LONDON SOUTH BANK UNIVERSITY

# Cells, Genes Evolution

SMK-1-302

Faculty of Science, Engineering
& the Built Environment

2006/2007

**become what you want to be**

# Table of Contents

# 1. UNIT DETAILS

| | |
|---|---|
| **Unit Title:** | Cells, Gene & Evolution |
| **Unit Level:** | 1 |
| **Unit Reference Number:** | SMK-1-302 |
| **Credit Value:** | 1 Credit = 15 CATS units |
| **Student Study Hours:** | 150 |
| **Contact Hours:** | 36 |
| **Private Study Hours:** | 114 |
| **Pre-requisite Learning (If applicable):** | None |
| **Co-requisite Units (If applicable):** | None |
| **Course(s):** | Biosciences & Food, Forensic Science |
| **Year and Semester** | 2006/2007 Semester 1 |
| **Unit Coordinator:** | Dr Anne-Maria Brennan |
| **UC Contact Details (Tel, Email, Room)** | 02078157929 brennan@lsbu.ac.uk E228 |
| **Teaching Team & Contact Details (If applicable):** | Dr Alan Beeby 02078157912 beebya@lsbu.ac.uk E227 |
| **Subject Area:** | Bioscience & Food |
| **Summary of Assessment Method:** | 100% examination |

# 2. SHORT DESCRIPTION

*"This guide is designed to help you structure your learning by providing an indicative structure and content for the unit. It is a guide and not a definitive statement of what you will be taught. We will try to follow this published schedule as far as possible, but there may be some variation as the unit develops and as we try to match the pace and content of our teaching to student needs."*

This is an introductory unit providing a foundation for further studies in all areas of biology. The cellular organisation of living organisms is introduced and the organisation and functions of eukaryotic cells are explored. Genetics, the study of heredity, is introduced and heredity is examined at the levels of organisms, cells and molecules. Current methods for studying cells and manipulating genes will be highlighted. The origin of life and its mechanisms underlying evolution will be introduced.

# 3. AIMS OF THE UNIT

- To transmit a body of information about the organization of different types of cell.
- To explore the relationships between structure and function in eukaryotic cells.
- To introduce biodiversity and the taxonomic classification of organisms.
- To present the principles of information storage and expression in living organisms, and of the genetic basis of variation.
- To introduce the theory of evolution by natural selection and its supporting evidence.

# 4. LEARNING OUTCOMES

## 4.1 Knowledge and Understanding

At the end of this unit, a student will be able to:

1. Appreciate the importance of the cell as the basic unit of living organisms and describe the key differences between different types of cell.

2. Outline the functions of the main compartments of eukaryotic cells and appreciate the relationships between them.

3. Use accurately, the principles of taxonomy and classification and the proper citation of scientific names.

4. Set out the theory of evolution by natural selection and the principle mechanisms of speciation.

5. Explain in simple terms the structures of DNA, RNA and protein, and appreciate their roles in information storage and expression.

## 4.2 Intellectual Skills

Students who engage fully with the unit and complete the lectures, tutorials and individual study programme will further develop skills acquired earlier in the course. In particular, there will be opportunities to develop:-

*learning how to learn*- there are a wide range of aspects to this skill which will be developed *e.g.* time management, finding and using information;

*use of information and communication technology*- the use of the textbooks and the internet to retrieve information.

## 4.3 Practical Skills

Although there are no formal practical sessions the unit will involve the students in developing skills gained that familiarise them with the subject area. These include:-

*understanding methodologies*- being familiar with the experimental techniques involved in cell biology.

## 4.4 Transferable Skills

Other transferable skills include:-

*communication skills*- written and oral communication will be required during preparation for tutorials especially those involving presentations;

*numeracy skills*- analysis and interpretation of numerical information.

# 5. ASSESSMENT OF THE UNIT

100% end-of-unit examination (2 hours). The pass mark for the unit is 40%. A specimen paper exam paper can be found at the back of the unit guide.

