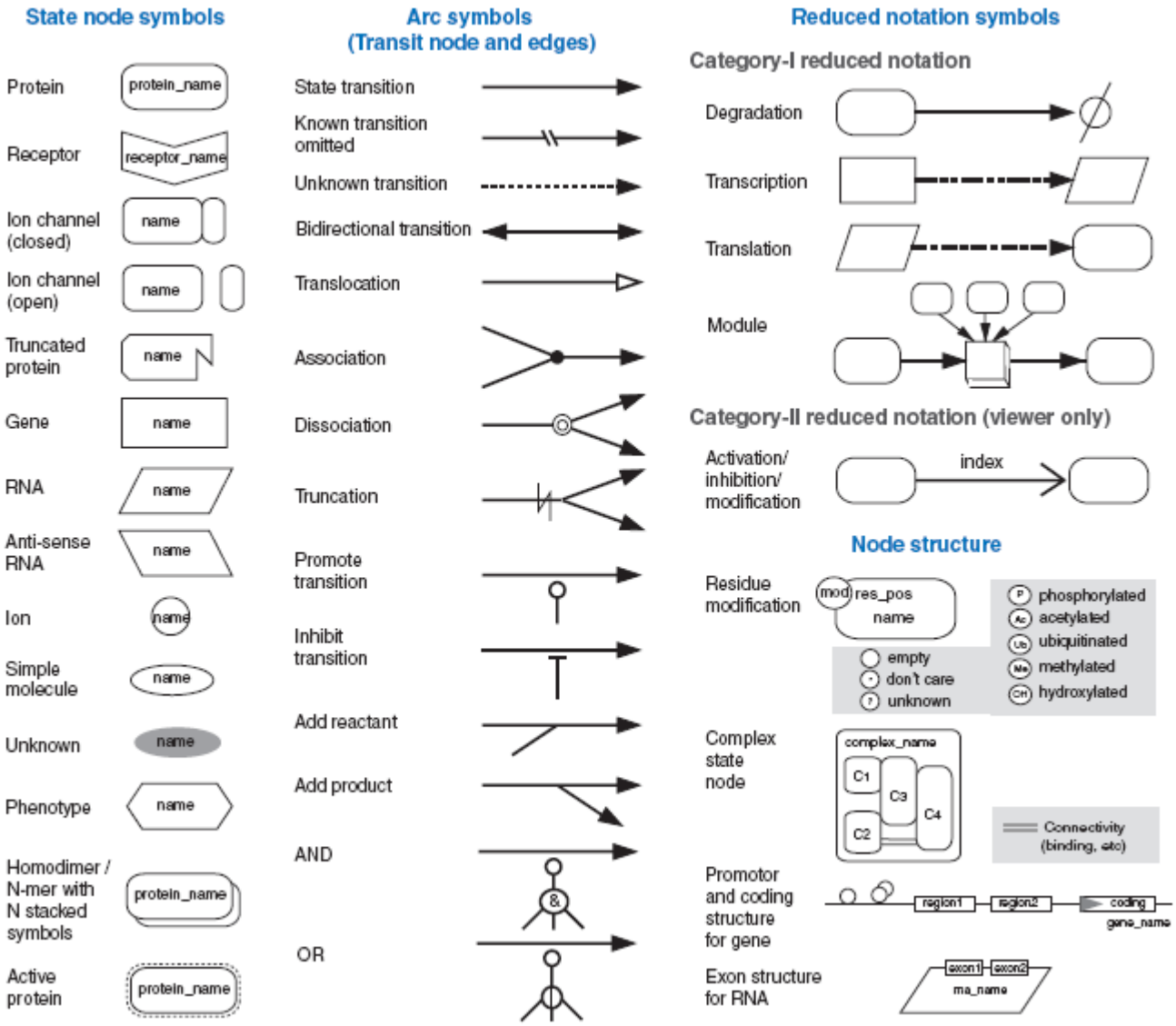
Kohn's Molecular Interaction Maps





- Kurt W Kohn (1998) *Oncogene*, 16: 1065-1075
- Kurt W. Kohn (1999) *Mol Biol Cell*, 10(8):2703-2734

Kitano's Process Diagram Notation



- Kitano (2003) *Biosilico*, 1: 169-170
- Kitano et al (2005) *Nat Biotech*, 23: 961-966

Why were those pioneer efforts not suitable?

