1 Introduction

If you are intending to study SK320, you should make sure that you have the necessary background knowledge and skills to be able to enjoy the module fully and to give yourself the best possible chance of completing it successfully.

Read through these notes carefully and work through the questions in Section 4. The notes cover the knowledge and skills you should already possess, and the questions will provide a useful exercise for all prospective students of SK320.

If you find that you can answer most of the questions in these notes then it is likely that you are well prepared to take on SK320. However, if you are not confident in answering most of the questions you should consider doing some additional preparatory work before starting SK320, or studying one of the modules mentioned in Section 2.

2 Suggested prior study

SK320 Infectious disease and public health is an OU Level 3 science module that makes intellectual demands appropriate to the third year of a conventional degree. The module is an optional component of the BSc in Natural Sciences and the named BSc in Life Sciences (available until 2014).

The module develops some of the subjects covered in the following OU Level 1 and Level 2 modules:

- S204 Biology: uniformity and diversity (last presentation 2011)
- S294 Cell biology (new in 2012)
- SDK125 Introducing health sciences: a case study approach
- SK277 Human biology.

It is not assumed you will have studied all of these modules. It is however assumed that you will have a level of biology knowledge that is commensurate with that in S204, S294 or SK277. If you have not studied any of these modules you are likely to find the biology in SK320 more challenging and may have to do more background reading. Studying SDK125 will help to prepare you for the health-related issues and the epidemiology in SK320, which is likely to be more of a challenge if you are from a purely biological academic background.

Some support in the form of background reading will be provided as part of the module material. If you have no background in biology or health sciences, we strongly advise you to begin by studying SDK125, followed by SK277 or S294 before undertaking SK320.

3 Module content

SK320 is arranged into three blocks that each require around 100 hours of study time. The following descriptions provide some detail about the content of these blocks.
Block 1 Infectious agents

Block 1 considers:

- an overview of present-day worldwide epidemiology of infectious disease
- the importance of climate, geography, biological, social and political factors in determining the distribution of infectious disease within and between countries
- the major transmission routes of infectious agents: food, water, air, person-to-person contact, animal vectors and medical procedures.

It then focuses on the range and diversity of infectious agents: viruses, prions, bacteria, single-celled protists, and parasitic invertebrates.

Finally it looks at the diagnosis of infection through a range of sample types and diagnostic tests, identifying and characterising pathogens found, and recommending possible treatments.

There are a number of case studies to be examined in this block, specifically: influenza, tuberculosis (TB), cholera, and malaria.

Block 2 Immunity and adaptation

Topics covered include:

- immune responses to infection
- mechanisms of adaptive and innate immunity
- selection and regulation of different types of immune defence
- ways in which pathogens avoid recognition or escape destruction by the immune system
- genetic variation in immune responses and host susceptibility to infection
- vaccine design, chemical strategies against infection.

The case study for Block 2 is polio.

Block 3 Public health

The final block discusses:

- public health approaches to infectious disease
- epidemiology of infections: rates and risks
- models of transmission
- the mechanism of herd immunity
- epidemiological parameters, such as the reproduction number and the critical immunisation threshold
- the impact of vaccination.

Some of this material will be illustrated by means of simple computer models.

Block 3 also considers:

- an overview of the range of strategies required in different situations, illustrating some interventions in both developed and developing countries
- evolution of host–pathogen (and pathogen–vector) relationships; Red Queen hypothesis and the importance of generation times
- infectivity and virulence
mutation rates and natural selection in the emergence of antibiotic resistance
pathogens with long dormancy or latency periods
variation in pathogenicity of an organism in different populations.
interventions to prevent, reduce the impact of, or treat infectious disease.
Case studies in this block include: healthcare-acquired infections, Guinea worm, and chlamydia.

4  Key concepts for SK320
Answering the questions below requires the sort of knowledge that you need in order to study SK320.

4.1  Cell structure and function

Question 1
Indicate by inserting P (plant), A (animal) and B (bacteria) alongside each cellular component, which features are present in eukaryotic cells (P and A) and prokaryotic cells (B).

<table>
<thead>
<tr>
<th>cell membrane</th>
<th>mitochondria</th>
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<tbody>
<tr>
<td>cell wall</td>
<td>nucleus</td>
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<tr>
<td>chloroplasts</td>
<td>nuclear membrane</td>
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<td>cytoskeleton</td>
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<td>cytoplasm</td>
<td>ribosomes</td>
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<td>cytosol</td>
<td>rough endoplasmic reticulum</td>
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<td>DNA</td>
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Question 2
What processes would probably be occurring to a major extent in each of the following cells?
(a) a cell in which there is a great deal of rough endoplasmic reticulum
(b) a cell in which the Golgi apparatus is large
(c) a cell with a high rate of lysosomal activity
(d) a cell in which there is a great deal of smooth endoplasmic reticulum
(e) a cell with large numbers of mitochondria.