*Any plagiarism will cause this case study to score zero, will be reported as Academic Misconduct and may result in disciplinary action. E**nsure that you are familiar with the University Regulations on plagiarism (these are in your student handbook and in your course guide).** All registered students are required to read and adhere to these as any breach of University Regulations may result in disciplinary action. You are encouraged to quote but you are **not** allowed to copy– **if the difference is not clear to you, ask a member of unit team.***

# 6. FEEDBACK

Feedback will normally be given to students 15 working days after the submission of an assignment.

# 7. INTRODUCTION TO STUDYING THE UNIT

## 7.1 Overview of the Main Content

**Cells**

The cell as the basic unit of living organisms. Common features of cells. Structure of eukaryotic cells. Endosymbionts. Functional significance of compartmentalisation. Key biochemical functions associated with particular compartments and the trafficking of molecules within the cell. Intra- and inter-cellular signalling. Cell division and its regulation. Methods for studying cells.

**Genes**

Chromosomes as carriers of genetic information. Sex chromosomes and sex-linkage. Meiosis. Linkage and gene maps. Mitosis and meiosis. Introduction to the molecular basis of information storage and expression and to methods for analyzing and manipulating genes. Genetically modified organisms.

**Evolution**

Mechanisms of evolutionary change. Speciation. Modern evolutionary theory including the concept of the selfish gene. Genes and behaviour. Selection- natural and artificial.

## 7.2 Overview of Types of Classes

**Teaching and Learning Pattern:**

The unit comprises 2 hours of formal lectures per week along with a 1-hour long tutorial alternate weeks. In week 13 a 2-hour revision lecture will be available to help prepare students for the examination.

## 7.3 Importance of Student Self-Managed Learning Time

Self-managed learning time is a key aspect of this unit and it is important that students make full use of this time to prepare for tutorials and consolidate lecture material.

## 7.4 Employability

The unit will develop written and verbal skills (including presentation skills) that are useful in future careers.

# 8. THE PROGRAMME OF TEACHING, LEARNING AND ASSESSMENT

**TUTORIALS**

These will run on alternate weeks according to the tutorial group you are assigned to. (As attendance registers are taken both at lectures *and* tutorials, it is essential that you remain in the tutorial group you are placed in.)

***Tutorial topics***

1. Characteristics of living organisms.
2. Problems of naming...classification systems.
3. My favourite cell.
4. Cell division and chromosomes.
5. Genes and environment.
6. Evolution and the new genetics.

**Tutorial Groups (provisional)**

| | | | |
|---|---|---|---|
| Applied Science | Wednesdays 1200-1300 | Weeks 1,3,5,7,9,11 | A-M Brennan |
| Bioscience (Group1) | Tuesdays 1400-1500 | Weeks 1,3,5,7,9,11 | A Beeby |
| Biosciences (Group2) | Tuesdays 1600-1700 | Weeks 1,3,5,7,9,11 | A Beeby |
| Food & Nutrition | Tuesdays 1000-1100 | Weeks 1,3,5,7,9,11 | A-M Brennan |
| Human Biology | Tuesdays 1100-1200 | Weeks 1,3,5,7,9,11 | A-M Brennan |
| Forensic Science (Group 1) | Wednesdays 1600-1700 | Weeks 1,3,5,7,9,11 | A-M Brennan |
| Forensic Science (Group 2) | Wednesdays 1600-1700 | Weeks 2,4,6,8,10,12 | A Beeby |

