CDB Lecture Synopses 2011-2012

Molecular Biology of the Cell Nucleus - Dr Torsten Krude & Prof Steve Jackson

The nucleus is the information centre of the eukaryotic cell. It synthesises the mRNA for thousands of proteins in a highly regulated manner. It also replicates its entire structure accurately once, and only once, during each cell division cycle. This course starts by considering the dynamic architecture that allows the nucleus to perform these functions. Later lectures discuss how the genetic information is stored, accessed, replicated and read.

1. Architecture of the nucleus I: Introduction, DNA, nucleosomes and chromatin
2. Architecture of the nucleus I: Chromosomes, matrix and the nuclear boundary
3. Gene transcription I: Introduction to transcription and RNA polymerase enzymes
4. Gene transcription II: Basal transcription factors
5. Gene transcription III: Mechanisms of transcriptional control
6. Eukaryotic chromosome replication I: Functional elements needed for chromosome replication
7. Eukaryotic chromosome replication II: Replication forks, repair and cell cycle control
8. Dynamics of nuclear structures: Assembly and disassembly of chromatin and the nuclear envelope
9. Nuclear transport: Import and export

Genetic Systems of Prokaryotes: Prokaryotic Strategies – Drs Philip Oliver and David Summers

1. Bacteriophage lambda: a model for gene regulation and development in prokaryotes. Infection and the choice between lysis and lysogeny; how is the decision made? Establishment of the lysogenic state: integration of the lambda genome into the bacterial genome by site-specific recombination.
2. Life without a nucleus: The prokaryotic cell cycle. The prokaryotic nucleiod and its structure. Consequences of the lack of a nuclear membrane for gene regulation.
3. Prokaryotic genomes: The prokaryotic chromosome. Plasmids in bacteria: their structure, plasmid-encoded phenotypes and mechanisms of plasmid inheritance.
4. Genetic flexibility of prokaryotes: Gene transfer by plasmid-mediated conjugation and the role of transposons in generating genetic diversity.

Yeast as a model organism for eukaryotic genetics and systems biology – Prof Steve Oliver

These lectures will to introduce you to the genetic system of a simple eukaryote, *Saccharomyces cerevisiae.* They will then describe the tools and resources that allow the exquisite manipulation of the yeast genome and allow it to be used as a model system for the study of molecular and cell biology. Finally, the use of yeast for systems biology studies will be examined, and the future uses of the organism in research and industry discussed.

Topics to be covered include:

The yeast life cycle and its exploitation in classical genetics.
The control of mating type.
Tools and resources for the genetic manipulation of *Saccharomyces cerevisiae*
The yeast genome and its analysis. From to genome to function.

Yeast as a model for systems-level studies of the eukaryotic cell.
Future prospects for the exploitation of the yeast as a cell system and factory.
Molecular genetics of yeast cells

Genome Organisation - Dr Cahir O'Kane

These five lectures are an introduction to the subject of the DNA sequence organisation of complex genomes. The basic emphasis will be on understanding the mechanisms of how DNA in genomes behaves. The lectures will also deal with some of the applications and the technological impact of this understanding.

1. Genome content and genome sequencing: high throughput sequencing, and uses of genome sequences in biology and medicine
2. Evolution of genes and repetitive sequences: duplicated genes, satellites and DNA fingerprinting.
3. Types of mobile DNA and mechanisms of transposition: DNA transposable elements, and retrotransposons, inlcuding some surprising ones.
4. Mobile DNA and evolution: Horizontaltransmission. Mobile introns. Mobile DNA as tools. Generation of transgenics, and insertional mutagenesis.
5. Genome information and the study of cell biology: Functional genomics. Biochemical and genetic strategies to study cell biology. RNA interference.

Organelle Biogenesis – Prof Alison Smith

The aim of the lectures is to introduce the molecular mechanisms involved in the assembly of mitochondria and plastids in plants, animals and fungi.

1. Morphology and behaviour or the organelles and how genetic approaches have contributed to our understanding of organelle inheritance and biogenesis.
2. Characteristics and expression of genes in mitochondrial genomes from yeast, animals, plants and protista, and the importance for respiration
3. Characteristics and expression of genes in chloroplast genomes in algae and land plants, and the role in photosynthesis
4. Protein synthesis in organelles, and import of nuclear-encoded chloroplast and mitochondrial proteins. Evolution of protein import apparatus
5. Protein sorting and assembly of multisubunit complexes in the energy transduction apparatus in chloroplasts and mitochondria
6. Anterograde and retrograde signalling between nucleus and chloroplasts & mitochondria to ensure biogenesis of functional organelles

The Eukaryotic Cytoskeleton and Mitotic Cell Division - Dr Marisa Segal

These four lectures will introduce the system of protein filaments and associated molecules by which eukaryotic cells control their shape, organise their contents, and generate movements.

