



Universitat de Lleida

DEGREE CURRICULUM  
**CELL COMMUNICATION AND  
FUNCTION**

Coordination: ESPINET MESTRE, CARMEN

Academic year 2019-20

Subject's general information

<b>Subject name</b>	CELL COMMUNICATION AND FUNCTION			
<b>Code</b>	14707			
<b>Semester</b>	1st Q(SEMESTER) CONTINUED EVALUATION			
<b>Typology</b>	<b>Degree</b>	<b>Course</b>	<b>Character</b>	<b>Modality</b>
	Master's Degree in Biomedical Research	1	OPTIONAL	Attendance-based
<b>Course number of credits (ECTS)</b>	4			
<b>Type of activity, credits, and groups</b>	<b>Activity type</b>	PRAULA		TEORIA
	<b>Number of credits</b>	1.4		2.6
	<b>Number of groups</b>	1		1
<b>Coordination</b>	ESPINET MESTRE, CARMEN			
<b>Department</b>	EXPERIMENTAL MEDICINE			
<b>Important information on data processing</b>	Consult <a href="#">this link</a> for more information.			

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
CALDERO PARDO, JORDI	jordi.caldero@udl.cat	,2	
CASAS HERRANZ, CELIA	celia.casas@udl.cat	,2	
EGEA NAVARRO, JOAQUÍN	joaquim.egea@udl.cat	,4	
ENCINAS MARTIN, MARIO	mario.encinas@udl.cat	,2	
ESPINET MESTRE, CARMEN	carme.espinet@udl.cat	,8	
GARCERA TERUEL, ANA	ana.garcera@udl.cat	,6	
HERNANDEZ ESTAÑOL, SARA	sara.hernandez@udl.cat	,2	
LLOVERA TOMAS, MARTA	marta.llovera@udl.cat	,4	
SOLER TATCHE, ROSA MARIA	rosa.soler@udl.cat	,2	
TARABAL MOSTAZO, OLGA	olga.tarabal@udl.cat	,8	

## Learning objectives

1. To know the processes involved in cell signalling that regulate cell proliferation and differentiation.
2. To know the structure and function of ion channels involved in membrane excitability and the techniques used for study.

3. To advance knowledge of the process of synaptic transmission.
4. To know the intracellular pathways related to cell survival or death processes.
5. To know the process of programmed cell death during development, the apoptotic death, the excitotoxic death and the cellular and molecular mechanisms that control these processes.
6. To know the signaling mechanisms related to axon guidance.
7. To understand the mechanisms of cell communication mediated by gases.

## Competences

CB1 Possess knowledge and understanding that provide a basis or opportunity for originality in developing and / or applying ideas, often within a research context

CB2 Being able to apply the acquired knowledge and have the ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study

CB5 Possessing learning skills to enable them to continue studying in a way that will be largely self-directed or autonomous

CG1 Knowing how to select and apply different analytical methods at the molecular, biochemical, cellular, genetic and phenotypic level for the diagnosis and study of the diseases.

CG5 Ability to prepare process and interpret the results rigorously and applying appropriate technologies

CS7 To identify the molecules and processes important in the functioning of cells and recognize the mechanisms of integration of external signals that regulate complex functions such as differentiation, proliferation and survival

CT2 Mastering a foreign language

CT3 Mastering ICT

## Subject contents

### 1. Overview (Carme Espinet, 2 hours)

Introduction to cell signaling. General principles of cell communication. G-protein coupled receptors. Cyclic AMP and protein kinase A. G-proteins and calcium signaling. G-proteins and ion channels. Tyrosine kinase receptors: docking proteins and modular signaling. Ras and other small GTPases. The MAP kinase and PI3-kinase pathways. Serine-threonine kinase receptors: the Jak-STAT and TGF pathways. Proteolysis and signaling: Notch and Wnt pathways, Sonic hedgehog, NFkB signaling. Nuclear receptors.

### 2. PDK1, the major transducer of PI 3-kinase actions (Jose Ramón Bayascas, 2 hours)

PI3-K pathway in the context of insulin signaling. PDK1 action as a master kinase phosphorylating and activating differentially up to 23 different substrates. Study of PDK1 pathway by knock-in mutation and its role regulating metabolic responses to insulin.

