Modeling in Biomedicine

Academic Year: (2021 / 2022) **Review date: 02/06/2021 11:02:01**

Department assigned to the subject: Mathematics Department

Coordinating teacher: TORRENTE ORIHUELA, ESTER AURORA

Type: Electives ECTS Credits : 6.0

Year : 1 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Ordinary differential equations / Dynamical systems (Year: 1 / Semester: 1).
Partial Differential Equations (Year: 1 / Semester: 1).
Numerical methods and programming (Year: 1 / Semester: 1).

OBJECTIVES

General:
CG1: To have knowledge that provide a basis or opportunity for originality in developing and / or applying ideas, often within a research context, knowing how to translate industrial needs in terms of R & D in the field of mathematics Industrial.
CG4: To have the ability to communicate the findings to specialist and non-specialist audiences in a clear and unambiguous way.
CG5: To have the appropriate learning skills to enable them to continue studying in a way that will be largely self-directed or autonomous, and also to be able to successfully undertake doctoral studies.

Specific:
CE2: To model specific ingredients and make appropriate simplifications in the model to facilitate their numerical treatment, maintaining the degree of accuracy, according to previous requirements.
CE3: To determine if a model of a process is well made and well mathematically formulated from a physical standpoint.
CE5: To be able to validate and interpret the results, comparing them with visualizations, experimental measurements and functional requirements of the physical engineering system.

Modelling specialization:
CM1: To be able to extract, using different analytical techniques, both qualitative and quantitative models.
CM2: To know how to model elements and complex systems leading to well-posed formulated problems.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction.

2. Migration of epithelial cells and application to tissue engineering. Cell proliferation, control factors. Measurements of cell velocity and density in two-dimensional tissues by using imaging techniques. Mechanisms of collective motion, quorum sensing. Mathematical models. Numerical solutions: results, validation and interpretation. Validation using experimental results.

3. Angiogenesis: formation of blood vessels induced by growth factors. Differentiation of epithelial cells: branching, extension and anastomosis. Capillary motion by following continuous gradient fields: Chemotaxis and haptotaxis. Blood circulation. Stochastic models using birth and death processes and stochastic differential equations. Numerical solutions. Law of large numbers and derivation of deterministic PDE equations. Numerical solutions. Hybrid models. Cellular Potts models and Monte Carlo methods: durotaxis and cell-cell Notch signalling.

4. Linear models for gene expression data. Identification of cancer-related genes. Analysis of variance: anova table and contrast of parameters. Simple factorial models. Factorial models with interactions.

LEARNING ACTIVITIES AND METHODOLOGY

1) Theory classes devoted to explanation of contents. Classes given by videoconference.

2) Formulation, analysis and solutions of problems and exercises. Assignments.

Office hours:
The students can ask questions via e-mail, videoconference or during the classes.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

Criteria for both the 1st and 2nd assessment opportunity:
Continuous evaluation by homeworks, participation in class and/or oral exposition of assigned practical work.

BASIC BIBLIOGRAPHY

- C. W. Gardiner Stochastic methods. A handbook for the natural and social sciences. 4th ed. , Springer, Berlin, 2010

- C.R. Jacobs, H. Huang, R.Y. Kwon Introduction to cell mechanics and mechanobiology, Garland Science (Taylor and Francis), 2013

- H. Causton, J. Quackenbush and A. Brazma Microarray Gene Expression Data Analysis: A Beginner's Guide, Blackwell publishing, 2003

- L.L. Bonilla, V. Capasso, M. Álvaro, and M. Carretero Hybrid modeling of tumor-induced angiogenesis. , Phys. Rev. E 90, 062716 , 2014

- M. Basan, J. Prost, J.-F. Joanny, and J. Elgeti Dissipative particle dynamics simulations for biological tissues: rheology and competition., Phys. Biol. 8, 026014 , 2011

- T. Adair, J.-P. Montani Angiogenesis, Morgan & Claypool Life Sciences, San Rafael CA, 2010

- W.G. Cochran and G.M. Cox M Experimental Designs., New York: Wiley, 1992