Question 3
Describe the following cellular processes:
(a) secretion
(b) phagocytosis
(c) apoptosis
(d) differentiation.
4.2 Microbiology

Question 4

(a) What are the differences between a virus and a bacterium?

(b) Which of the following diseases are caused by viruses and which by bacteria?
   (i) anthrax
   (ii) acquired immunodeficiency syndrome (AIDS)
   (iii) common cold
   (iv) bubonic plague
   (v) polio
   (vi) food poisoning
   (vii) smallpox.

Question 5

Are prions best described as microbes? Give reasons for your answer.

4.3 Immunology

Question 6

List the ways in which a microbe can overcome a host’s adaptive immunity.

Question 7

Briefly distinguish between the following:
(a) antigens and epitopes
(b) antibodies and antigen binding sites
(c) innate and adaptive immunity
(d) lymphocytes and macrophages.

Question 8

Describe what happens during the primary and secondary immune responses to an infectious agent. How has this feature of adaptive immunity been exploited in vaccination programmes?

Question 9

Measles and chickenpox are both caused by viruses. Explain why a person who has recovered from measles and has never had chickenpox, is unlikely ever to suffer from measles again but is just as susceptible to chickenpox as before.

4.4 Evolution

Question 10

Use the terms ‘best adapted’, ‘fitness’ and ‘selection pressure’ in explaining the evolution of antibiotic-resistant bacteria in a society where antibiotics have been over-prescribed and people have often failed to complete the course of treatment.
4.5 Mathematical skills

The section of the module on epidemiological modelling requires some acquaintance with symbolic notation, manipulation of simple algebraic equations, and simple arithmetic calculations. The SK320 material will explain the steps, but here is a taster of the type of calculations you will meet.

Question 11

In a particular population it has been calculated that, on average, people catch a cold once every two years. Calculate the average number of colds people from this population might expect to catch in a five-year period and in a six-month period.

Question 12

Four quantities, none equal to zero, are represented by the letters $a$, $b$, $c$ and $d$ and are in the relation $a \times b = c \times d$. Express quantity $c$ in terms of $a$, $b$ and $d$.

Question 13

550 children attend school A, 250 attend school B. Over a given year, 20 children from school A get measles, and 10 from school B. Calculate the overall proportion of children from schools A and B who get measles, and express this as a percentage.

Question 14

Four quantities, none equal to zero, are represented by the letters $a$, $b$, $c$ and $d$ and are in the relation $c = (a \times b)/d$. Express quantity $b$ in terms of $a$, $c$ and $d$.

5 Other skills

Other than subject-specific knowledge, there are a number of other skills that you need to study SK320 successfully.

5.1 Basic study skills

You should have the ability to organise time for study; to pace study; to interpret figures and graphs and to make effective notes on the material you study. You should be able to use information from a variety of sources (journals, books, the internet) and distinguish between relevant and irrelevant information.

5.2 Writing skills

You should have the ability to write clearly and unambiguously, concisely and coherently, presenting your arguments in a logical way and using clear and appropriate diagrams.

5.3 Information technology

SK320 is taught online, but includes a DVD that contains required software (the Digital Microscope) and off-line copies of the module materials. You should be reasonably conversant with the use of the internet for searching and information retrieval.
6 Answers to questions

Question 1

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Where P = plant, a = animal and b = bacteria.

Question 2

The processes would be:

(a) synthesis and export of proteins
(b) secretion
(c) degradation of cell debris or ingested particles
(d) production of phospholipids and steroids or detoxification of ingested substances
(e) production of ATP.

Question 3

(a) Secretion is the process whereby substances, predominantly proteins or glycoproteins, are released from the cells where they have been produced, e.g. hormones, enzymes.
(b) Phagocytosis is the engulfing and subsequent digestion of particulate matter, e.g. cell debris, foreign particles, invading pathogens.
(c) Apoptosis is the controlled destruction of cells, also known as programmed cell death.
(d) Differentiation is the collection of changes that take place in a cell as it becomes specialised.

Question 4

(a) A virus generally consists of nucleic acid (DNA or RNA) enclosed within a protein coat. Viruses are not cells and can only reproduce by infecting host cells and utilising their mechanisms to produce new viral particles. Bacteria are cells containing their own genetic material and can grow and reproduce independently.
(b) (i) anthrax – bacterium
(ii) AIDS – virus
(iii) common cold – virus
(iv) bubonic plague – bacterium
(v) polio – virus
(vi) food poisoning – bacteria
(vii) smallpox – virus.

Question 5

Microbes are small and consist of nucleic acid surrounded by some form of protective layers made of complex molecules such as proteins and carbohydrates. Prions consist of single protein molecules. All the information necessary to cause a disease resides in the conformation of the protein; there is no nucleic acid and no structural complexity. Therefore prions cannot be described as microbes, although they can be classed as infective particles.

