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A systems biology approach of oestrous behaviour in dairy cows

Marike Boer[1,2], Roel Veerkamp[1] and Henri Woelders[1]

Introduction

Expression of oestrous behaviour (heat) in dairy cows has declined in the last decades, but the underlying mechanism is unclear.

Objective

To describe and understand the genomic regulation of oestrous behaviour in dairy cows, using a systems biology approach.

Oestrous behaviour

We have prepared a review paper on genes and mechanisms involved in the regulation of oestrous behaviour. Oestrous behaviour is controlled by interactions between hypothalamus, pituitary and ovaries. Genomic studies in a number of animal species (Pfaff et al., 2008) have shown that E2 induced gene expression in hypothalamus and other brain areas plays a pivotal role in the regulation of oestrous behaviour (see table).

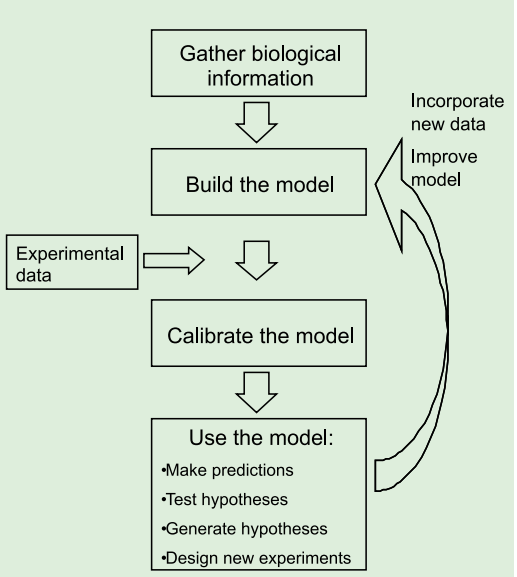
E2 induced gene	*Function*
Oxytocin	Anxiety reduction
Enkephalin and opioid receptor	Analgesia
Muscarinic receptor	Neuronal excitability
Adrenergic receptor	E2 signaling pathway
Nitric oxide	Neurotransmission
rRNA and growth	Facilitation of lordosis
P4 receptor	Stimulation of lordosis
GnRH receptor	Synchronization with ovulation

Gene expression data

Analysis of our own data of gene expression profiles in brain samples from heifers in oestrus or in the luteal phase, have indicated a number of genes that are associated with oestrous behaviour (Beerda *et al.*, 2008; Kommadath et al., in preparation). However, it is difficult to derive understanding of the underlying mechanisms from lists of differentially expressed genes.

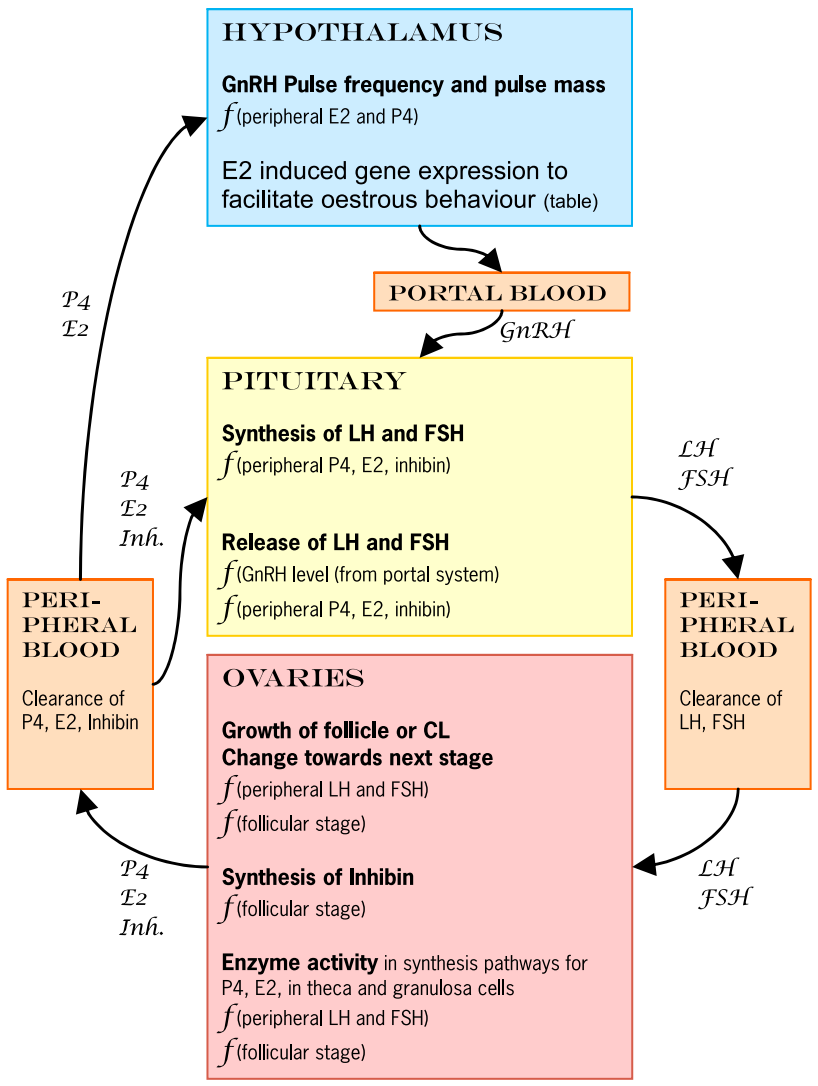
Systems biology

Systems biology aims to improve the biological interpretation of 'omics' data and to predict the behaviour of complex biological systems, e.g. by (mathematical) modelling (see box).
Our objective is to develop a model of the regulation of oestrus (behaviour) in dairy cows, in order to predict and simulate the effects of key genes and other factors. Our model will be based on existing models, like the recent mechanistic model of the human menstrual cycle (Reinecke and Deuflhard, 2007), and will be combined with our bovine gene expression data and mechanisms described in literature.



Box: schematic representation of the modelling process in systems biology (Potter and Tobin, 2007)

Mechanistic model of the oestrous cycle



Schematic representation of the basis for a mathematical model of the estrous cycle. Each process must be represented by a set of equations, which may be functions of external effectors, indicated by $f(\ldots)$. For example, the model of Reinecke and Deuflhard (2007) for the human menstrual cycle comprises 43 equations and 191 parameters.

Conclusion

The development of a simulation model for oestrus in dairy cows, combining human models, our bovine gene expression data and mechanisms described in literature, is expected to improve the understanding of genomic regulation of oestrous behaviour.

List of abbreviations: E2: estradiol, P4: progesterone, GnRH: gonadotropin releasing hormone, LH: luteinizing hormone, FSH: follicle stimulating hormone, Inh: inhibin, CL: corpus luteum.

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[1]Animal Sciences Group, Wageningen University and Research Centre,
Animal Breeding and Genomics Centre,
PO Box 65, 8200 AB Lelystad, The Netherlands
Tel. +31 320 293 527
e-mail: Marike.boer@wur.nl
www.asg.wur.nl

[2]Department of Animal Sciences, Wageningen University,
Adaptation Physiology,
P.O. Box 338, 6700 AH Wageningen, The Netherlands