

International Master in
ANIMAL BREEDING AND REPRODUCTION BIOTECHNOLOGY

PROGRAMME

MODULE I

UNIT 1: MOLECULAR GENETICS Autonomous University of Barcelona

1.1. Molecular bases of animal genetics (5 ECTs) (35 L)

- 1.1.1. Basic concepts of animal genetics (0.5 ECTs)
M. Amills. UAB. Barcelona
- 1.1.2. Organisation and structure of the eukaryotic genome (0.5 ECTs)
M. Amills. UAB. Barcelona
- 1.1.3. Control of gene expression in eukaryotes (1 ECT)
M. Amills. UAB. Barcelona
- 1.1.4. Molecular techniques to study variability (2.5 ECTs)
A. Sánchez. UAB. Barcelona
- 1.1.5. Genetic markers (0.5 ECTs)
M. Ballester. IRTA. Barcelona

1.2. Animal genomics (5 ECTs) (35 L)

- 1.2.1. Structural genomics (2.5 ECTs)
JM. Folch. UAB. Barcelona. **M. Amills.** UAB. Barcelona
 - 1.2.1.1. Genetic maps
 - 1.2.1.2. Comparative mapping
 - 1.2.1.3. Gene identification
 - 1.2.1.4. Genome sequencing: strategies and results
- 1.2.2. Functional genomics: (2.5 ECTs)
M. Pérez-Enciso. ICREA-UAB. Barcelona. **B. Amorena.** CSIC-UPNA. Pamplona. **A. Sánchez.** UAB. Barcelona.
 - 1.2.2.1. General techniques in the studies of gene function
 - 1.2.2.2. Microarrays
 - 1.2.2.3. Proteome analysis
 - 1.2.2.4. Mutation-independent techniques
 - 1.2.2.5. Molecular bases for disease resistance
 - 1.2.2.6. Animal transgenics and genome modifications

1.3. Laboratory of molecular genetics (5 ECTs) (35 P)

M. Ballester. IRTA. Barcelona. **O. Vidal.** Univ. Girona. **A. Sánchez** UAB. Barcelona. **JM. Folch.** UAB. Barcelona

- 1.3.1. Extraction and quantification of nucleic acids (DNA and RNA) from different types of biological samples. Electrophoresis of nucleic acids in agarose and acrylamide gels, and capillary electrophoresis
- 1.3.2. DNA amplification. Conventional PCR. RT-PCR and quantitative PCR
- 1.3.3. Analysis of amplified products: DNA sequencing
- 1.3.4. Microsatellite genotyping
- 1.3.5. SNP genotyping: RFLPs. *Primer extension analysis*. *SNPlex*, *pyrosequencing*, allelic discrimination using *Taqman* probes

1.4. Bioinformatics practicals (5 ECTs) (35 P)

M. Amills. UAB. Barcelona. **JM. Folch,** UAB. Barcelona. **O. Vidal.** Univ. Girona. **M. Pérez-Enciso.** ICREA-UAB. Barcelona. **S. Ramos.** ICREA-UAB. Barcelona

- 1.4.1. Design and optimisation of PCR primers
- 1.4.2. Use of databases (DNA and proteins)
- 1.4.3. Sequence alignment (BLAST. CLUSTAL)
- 1.4.4. Interpreting sequencing results: sequence analysis
- 1.4.5. Microsatellite analysis: interpreting patterns
- 1.4.6. Solving electropherogram interpretation problems
- 1.4.7. Use of software packages to analyse genetic markers (GENEPOP. FSTAT)
- 1.4.8. Molecular phylogeny (PHYLIP)
- 1.4.9. Analysis of gene expression data obtained from microarrays