Question 6

The microbe can: hide where the immune system can’t find it; conceal its antigens; vary its antigens; shed its antigens as a decoy; destroy the antibody; display Fc receptors on its surface; suppress immune functions; induce tolerance.

Question 7

(a) Antigens are macromolecules that elicit an immune response if they enter a vertebrate’s body. They are recognised as ‘non-self’ by the responding organism’s immune system because they contain epitopes in their structure, i.e. small regions where the arrangement of molecules is unlike anything that naturally occurs in the respondent’s body. Antigens may be macromolecules circulating in the body fluids (e.g. a bacterial toxin), or part of the structure of an infectious agent (e.g. a virus), or a tissue graft (e.g. a kidney transplant).

(b) Antibodies are complex protein molecules, composed of four protein chains arranged to incorporate two identical antigen binding sites, each of which exactly fits the shape of (and thus can bind to) a particular epitope on an antigen.

(c) Innate immunity refers to the non-specific cellular and molecular defence mechanisms that organisms throughout the animal kingdom can direct against infectious agents that enter the body. These mechanisms cannot distinguish between one type of infectious agent and another (hence they are ‘non-specific’). Adaptive immunity is only found in higher vertebrates and is highly specific, distinguishing between different infectious agents on the basis of differences in their epitopes. The adaptive immune response becomes more effective each time it encounters the same infectious agent (i.e. it ‘adapts’).

(d) Lymphocytes and macrophages are both types of white cell (leukocyte) found in higher vertebrates and involved in the defence against infection. Lymphocytes are the principal cell type involved in adaptive immunity, and include B cells, which synthesise antibodies, helper T cells, which stimulate the immune response, and cytotoxic T cells, which kill infected host cells. Macrophages are phagocytic cells involved in innate immunity, which engulf and break down cellular antigens and debris; they are also involved in ‘presenting’ antigens to T cells.
Question 8

The primary immune response occurs the first time a higher vertebrate is exposed to an infectious agent. It takes several days before the primary cellular and molecular response mechanisms are sufficiently effective to begin eliminating the infection, and in that time symptoms can generally develop. As the primary response grows, some of the cells in the immune system with the ability to recognise the infectious agent differentiate into long-lived ‘memory cells’. If a subsequent infection occurs with the same infectious agent, the memory cells are activated and a secondary immune response develops so quickly and effectively that symptoms are reduced or prevented. Vaccination programmes reduce or prevent infections from developing by exposing the target population to harmless extracts from the infectious agent in question. Vaccinated individuals develop a primary immune response to the antigens in these extracts and memory cells are formed. If the infectious agent gets into the body subsequently, it will be quickly recognised and eliminated by the secondary immune response. Immunity can be ‘boosted’ by giving a repeat vaccination at a later date.

Question 9

The molecular structures of the measles and chickenpox viruses include different epitopes, which can be distinguished by the human immune system. Memory cells that are committed to respond to the measles epitopes develop as the person recovers from the first infection, and these give protection against a subsequent infection with measles. But these memory cells have specific receptors that bind only to the measles epitopes; they cannot give any protection against the chickenpox virus.

Question 10

A bacterial population in a single person consists of many billions of bacterial cells, which vary in their susceptibility to being killed by a particular antibiotic. When the bacteria are exposed to the antibiotic, the most susceptible bacteria die first, so – over time – the proportion of more resistant bacteria increases in the population. These bacteria have the highest fitness under these conditions, that is, they are the best adapted to survive exposure to the antibiotic for long enough to reproduce and pass on their ‘resistance’ genes to their progeny. The antibiotic exerts selection pressure on the bacterial population, driving it towards greater antibiotic resistance. If the antibiotic is not administered in an optimal dose for a long enough period, the best adapted (i.e. most resistant) variants will survive and re-populate the person. Everyone who subsequently becomes infected with these more resistant bacteria will need even stronger doses of that antibiotic to eradicate the infection. If the cycle of inadequate antibiotic treatment is repeated often enough, after many generations all of the bacteria in the population will have evolved complete antibiotic resistance.

Question 11

In five years: $5 \times (1/2) = 2.5$ colds. In six months: $(1/2) \times (1/2) = 1/4 = 0.25$ cold.

Question 12

Dividing both sides by $d$ (this is acceptable since $d$ is not zero) gives

$$c = (a \times b)/d.$$
Question 13

The total number of children is $550 + 250 = 800$, of whom $20 + 10 = 30$ get measles. So the proportion required is $30/800 = 0.0375$ or $3.75\%$.

Question 14

Multiplying both sides by $d$, then dividing both sides by $a$ (this is acceptable since $d$ and $a$ are not zero) gives $b = (c \times d)/a$. 