### 3. Autophagy in the pathology of the Central Nervous System (Anna Garcerà, 2 hours)

Autophagy pathways in neurons. Autophagy involvement in pathogenesis of neurodevelopmental and neurodegenerative disorders. Autophagy as a therapeutic target.

### 4. The neurodegenerative disease as a prion-like proteinopathy. (Sara Hernandez, 2 hours).

Neurodegenerative diseases and proteinopathies. Prion and prion-like phenomena. Spreading mechanisms of misfolded proteins. Prion-like spreading in ALS.

### 5. Nuclear receptors. The vitamin D receptor and its role in cardiovascular diseases (José Manuel

Valdivielso, 2 hours). Nuclear receptors and their function regulating the rate of gene transcription. Review of the preclinical and clinical data that support a key role of vitamin D receptor activation in cardiovascular health.

6. Intracellular pathways related to neuronal cell survival or death: role in neurodegenerative diseases (Rosa Soler, 2 hours)

Neurotrophic factors and their specific receptors: activation. Intracellular pathways: from the external signal to their effect in the cell. Suppressors or activators of intracellular proteins in neurodegenerative diseases.

7. Sprouty proteins as negative regulators of RTK signaling (Mario Encinas, 2 hours)

The Spry family members: from *Drosophila* to mammals. Functions of Spry genes as defined by gene targeting. Mechanisms of action: many open questions. Role of Spry proteins in tumor suppression. Novel functions of Spry genes and perspectives.

8. Pro-neurotrophins and neurodegenerative diseases (Carme Espinet, 2 hours).

Pro-NGF and pro-BDNF as ligands of p75NTR. p75NTR signalling pathways, intracellular interacting molecules and interaction with co-receptor partners. p75NTR processing and internalization. Pro-NGF/p75NTR modifications in Alzheimer's disease. pro-BDNF/p75NTR involvement in familial depression.

9. Programmed cell death in spinal cord motoneurons during development (Jordi Calderó, 2 hours).

The process of naturally (programmed) cell death of neurons, particularly of motoneurons. Apoptotic death. Cellular and molecular mechanisms that control these processes and the role played by specific neurotrophic factors as modulator agents.

10. Excitotoxicity and selective motoneuron vulnerability (Olga Tarabal, 2 hours).

Glutamate receptors expression in neurons. Excitotoxic molecular mechanisms. Excitotoxic necrosis: the organotypic culture of chick embryonic spinal cord as a model to study excitotoxic necrosis. Chronic excitotoxicity and degeneration. Acute and chronic excitotoxicity in the model of chick embryo *in vivo*.

11. Signaling mechanisms of axon guidance receptors (Joaquim Egea, 4 hours)

Description of the signaling mechanisms of Eph receptors and the mouse genetic approaches used to address their relevance *in vivo*.

## SEMINAR PROGRAM

- Analysis of Membrane Protein Complexes by Blue Native PAGE (Celia Casas, 2 hours). Solubilization of membrane protein complexes. Types of detergents. Effect of lipids on protein solubilization. Protocols for BN-PAGE. Applications of BN-PAGE.
- Fluorescence Resonance Energy Transfer in living cells (FRET) (Marta Llovera, 2 hours). The principle of FRET. Fluorochrom pairs useful on FRET analysis. Applications. Methods for FRET detection. FRET-based biosensors. Real-time molecular interactions within living cells.
- Image acquisition and processing on FRET experiments (Marta Llovera, 2 hours). Confocal microscope parameters for FRET image acquisition. MBF ImageJ software: image processing and quantification. Pseudocolouring and image composition.

## PRACTICAL PROGRAM

- Methods to evaluate the involvement of a particular intracellular pathway in neuronal survival: experimental design (Rosa Soler and Ana Galcerá, 4 hours). To define the pathway that we want to analyze; and to develop and experimental design to study which effect causes the activation or the inhibition of this pathway on cultured neurons.
- Calcium signalling (Olga Tarabal, 4 hours). Intracellular calcium imaging after loading neurons with Fura-2 AM. Calcium transients after application of agonists and antagonists of glutamate receptors.  
Calcium release from intracellular stores. Calcium induced calcium release (CICR) mechanism.