UNIT 2: APPLIED BREEDING

Polytechnic University of Valencia

2. APPLIED BREEDING (27.5 ECTs) (105 hours: 52.5 L + 52.5 P)

2.1. Fundamentals of statistical genetics (4 ECTs) (12 L + 12 P)

A. Blasco. UPV. Valencia

2.1.1. Basic concepts of statistics (2 ECTs)

2.1.1.1. Descriptive statistics and statistical parameters

- Mean, median, mode, variance, standard deviation, range, variation coefficient
- Standardisation. Covariance, correlation, variance from the mean, covariance with one mean
- Regression, coefficient of determination

2.1.1.2. Measuring uncertainty and testing the hypothesis

- Standard error, confidence interval, confidence interval for difference between means
- Hypothesis test: significance, experimental design

2.1.1.3. Linear models

- The general linear model. Minimum squares. Matrix products, meaning of $X'X$ with one effect? Meaning with two effects, meaning of $X'Y$, invertible matrices, arbitrary restrictions and estimable functions

2.1.2. Population genetics (2 ECTs)

2.1.2.1. Genetic structure of a population

- The gene of molecular genetics and the gene of population genetics
- Equilibrium with one locus
- Equilibrium with two loci. Consequences of disequilibrium in a selection programme

2.1.2.2. Changes in population gene frequencies

- Selection
- Mutation. Long-term importance
- Migration. Importing alleles in a breeding programme
- Genetic drift. Loss of alleles in small populations

2.1.2.3. Inbreeding and kinship

- Kinship coefficient and inbreeding coefficient
- Inbreeding and heterosis
- Effect of inbreeding on genotype frequencies
- Effect of inbreeding on the mean of a trait
- Control of inbreeding

2.2. Quantitative genetics I (5.5 ECTs) (16.5 L + 16.5 P)

2.2.1. Variation and types of gene action (3.5 ECTs)

M.A. Santacreu. UPV. Valencia

2.2.1.1. Continuous variation

- Introduction
- Genotype x environment interaction

- Environmental effects
 - Maternal effects
 - Concept of repeatability
 - Estimation of repeatability
 - 2.2.1.2. Gene effects
 - Concept of additivity. Dominance and epistasis
 - Additive and dominant values
 - Average effect of a gene, additive value and breeding value
 - Breakdown of genotypic value with several genes.
 - 2.2.1.3. Heritability
 - Definition
 - Heritability of the mean of several means
 - Using heritability to predict the additive value of an individual
 - Estimation of heritability: covariance between relatives.
 - 2.2.1.4. Threshold traits
 - Concept
 - The observable scale and the underlying scale
 - Heritabilities on both scales
 - 2.2.1.5. Genetic correlation
 - Introduction
 - Relationship between phenotypic, genetic and environmental correlation
 - Covariance between relatives for two traits
 - Estimating genetic correlation
- 2.2.2. Basic concepts and types of selection by additive value (2 ECTs)
N. Ibáñez UPV. Valencia
- 2.2.2.1. Individual selection
 - Introduction
 - Selection pressure, selection intensity, selection differential
 - Predicting response to selection
 - Generation interval and response per unit of time
 - Generation interval and response to selection in overlapping generations
 - Experimental evaluation of selection theory
 - Evaluation of response
 - 2.2.2.2. Predicting additive value
 - Individual selection and prediction of additive value
 - Prediction by regression in a general context
 - Standard error and confidence interval of prediction
 - Prediction precision
 - Selection index for a single trait
 - 2.2.2.3. Selection methods
 - Selection by various controls
 - Indirect selection. Correlated response
 - Selection by partial control
 - Family selection
 - Intrafamily selection
 - Selection by relatives, progeny test
 - 2.2.2.4. Joint selection of several traits
 - Selection index with individual information
 - Tandem selection
 - Selection by independent levels
 - Comparison between methods

2.3. Quantitative genetics II (4 ECTs) (18 L + 18 P)

2.3.1. Mixed linear model (4 ECTs)

N. Ibáñez. UPV. Valencia

2.3.1.1. Linear models

- Introduction
- Factors and variables
- Fixed and random factors
- The model

2.3.1.2. Estimation

- Properties of an estimator
- Deduction
- Estimability

2.3.1.3. Prediction

- BLUP: deduction. Variance in predictors and variance in prediction error
- Mixed model equations: variance of predictors and prediction errors and resolution algorithms