- Incompletely defined semantics
  - No structured data model or ontology behind the notation
  - Overlapping concepts rather than sub-classing
  - Gaps in the coverage of biochemistry or modelling
  - Ambiguous interpretation of the graph
- No software support (except Cell Designer for Kitano's Process Diagrams)
- No community involvement
  - No systematic bug tracking and consistency checking
  - No comprehensive coverage (focussed on some use-cases)
  - No endorsement by the tool developers or by the end-users

What is SBGN?

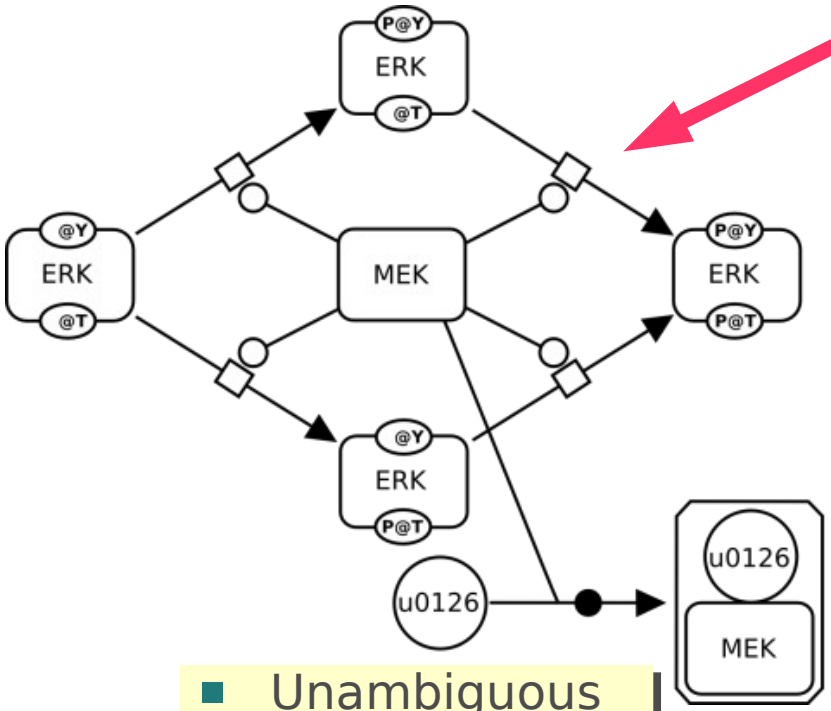
- A community effort initiated by Hiroaki Kitano, developed over four years by modellers, biologists and software developers, covering model and pathway generation and processing
- Three orthogonal languages to unambiguously describe biochemical and cellular events in graphs
- Limited amount of symbols (32 in SBGN PD, 21 in SBGN ER)
  ☞ Smooth learning curve
- Can graphically represent quantitative models, biochemical pathways, genetic interactions, at different levels of granularity

A few rules

- Not guidelines to how to draw things
- Rules to interpret maps unambiguously
- Insensitive to colour, motives, gradients
- Should resist to scaling (no dash lines etc)