## LECTURE SEQUENCE

| | | |
|---|---|---|
| Week 1 | | |
| 1400-1500 | Introduction to the Unit. What is life? | ANB |
| 1500-1600 | Biological diversity | AMB |
| Week 2 | | |
| 1400-1500 | The origin of life | ANB |
| 1500-1600 | The evidence for biological evolution | ANB |
| Week 3 | | |
| 1400-1500 | Diversity and classification | AMB |
| 1500-1600 | The five main kingdoms. Symbiont theory | AMB |
| Week 4 | | |
| 1400-1500 | Mechanisms of evolutionary change | ANB |
| 1500-1600 | Chromosome structure. DNA and the genetic code I | ANB |
| Week 5 | | |
| 1400-1500 | The structure & organisation of the cell | AMB |
| 1500-1600 | Nucleus and cytosol | AMB |
| Week 6 | | |
| 1400-1500 | The genetic code II. Translation and transcription | ANB |
| 1500-1600 | Meiosis and genetic variation | ANB |
| Week 7 | | |
| 1400-1500 | Endomembrane system and intracellular traffic | AMB |
| 1500-1600 | Mitochondria and chloroplasts | AMB |
| Week 8 | | |
| 1400-1500 | Cell division and chromosomes. Mitosis. Replication. | ANB |
| 1500-1600 | Contact and communication between cells | AMB |
| Week 9 | | |
| 1400-1500 | Meiosis. sex and gametes | ANB |
| 1500-1600 | Speciation | AMB |
| Week 10 | | |
| 1400-1500 | The natural history of sex | ANB |
| 1400-1500 | Modern synthesis of evolution. The 'selfish gene' theory | AMB |
| Week 11 | | |
| 1400-1500 | Chromosomal abnormalities | ANB |
| 1500-1600 | Artificial selection | AMB |
| Week 12 | | |
| 1400-1500 | Heredity in humans | ANB |
| 1500-1600 | Human pedigrees and their applications | ANB |
| Week 13 | | |
| 1400-1600 | Revision session | AMB/ANB |

# 9. LEARNING RESOURCES

## 9.1 Core Materials

Beeby, A.N. & Brennan A-M (2004) *First Ecology.* (2nd Edition) Oxford University Press, Oxford.

Campbell, N.A, Reece JB & Mitchell LG (1999) *Biology.* (6th Edn.) Benjamin/Cummings, San Francisco.[www.campbellbiology.com]

## 9.2 Optional Materials

Bell, J. (1986) Becker, W.M., Kleinsmith, L.J. & Hardin. (2002) *The World of the Cell.* (5th Edn.) Benjamin/Cummings, San Francisco. [www.thecellplace.com]

Bolsover, S.R., Hyams, J.S., Jones, S., Shephard, E.A. & White, H.A. (1997) *From Genes to Cells.* Wiley-Liss.

Jones S. (2000) *The language of the genes (revised edition.)* Flamingo.

Skelton, J. *Evolution.* Longman, Harlow.

Virtual library (Biosciences) operated by University of Illinois at Chicago (www.vlib.org/Biosciences.html)

# Tutorial Exercises

## Tutorial 1

## Characteristics of Living Organisms

A list of the characteristics possessed by all living organisms is given below:

- Composed of one or more cells
- Grow and maintain complex organisation by acquiring molecules and energy from the environment.
- Undergo metabolic reactions.
- Maintain homeostasis.
- Irritability.
- Reproduction.
- Carry genetic information in the form of nucleic acids.

For each of the 'five Kingdoms' and for viruses discuss:

- What form do the characteristics take in the different groups?
- Do all the organisms display these characteristics?
- All of the time or some of the time?

*Focus on Cells*

What are the key features of cells?

What are the main differences between prokaryotic and eukaryotic cells?

Calculate the surface area and volume of typical prokaryotic and eukaryotic cells (for simplicity, assume that they are cubes 1um and 20 um across respectively).

What groups of organisms are multicellular?

Why do you think multicellularity evolved?

## Tutorial 2

## The problem of naming.... classification systems

*Preparation*

Read through your lecture notes and make additional notes having read the relevant parts of your textbook (either Campbell or Purves). [The necessary background reading is Campbell and, if you want to read about vertebrate and human evolution look at Chapter 30.]

*Introduction*

How do we classify organisms into progressively larger and more inclusive groups? Why is this kind of activity useful? In this tutorial you will discuss questions exercises to help you think about these issues

*Some Important Terms*

**Phylogeny**: the evolutionary relationship and history of a specie or group of species (as in 'phylogenitic trees').

**Homology**: a shared characteristic that is attributable to shared ancestry.

**Analogy**: a shared characteristic that evolved independently in two groups (sometimes referred to as 'convergent evolution').

