EADGENE

European Animal Disease Genomics Network of Excellence for Animal Health and Food Safety

Genomics for Animal Health: Outlook for the Future

13- 14th October 2009, Muséum National d'Histoire Naturelle, Paris, France

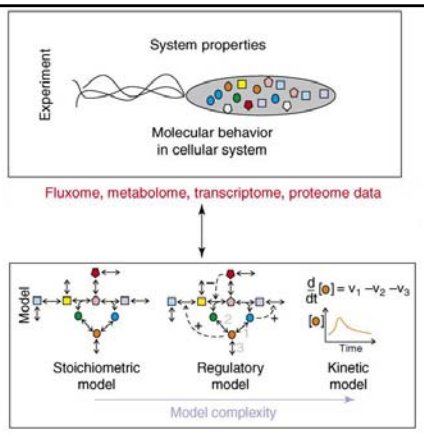
Systems Biology in Animal Sciences

H. Woelders, M.F.W. Te Pas, A. Bannink, R.F. Veerkamp, and M.A. Smits

What is Systems Biology

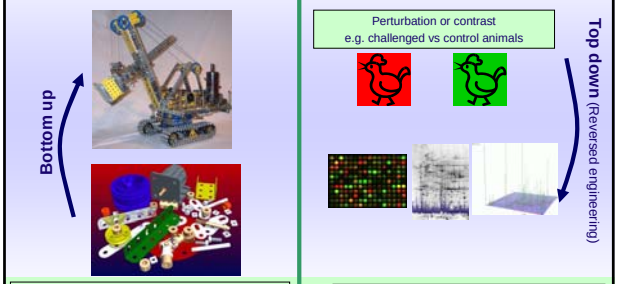
- Systems biology: looking at the whole system rather than at components
- Completeness is a recent aspect
  - Genomics, proteomics: Large datasets
- Mathematics/modelling virtually essential
- Whole > sum of parts: Emerging properties. Properties 'arise' from the interaction between components

Modeling



Bruggeman and Westerhoff 2006

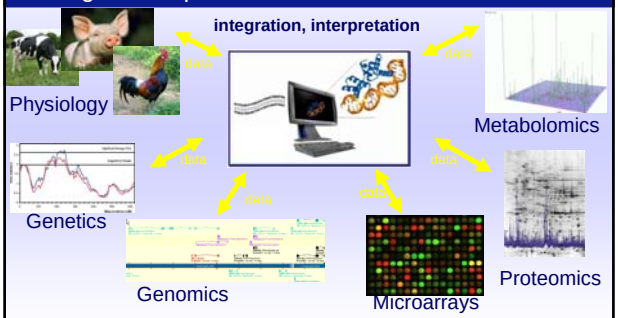
Bottom up and top down approaches



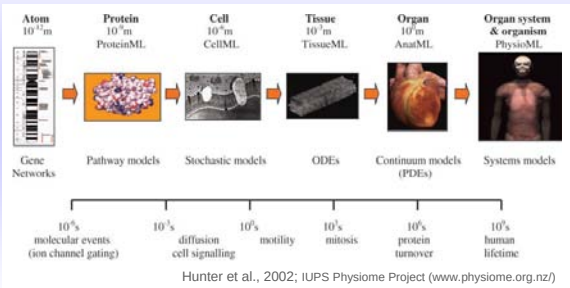
Deductive reasoning:
→ from known properties of the components one deduces system functions
Properties emerge from interaction of components

Inductive reasoning
From how the system reacts to perturbations, one infers which components are critical and how the system may function

Integrative process



Integrative process



Hunter et al., 2002; IUPS Physiome Project (www.physiome.org.nz/)

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Future trends in data acquisition technologies

- Sequencing capacity ↑
- Number of sequenced genomes ↑
- Number of SNPs identified ↑
- SNP typing capacity ↑
- Microarray data ↑
- Proteomics data ↑
- Metabolomics data ↑
- Data in databases ↑

Sequencing costs ↓
SNP genotyping costs ↓
Profiling costs ↓

Computational platforms

- Statistical analysis of raw 'omics' data
- Pathways and gene function: GO, KEGG, BioCarta, Pathway Commons, etc
- Regulatory networks: Osprey, Cytoscape, Ingenuity, Acuity, MetaCore, etc.
- Mechanistic modeling of cells
  - Virtual Cell www.nrcam.uchc.edu
  - E-Cell http://www.e-cell.org/
  - Silicon Cell http://www.siliconcell.net
- Physiology and functional morphology:
  - Physiome consortium www.physiome.org.nz/
- Systems Biology Markup Language (SMBL)
  - The SBML webpage lists over 100 software systems and databases of biological models.