Graph trinity: three languages in one

Process diagrams



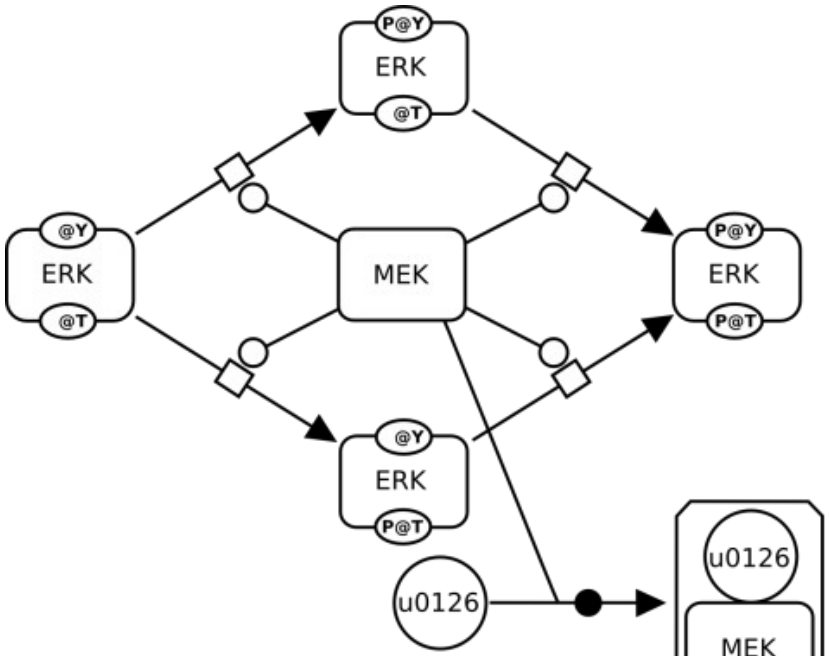
process (flux)

entity pools (quantity)

- Unambiguous
- Mechanistic
- Sequential
- Combinatorial explosion

Graph trinity: three languages in one

Process diagrams



- Unambiguous
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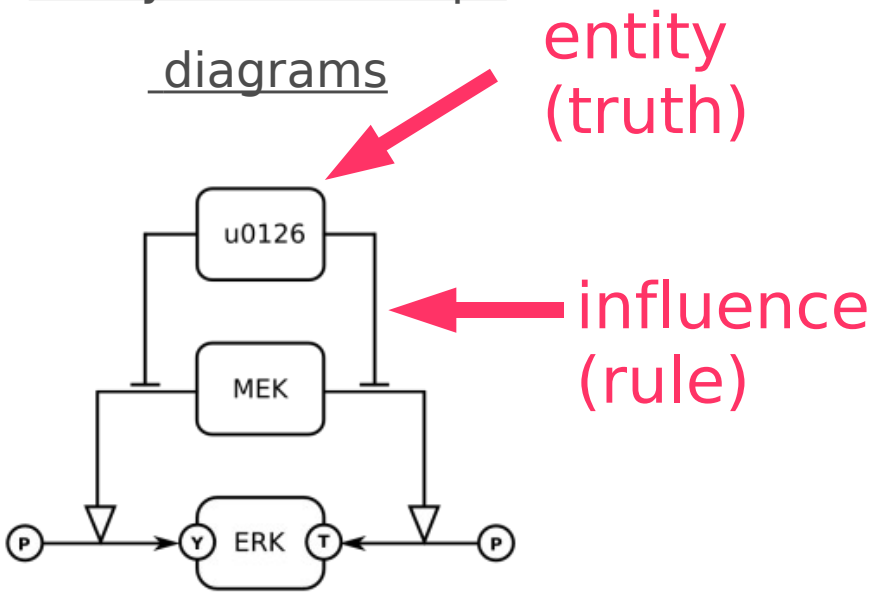
Entity Relationships diagrams



- Unambiguous
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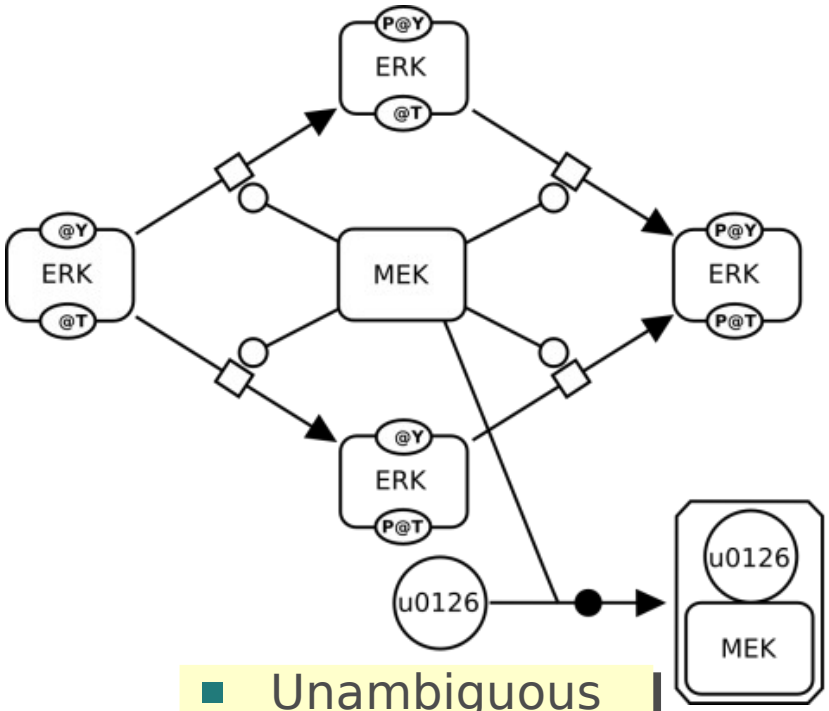
Graph trinity: three languages in one