## Methodology

Development and homeostasis of metazoan organisms is absolutely dependent on communication between their

building blocks, the cells. Such communication is usually achieved by the use of small, extracellular signaling molecules which act locally or globally to coordinate growth, differentiation, survival or metabolism of cells. Signaling molecules exert their actions on target cells through binding to specific receptors usually but not always located at the cell surface. Receptor binding causes a plethora of molecular responses, known as signal transduction pathways, meant to produce a characteristic biological response. In this course we aim to provide a general view of the vast field of signal transduction. Rather than systematically presenting current knowledge on the field, we will provide a first-hand view of specific topics, which will be presented by specialists who are actively developing their research on that particular aspect of the field. A practical block introducing state-of-the-art laboratory techniques will complement the theoretical sessions.

## Evaluation

Attendance to lectures, practical and seminar sessions. (20%)

Presentation and discussion of scientific articles. (80%)

## Bibliography

Ashcroft FM. From molecule to malady (2006) *Nature* 440, 440-447.

Armstrong CM, Hille B. Voltage-gated ion channels and electrical excitability (1998) *Neuron* 20, 371-380.

Bredesen DE, Rao RV, Mehlen P. Cell death in the nervous system (2006) *Nature*, vol 443, pages 796-802.

Bus RR, Sun W, Oppenheim RW. Adaptive roles of programmed cell death during the nervous system development (2006) *Annu. Rev. Neurosci.* 29, 1-35.

Cadigan KM, Liu YI. Wnt signaling: complexity at the surface (2006) *J Cell Sci* 119(Pt 3), 395-402.

Ciani L, Salinas PC. WNTs in the vertebrate nervous system: from patterning to neuronal connectivity (2005) *Nat Rev Neurosci* 6(5), 351-362.

Conforti L, Adalbert R, Coleman MP. Neuronal death: where does the end begin? (2007) *Trends in Neuroscience*, vol 30, pages 159-166.

Cooper JR, Bloom FE, Roth RH. *The biochemical basis of neuropharmacology* (2003) Oxford University Press.

**Davis KL, Martin E, Turko IV, Murad F.** Novel effects of nitric oxide (2001) *Annual Review of Pharmacology and Toxicology*. 41: 203-236.

Dawson TD. Neurobiology of the nitric oxide in the nervous system. (1998) *Amino Acids* 14:83-85.

Etienne-Manneville S and Hall A. Rho GTPases in cell biology (2002) *Nature* 420, 629-635.

Finocchietto PV, Franco MC, Holod S, Gonzalez AS, Converso DP, Arciuch VG, Serra MP, Poderoso JJ, Carreras MC. Mitochondrial nitric oxide synthase: a masterpiece of metabolic adaptation, cell growth, transformation, and death (2009) *Exp Biol Med* (Maywood). 234:1020-8. PMID: 19546350.

Gao Y. The multiple actions of NO (2009) *Pflugers Arch.* 2009 Dec 19. [Epub ahead of print]

Gould TW and Enomoto H. Neurotrophic modulation of motor neuron development (2009) *The Neuroscientist*, vol. 15, number 1, pages 105-116.

**Heales SJR, Bolaños JP, Stewart VC, Brookes PS, Land J M, Clark JB.** Nitric oxide, mitochondria and neurological disease (1999) *Biochimica et Biophysica Acta (BBA)* – 104: 215-228.

Hempstead BL. The many faces of p75NTR (2002) *Curr Opin in Neurobiology.* 12:260-267.