**Phenetics**: basing classification strictly on measurable differences in a large number of characters, without worrying about phylogeny.

**Cladistics**: basing classification strictly on phylogeny, according to the positions of branches on a phylogenetic tree.

**Discussion questions**

- Give some examples of homologous characters and some examples of analogous characters.
- Draw a phylogenetic tree showing birds, crocodilians and 'other reptiles' (lizards and snakes), accepting that crocodiles and birds share a common ancestor more recently than either of them do with 'other reptiles'. Which of the three groups would be classified together according to cladistics?
- Bacterial have few visible features that can be used in taxonomy. What characteristics are used instead?

- Which would be more useful to a hospital microbiologist – a classification based on phenetics, one based on cladistics, or something else?

*Comment*

Most taxonomists today accept that, ideally, classification should be phylogenetically based. However, they are prepared to depart from this in situations where an alternative classification is particularly useful, and will be reluctant to change a long-established scheme. Because most similarities ***are*** due to common descent the conflicts are usually resolvable.

- Why are taxonomists often reluctant to change existing schemes of classification, even in the light of new phlylogenetic evidence?

**Exercise**

You will be provided with a set of cards, each showing one of the taxons used in the taxonomic classification of humans. Working in groups, arrange the cards in order - from the smallest to the most inclusive taxon. Then write down another species or group that also falls within each of the taxons. *(Please do not write on the cards.)*

Compare your answer with the other groups.

- If the classification is strictly phylogenetically based, all the species that fall into any taxon share a common ancestor. What statement could you make about when in history of the common ancestor of all members of the hominid family existed, compared to when the common ancestor of all members of the primate order existed?

- Does a particular taxonomic level have an absolute meaning? Is there a definition of a species that works for humans *and* for insects? How about other taxonomic levels (family, class *etc.*)?

- What do biologists mean by binomial nomenclature? How are such names usually written?

## Tutorial 3

## My Favourite Cell

*Preparation*

How many distinct cell types are there in an adult human being? Most estimates suggest that it takes about 200 different varieties of cell to make up all the tissues and organs of the human body. In this tutorial you will present a description of the features that make *one* of these cell types different from all the others.

Each group (of 4 students) should select a different type of cell and prepare a short talk (10 minutes maximum) to be delivered to the rest of the tutorial class. Visual aids in form of OHPs or handouts can be used, if appropriate.

*Hints*

Arrange a time for your group to meet and discuss and another longer period to bring your findings together and prepare the final presentation.

You can choose any human cell type you like. Choose a specific cell type: "muscle cell" for example, is not specific enough – choose "ordinary cardiac muscle cell" or "red (slow) skeletal muscle cell" instead.

Information on most cell types can be found in any large histology books – there a number of them available for consultation in the library. You will also find information in physiology books dealing with the appropriate system (*e.g.* the endocrine system for cells that make hormones, the digestive system for gut cell types).

Presentations always work better if they are properly organised, with an introduction and a summary at the end. Emphasise what is special about your cell and how it differs from other cells in the body. You may like to organise your talk around some of the following questions.

**Introduction** What is your cell type called?

Where is it found in the body?

What are its main functions?

When does it arise during development, and when does it die?

**Features** Size and shape?

Surface features?

Large amounts of particular organelles?

Large amounts of particular proteins?

Distinctive metabolic functions?

Does it secrete anything?

Is it influenced by particular signals from other cells?

Does it signal to other cells?

**Conclusions**

Relate the special features of the cell to it's function(s) in the body (you have probably been doing this throughout your talk – but restate the main points anyway).

# Tutorial 4

## Cell Division & Chromosomes

### Preparation

Review your notes and textbook on mitosis, meiosis and chromosomes and ***bring these to the tutorial.***

### Mitosis & Meiosis

Both mitosis and meiosis are divided into four stages:

**Prophase**: the chromosomes condense.

**Metaphase**: the nuclear envelope breaks apart, and chromosomes attach to the spindle and become arranged on the 'metaphase plate' in the centre of the cell.