2.3.1.4. The animal model

- The model and the mixed model equations
- Kinship. A and A^{-1} matrices. Factorisation of A and calculation of A^{-1} ignoring inbreeding

2.3.1.5. The problem of the base population

- The animal model with genetic groups
- Equations of the model

2.3.1.6. Other animal models

- Repeatability
- Common environmental effects
- Maternal effects

2.3.1.7. Multivariate animal models

- Definition. Precision and selection bias
- Traits with similar or different design
- Traits measured in different relatives

2.3.2. Detection and use of QTLs (0.5 ECTs)

N. Ibáñez UPV. Valencia

2.3.2.1. Detection

- Linkage analysis
- Statistical aspects

2.3.2.2. Use

- Gene introgression
- Marker assisted selection

2.3.3. Crossbreeding (0.5 ECTs)

N. Ibáñez. UPV. Valencia

2.3.3.1. Taking advantage of non-additive genetic variance

- Inbreeding depression
- Heterosis
- General and specific combining ability
- Selection for improving crossbreeding: Recurrent selection. Recurrent reciprocal selection

2.3.3.2. Crossbreeding in animal production

- Interest of crossbreeding in livestock production
- Two-way, three-way or four-way crosses. Selection of the lines used in crossbreeding

- Rotation crossing
- Comparison between crosses
- Use of specialised lines

2.4. Quantitative genetics III (4 ECTs) (12 L + 12 P)

- 2.4.1. Estimation of variance components by REML (0.4 ECTs)
A. Blasco. UPV. Valencia
- 2.4.1.1. Variance components in the mixed model
 - 2.4.1.2. REML to estimate the variance of a normal population
 - 2.4.1.3. Estimation of variance components using the VCE program
- 2.4.2. Random regression (0.1 ECTs)
A. Blasco. UPV. Valencia
- 2.4.3. Bayesian estimation (3.5 ECTs)
A. Blasco. UPV. Valencia
- 2.4.3.1. Introduction to Bayesian inference
 - 2.4.3.2. MCMC and Gibbs sampling
 - 2.4.3.3. Estimation of the mean and the variance in a simple model
 - 2.4.3.4. Estimation of genetic values and variance components
 - 2.4.3.5. Genomic selection

2.5. Management and conservation of genetic resources (ECTs) (12 L + 4P)

- B. Villanueva** (Polytechnic University of Madrid)
- 2.5.1. The importance of genetic resource conservation
 - 2.5.2. Genetic diversity
 - 2.5.2.1 Inbreeding, kinship and effective size
 - 2.5.2.2 Genealogical and molecular measurements of inbreeding and kinship
 - 2.5.3. Genetic management of conservation programmes
 - 2.5.4 Genetic management of selection programmes
 - 2.5.5 Applications (examples): Indicators of genetic diversity, Iberian pig, Atlantic salmon

2.6. Breeding programmes (7 ECTs) (63 L + 21 P)

- 2.6.1. Beef cattle
M.J. Carabaño (INIA. Madrid)
- 2.6.2. Dairy cattle
R. Cantet (UAB. Argentina)
- 2.6.3. Dairy sheep
E. Ugarte (Neiker. Vitoria)
- 2.6.4. Beef sheep
M. Serrano (INIA. Madrid)
- 2.6.5. Goat
E. Gómez (CITA-IVIA. Valencia)

- 2.6.6. Pigs
B. Nielsen (SEGAS, Denmark)
- 2.6.7. Poultry
J. Arango (Logman. EEUU) y **S. Avendaño** (Aviagen, United Kingdom)
- 2.6.8. Rabbits
M.A. Santacreu (UPV. Valencia)
- 2.6.9. Aquaculture
A. Sonneson (Nofima, Norway)
- 2.6.10. Breeding applications in developing countries
A. Haile(ICARDA, Lebanon)
- 2.6.11. Technical visits