1. Introduction to the eukaryotic cytoskeleton. The dynamic nature of cytoskeletal structures in cells. General properties and functions.

2. Cellular organisation of the actin cytoskeleton. Control of F-actin nucleation and dynamics. Cell polarity, cell shape and motility. Actin-based motors - myosins.
3. Organisation of microtubule-based structures in cells. Control of microtubule nucleation and dynamics. Microtubule organising centres. Microtubule-based motors - kinesins and dyneins. Microtubule-based transport and motility.
4. Mitosis and cell division. The role of the cytoskeleton in mitosis: cooperation between actin and microtubule systems. The mitotic spindle: control of ssembly and dynamics. Cytokinesis: temporal and spatial control. Positioning the actomyosin ring. Symmetric vs. asymmetric divisions.

Membrane Trafficking – Prof Paul Dupree

The mechanisms of protein sorting and targeting that lead to the variety of endomembrane organelles found in eukaryotic cells will be discussed.

1. The mechanism of protein targeting and insertion into the endoplasmic reticulum.
2. Protein trafficking pathways between endomembrane compartments. Both endocytic pathways and secretory pathways will be discussed.
3. Formation of transport vesicles and protein sorting.
4. Vesicles targeting and fusion with the appropriate target membrane.

Intercellular Communication - Alex Webb & Howard Baylis

The ability of cells to communicate with each other and modify their behaviour is fundamental to the ability of organisms to respond to their environment. These four lectures illustrate the principles and complexity of intercellular signalling. Examples will be drawn from a wide range of organisms. The role of oscillations in chemical, electrical and genetic signals, and their roles in co-ordinating intracellular responses and cell activities in multicellular systems will be considered.

1. Photoperiodic control of flowering I.
2. Photoperiodic control of flowering II
3. Oscillations in Insulin signalling.
4. Communication downstream of insulin perception.

Development
There are three blocks of lectures covering different aspects of development in multicellular animals and plants

Development I – Prof Helen Skaer

<u>Establishing cell fate and early embryonic patterning</u>
1. Introduction and the significance of cell lineage during development. The segregation of determinants during C. elegans early development.
2. The significance of cell interactions during development. Interactions between equivalent cells, the process of lateral inhibition. Interactions between non-equivalent cells, the process of induction.
3. Development of the insect central nervous system. How the integration of lineage dependent mechanisms and cell interactions leads to the formation of specific neurons.
4. The genes controlling segmentation in Drosophila. The interpretation of maternal information.

Analysis of the molecular interactions leading to segment pattern formation. Regulatory hierarchies. How genes work as information processors..

5. Hox genes and the specification of segment identities. The role of Hox genes in other organisms, including vertebrates.
6. Establishing the dorso-ventral axis in Drosophila.

Development II – Dr Anna Philpott

<u>Principles of vertebrate development</u>

1. Xenopus as a model: Oocyte maturation, egg formation and the origin of the animal vegetal axis.
2. Fertilisation and axis formation; generation of embryonic asymmetry.
3. Induction and patterning of the mesoderm.
4. Further reorganization and refinement of the body plan: dorsalisation, neural induction and gastrulation.
5. Tissue differentiation and patterning. Somite formation and muscle differentiation.
6. Tissue stem cells and embryonic stem cells.

Development III – Dr Jim Haseloff

<u>Morphogenesis in plants</u>

In these six lectures some of the unusual features of plant development will be outlined using examples from the model plant, Arabidopsis thaliana. Plant cells are immobile, constrained by a rigid cell wall – yet plant development is plastic and indeterminate. Communication between neighbouring cells controls plant cell fate, and we'll look at how this exchange takes place.

1: Introduction to plant development
2: Polarity in plants and auxin traffic
3: Radial polarity and indeterminate growth of meristems
4: Architecture of lateral organs
5: Epidermal cell patterning and principles of self-organisation
6: Morphogenesis and engineering of microbial and plant systems