Process diagrams



- Unambiguous
- Mechanistic
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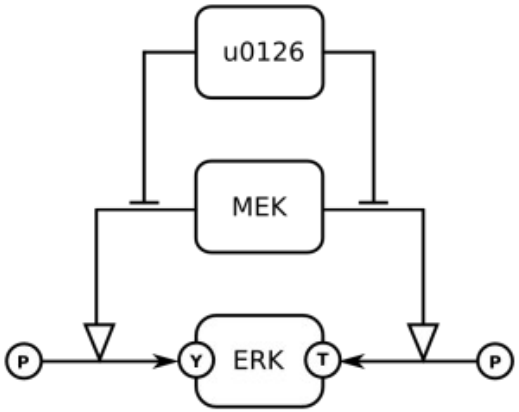
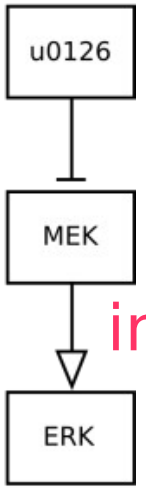
Entity Relationships diagrams



- Unambiguous
- Mechanistic
- Non-sequential

Activity Flow diagrams

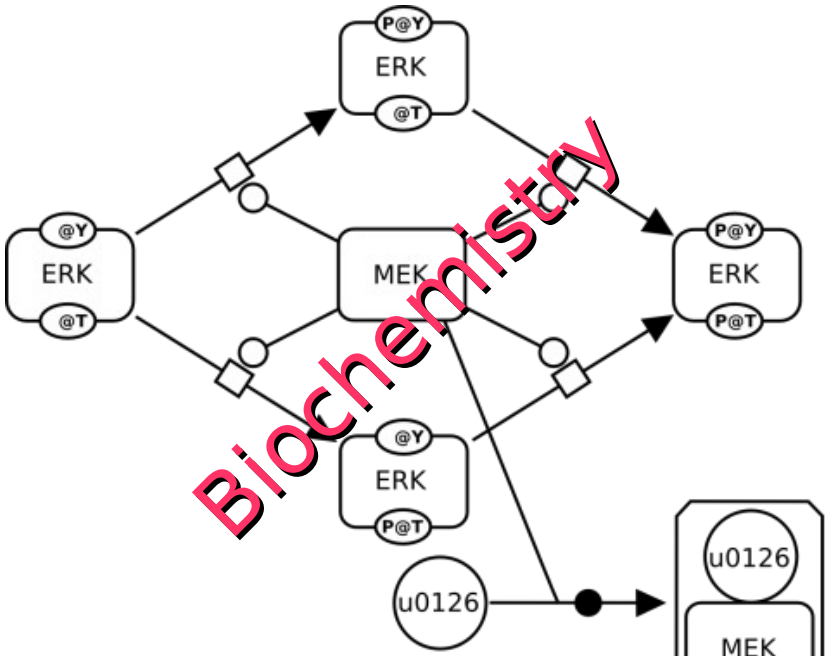


activity influence

- Ambiguous
- Conceptual
- Sequential

Graph trinity: three languages in one

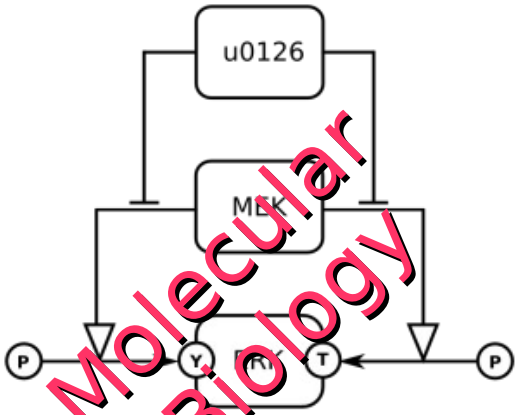
Process diagrams



Biochemistry

- Unambiguous
- Mechanistic
- Sequential
- Combinatorial explosion

Entity Relationships diagrams



Molecular Biology

- Unambiguous
- Mechanistic
- Non-sequential

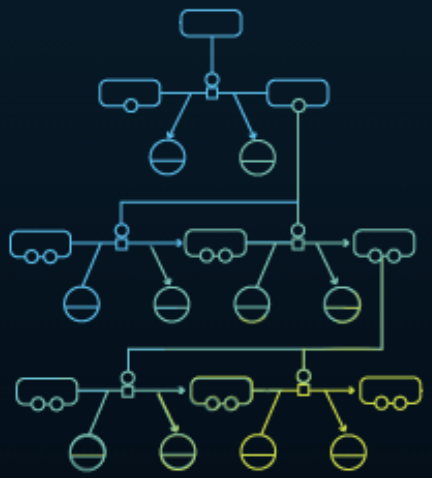
Activity Flow diagrams

Physiology genetics

- Ambiguous
- Conceptual
- Sequential

SBGN Systems Biology Graphical Notation

http://www.sbgn.org/



A Visual Notation for Network Diagrams in Biology

SBGN.org is the global portal for documentation, news, and other information about the Systems Biology Graphical Notation (SBGN) project, an effort to standardize the graphical notation used in diagrams of biochemical and cellular processes studied in systems biology.

Standardizing the diagrammatic notation is crucial for more efficient and accurate transmission of biological knowledge between different research communities in the expanding field of systems biology. Notations traditionally used by researchers and software have been informal, idiosyncratic and highly variable. Until SBGN, there has been no standard agreed-upon convention defining precisely how to draw biochemical interaction diagrams in a regular and systematic way that helps readers interpret them consistently and unambiguously.