Systems Biology in Animal Sciences

- High level of biological organization.
- Traits broader than in human medicine: Productivity, product quality, disease resistance, fertility, behaviour, welfare, footprint
- Divergently selected lines that differ quantitatively in specific traits.
- Samples from tissues, blood or other body fluids (milk) from a large number of animals with well-documented management, and performance recordings are available
- Understand underlying mechanisms of complex traits, and genotype-environment-phenotype relationships
- Fill the gap between genotype and phenotype: 'Deep' phenotyping.
- "predictive biology"; Biomarkers for product quality or health issues

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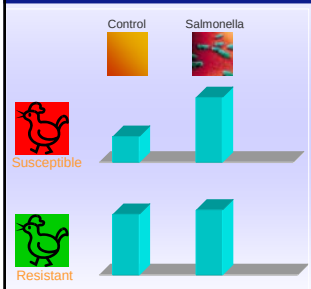
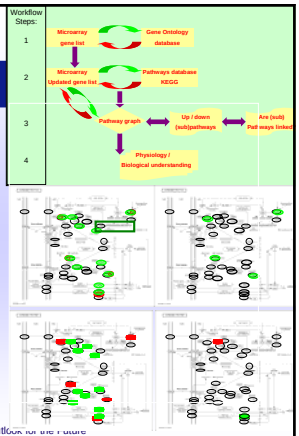
Some examples from our current projects:

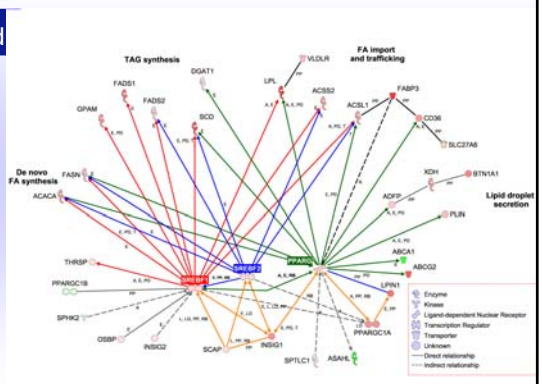
Gut health



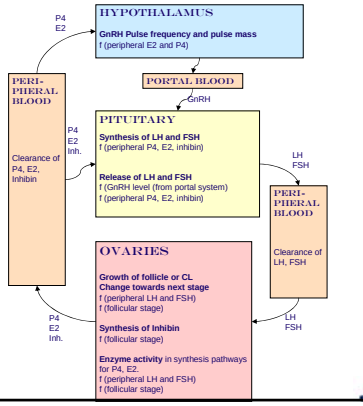


Fatty acid synthesis in udder

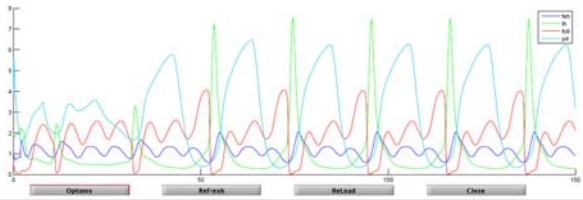
Mod



Bovine oestrous cycle



Bovine oestrous cycle



Unpublished
Boer et al, Livestock Research Lelystad
Stötzel et al, Zuse Institut Berlin

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Conclusion

- '-omics' has come a long way towards characterizing the molecular components of life.
- Systems biology may now be essential to extract understanding from data of these components.
- And to describe system properties that arise from their dynamic interactions.
- Systems biology in animal sciences is just beginning, but will grow in importance and usefulness.

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