- Iden S, Collard JG. [Crosstalk between small GTPases and polarity proteins in cell polarization](#) (2008) Nat Rev Mol Cell Biol. 2008 9, 846-59.
- Inestrosa NC, Arenas E. Emerging roles of Wnts in the adult nervous system. (2009). Nat Rev Neurosci.
- Kandel ER, Schwart JH, Jessell TM. Principles of Neural Science (2000) 4<sup>th</sup>Ed. McGraw Hill, USA.
- Li R, Gundersen GG. [Beyond polymer polarity: how the cytoskeleton builds a polarized cell \(2008\)](#) Nat Rev Mol Cell Biol. 9, 860-73.
- MacMicking J; Xie Q; Nathan C** Nitric oxide and macrophage function (1997) Annual Review of Immunology 15: 323-350.
- Mellman I, Nelson WJ. [Coordinated protein sorting, targeting and distribution in polarized cells \(2008\)](#) Nat Rev Mol Cell Biol. 2008 9, 833-45.
- Michaelidis TM, Lie DC. Wnt signaling and neural stem cells: caught in the Wnt web (2008) Cell Tissue Res 331(1), 193-210.
- Moncada S, Palmer RM, Higgs EA. Nitric oxide: physiology, pathophysiology, and pharmacology (1991) Pharmacological Reviews, 43:109-42.
- Moon RT, Kohn AD, De Ferrari GV, Kaykas A. WNT and beta-catenin signalling: diseases and therapies (2004) Nat Rev Genet 5(9),691-701.
- Nathan C. Nitric oxide as a secretory product of mammalian cells (1992) FASEB J. 6:3051-64.
- Nelson WJ, Nusse R. Convergence of Wnt, beta-catenin, and cadherin pathways (2004) Science 303(5663),1483-1487.
- Nykjaer A. p75<sup>NTR</sup>-live or let die (2005) Curr. Opinion in Neurobiology. 15:49-57.
- Oppenheim RW, von Bartheld CS. Programmed cell death and neurotrophic factors (2008) In: Squire L, editor. Fundamental neuroscience, 3rd ed. San Diego: Elsevier. p437-467.
- Ortega S. Excitotoxicidad y muerte de las neuronas (2005) Mente y cerebro 11, 10-14.
- Reisinger V. Analysis of Membrane Protein Complexes by Blue Native PAGE (2006) Practical Proteomics 6-15.
- Reisinger V. Solubilization of membrane protein complexes for blue native PAGE. (2008) Journal of Proteomics 277-283.
- Simpson RJ. Proteins and Proteomics. A laboratory manual (2003) Cold Spring Harbor NY.
- Squire L, Berg LR, Bloom D, Floyd E., Lac D. Fundamental neuroscience (2008) Academic Press.
- Stamler JS, Simon DI, Osborne JA, Mullins ME, Jaraki O, Michel T, Singel DJ, Loscalzo J. S-nitrosylation of proteins with nitric oxide: synthesis and characterization of biologically active compounds (1992). Proc Natl Acad Sci U S A. 89:444-8.
- Van Den Bosch L, Van Damme P, Bogaert E, Robberecht, W. The role of excitotoxicity in the patogénesis of amyotrophic lateral sclerosis (2006) Biochimica et Biophysica Acta 1762, 1068-1082.
- Yuan J, Lipinski M, Degtrev A. Diversity in the mechanisms of neuronal cell death (2003) Neuron 40, 401-413.

## INTERNET RESOURCES

The Wnt webpage: <http://www.stanford.edu/~rnusse/wntwindow.html>

<http://www.ionchannels.org/>

<http://www.nature.com/nrm/focus/polarity/index.html>

Blue Native Electrophoresis Protocol. MitoSciences

<http://www.mitosciences.com>

Dr. Louis Ignarro Explains Nitric Oxide:

<http://www.youtube.com/watch?v=DclWX8C91s4> i <http://www.youtube.com/watch?v=NBPjZJSHr4A>

MBF ImageJ webpage:

<http://www.macbiophotonics.ca/imagej/>

Olympus Confocal Microscopy Tutorials

<http://www.olympusfluoview.com/java/index.html>

Olympus FRET webpage

<http://www.olympusfluoview.com/applications/fretintro.html>

Nikon FRET webpage

<http://www.microscopyu.com/tutorials/java/fluorescence/fpfret/>

Interactive tutorial explores various combinations of fluorescent proteins as potential FRET partners and provides information about critical resonance energy transfer parameters, as well as suggestions for microscope optical filter and light source configuration.