UNIT 3: REPRODUCTION BIOTECHNOLOGY

Polytechnic University of Valencia

3. REPRODUCTION BIOTECHNOLOGY (12.5 ECTs) (117 horas: 71 L + 46 P)

3.1. Reproduction fundamentals and techniques (5 ECTs) (42 L)

3.1.1. Bases of reproduction (1 ECT)

E. Mocé, M.P. Viudes (CITA-IVIA. Valencia), **F. Forcada** and **J. Yáñez**.
(Univ. Zaragoza)

- 3.1.1.1. Reproduction endocrinology
- 3.1.1.2. Spermatogenesis
- 3.1.1.3. Oogenesis and folliculogenesis. Oestrus cycle
- 3.1.1.4. Fertilization. Embryo development. Pregnancy and parturition
- 3.1.1.5. Factors that influence reproduction
- 3.1.1.6. Reproduction pathology

3.1.2. Reproduction techniques (4 ECTs)

E. Mocé, M.P. Viudes (CITA-IVIA. Valencia), **A. Gutiérrez** (INIA. Madrid)
and **J.S. Vicente** (UPV. Valencia)

- 3.1.2.1. Semen technology
 - Recovery
 - Quality evaluation techniques
 - Conservation methods
 - Sperm sexing
- 3.1.2.2. In vivo production of oocytes and embryos
 - Superovulation treatments
 - OPU (Ovum Pick-Up)
 - Laparoscopy
- 3.1.2.3. In vitro embryo production
 - In vitro maturation
 - In vitro fertilisation. Intracytoplasmic injection (ICSI)
 - In vitro embryo culture
 - Embryo quality evaluation
- 3.1.2.4. Embryo transfer
- 3.1.2.5. Fundamentals of cryobiology: cryoconservation of oocytes and embryos
- 3.1.2.6. Transgenic embryo production. Microinjection. ICSI and somatic cloning

3.2. Practicals in reproduction techniques (3.5 ECTs) (32 P)

J.S. Vicente y F. Marco (UPV. Valencia)

- 3.2.1. Recovery. Semen valuation and freezing (0.9 ECTs)
- 3.2.2. Thawing. Synchronisation and AI (0.9 ECTs)
- 3.2.3. In vitro embryo production: IVM. IVF. EC (0.9 ECTs)
- 3.2.4. Embryo recovery. Freezing (0.8 ECTs)

3.3. Reproduction biotechnologies per specie (4 ECTs) (29 L + 14 P)

- 3.3.1. Cattle
D. Rizos (INIA. Madrid)
- 3.3.2. Sheep
E. Mocé (CITA-IVIA. Valencia)
- 3.3.3. Goats
M.P. Viudes (CITA-IVIA. Valencia)
- 3.3.4. Pigs
J. Roca y M.A. Gil (Univ. Murcia)
- 3.3.5. Rabbits
J.S. Vicente (UPV. Valencia)
- 3.3.6. Poultry
E. Blesbois (INRA. Tours, France)
- 3.3.7. Round tables
 - 3.3.7.1. Establishment and management of germplasm banks and health control
 - 3.3.7.2. Current status of semen conservation and AI
 - 3.3.7.3. Challenges for embryo production. Conservation and ET
- 3.3.8. Technical visits to research and insemination centres

MODULE II

UNIT 4: PRINCIPLES AND TECHNIQUES ASSOCIATED WITH RESEARCH

Research centre associated with the Master

- 4. PRINCIPLES AND TECHNIQUES ASSOCIATED WITH RESEARCH (30 ECTs)**
 - 4.1. Initiation to scientific research (10 ECTs)**
 - 4.2. Techniques and data analysis (10 ECTs)**
 - 4.3. Scientific documentation (10 ECTs)**

UNIT 5: MASTER OF SCIENCE THESIS

Research centre associated with the Master

- 5. MASTER THESIS (30 ECTs)**