SBGN defines a comprehensive set of symbols with precise semantics, together with detailed syntactic rules defining their use and how diagrams are to be interpreted. By standardizing the visual notation, SBGN can serve as a bridge between different communities in research, education, publishing, and more. The real payoff will come when researchers are as familiar with the notation as electronics engineers are familiar with the notation of circuit schematics. If researchers are saved the time and effort required to familiarize themselves with different notations, they can spend more time thinking about the biology being depicted.

On this site, you can browse some example diagrams to get a feeling for SBGN, read the SBGN specification documents, join online discussions, see current working documents in the SBGN wiki, and much more.

SBGN is the work of many people. It would not have been possible without the generous support of multiple organizations over the years, for which we are very thankful.

SBGN News

(23 Aug.'08) The first **SBGN Process Diagrams Level 1** specification is out! Download the specification and tell us what you think!

Acknowledgements

The Systems Biology Graphical Notation

Nicolas Le Novère[1], Stuart Moodie[2], Anatoly Sorokin[3], Michael Hucka[4], Falk Schreiber[5], Huaiyu Mi[6], Emek Demir[7], Katja Wegner[8], Mirit Aladjem[9], Sarala Wimalaratne[10], Frank T. Bergman[11], Ralph Gauges[12], Peter Ghazal[2,20], Kawaji Hideya[13], Lu Li[1], Yukiko Matsuoka[14], Alice Villéger[15,16], Laurence Calzone[17], Melanie Courtot[18], Ugur Dogrusoz[19], Tom Freeman[20], Akira Funahashi[21], Samik Ghosh[14], Akiya Jouraku[21], Sohyoung Kim[9], Fedor Kolpakov[22], Augustin Luna[9], Sven Sahle[23], Steven Watterson[2,20], Chris Sander[7], Igor Goryanin[2], Douglas B. Kell[16,24], Herbert Sauro[11], Jacky L Snoep[25], Kurt Kohn[9], Hiroaki Kitano[14]