**Anaphase**: the chomatids (in mitosis and meiosis II) or the homologous chromosomes (in meiosis I) separate and move to opposite poles of the cell; and

**Telophase**: the chromosomes decondense and the nuclear envelopes reform.

Mitosis is a single division, while meiosis consists of two divisions. There is usually no telophase between the first and second meiotic divisions: anaphase I is followed by metaphase II.

- Examine the drawings A-H of mitosis. Cut out the individual drawings and arrange them in order. Stick them down on a sheet of paper and label them with the appropriate stage.
- Do the same for drawings A-H of meiosis. Remember that you have to decide not only what stage is represented, but also whether the first and second meiotic division is represented.

### Some more questions to consider...

Consider a diploid organism with a haploid chromosome number of 7. Remember that, after DNA replication in the S-phase, a chromosome consists of two identical DNA molecules, which we call chromatids until they separate from one another and become chromosomes in their own right.

- How many chromatids are present in its mitotic metaphase nuclei?
- How many chromatids are present in its meiotic metaphase I nuclei?
- How many chromatids are present in its meiotic metaphase II nuclei?
- How many different gametes could be produced by this organism (ignoring the possibility of crossing over)?

# Tutorial 5

## Genes & Environment

### Preparation

Read through this page and the next in advance and think about the questions.

### Introduction

The phenotype of an individual organism (the morphological, biochemical, behavioural and other characteristics) is a result of both the genotype of that individual and the environmental influences that the individual has experienced. Most characteristics are a result of both genetic and environmental influences.

Can you think of characteristics that could reasonably be called:

- entirely genetically determined?
- entirely environmentally determined?

These issues are not only of academic interest. Politicians frequently try to justify inequalities in society on the grounds that the privileged are genetically better-endowed with intelligence. Eugenics movements have sought to sterilise 'genetically inferior' individuals and their activities are of considerable concern in terms of human rights.

To help you focus on these issues, you should start by discussing the two case-studies below; one which deals with PKU and the other height and then move on to the more contentious topics. Don't expect your tutor to know all the answer! We will be concentrating on humans – but remember that the same principles apply to other organisms.

### Phenylketonuria (PKU)

***Background information:***

This is a classic example of as single-gene defect and is due to recessive autosomal pattern of inheritance. The incidence is 1 in 15,000 in the USA, but in Ireland and Scotland it is as high asl in 6,000. It is very uncommon in Africans. The disease leads to mental retardation and seizures. Hair and skin colour is characteristically light. It is caused by excess phenylalanine not breaking down due to the absence of the enzyme phenyalanine hydroxylase. The amino acid, an its metabolite, phenylpyruvic acid, accumulate in the bloodstream and block uptake of other necessary amino acids by developing nerve cells. It used to be treated by a special low phenylalanine diet until 6 years, although recent evidence has raised the question of whether this is too short. Excess phenyalanine can be a serious problem for pregnant women.

***Questions:***

Is the phenotypic characteristic of suffering (or not) from phenylketonuria determined by genes or environment?

**Height**

***Background information:***

Height is a trait that shows continuous variation – people don't fall into discrete groups. Children of tall parents tend to be taller than average, and children of short parents tend to be shorter than average. Children of people who immigrated to 'rich' from 'poor' countries are often taller than their parents (and the grandchildren of the immigrants are even taller!).

***Questions:***

Is there a single gene for height?

What kinds of gene might affect height?

Do men and women have the same average height?

Does nutrition affect height?

Might it be an evolutionary advantage to produce small children in bad times?

**Other possible topics**

Skin colour

Wealth (tends to run in families – does that mean it is genetic?)

Language

Intelligence

Sex differences in behaviour

Criminality

Cancer

## Tutorial 6

## Evolution & the new genetics

### Preparation

Read round the subject of gene technology and its evolutionary implications. As well as reading textbooks keep your eyes on the media for any news items concerning genetic manipulation- be ready to discuss these current affairs issues critically, recognising the 'take' that some people place on the matter and then be prepared to discuss the scientific facts behind the issues.

### Introduction

### Some case studies

Stem-cell therapeutics

Bt modification

The quest for high-methionine grain