1 Introduction

S290 Investigating human health and disease explores a range of health science topics at the cell and molecular level. It is a fully online module but does have a mailed workbook to support study of interactive screen investigations.

S290 is the Stage 2 module in The Open University’s Health Sciences qualification pathway. Alternatively, you may be studying it as part of an Open qualification. S290 develops knowledge and skills about how human health is studied experimentally and to detail approaches to diagnosis and treatments that are based upon experimental findings.

In order to study S290 successfully you need to be sufficiently prepared. This module is delivered entirely online, so you need access to a computer linked to the internet and you need a level of numeracy skills from Level 1 and Level 2 study. You also need an ability to read text that is scientifically technical, understand and prepare data presented in graphical form and have reached a good standard in English. Your study will involve you collecting data using onscreen tools such as digital microscopes and other types of interactive experiments. It essential to have some wider basic science knowledge, including some basic chemistry and aspects of physics including an understanding of the electromagnetic spectrum. Finally, you will also need enough time to study a 60-credit module - a minimum of 20 hours per week.

Are you ready for S290? is a quiz with a set of self-assessment questions, designed to help you decide whether you are sufficiently prepared to start studying this module. When you have completed the quiz, you will be able to decide whether S290 is a sensible choice for you at the present time, or whether you need to engage with some additional preparatory work before starting out.
Please read through this information carefully, and work through the self-assessment questions (SAQs). Sections 2 and 3 below detail some of the recommendations and requirements, and Section 4 is a series of self-assessment questions to assess your readiness in terms of skills, knowledge and understanding required. These questions are to help you gauge whether you understand the relevant principles and concepts. If, after working through the questions in Section 4, you are still unsure about whether S290 is the right module for you, we advise you to seek further help and advice from Student Support.

The S290 module team look forward to welcoming you as an S290 student.

2 Suggested prior study

S290 builds on the core health science modules from Level 1, particularly SDK100 and the Level 2 module SK299.

3 Are you ready to study S290?

3.1 Available study time

S290 Investigating human health and disease runs for nine months, starting in October. You will need to find about 20 hours study time per week. Think now about whether you will be able to find enough time.

Think about your other commitments e.g. paid employment, childcare, hobbies, holidays. You should also take into consideration any other study you have also committed to. For example, studying other OU modules at the same time as S290 to a total of 120 credits would require a total study time of 32–36 hours a week. We provide breaks in late December and in March or April, but otherwise you will need to keep up to date with your studies throughout the nine-month period, submitting assignments at regular intervals.

You can use the grid below to help you decide whether you are going to be able to find enough time to study S290. Consider your other commitments in a typical week. For each day, enter the amount of time that you are likely to be able to spend in studying, then add them up to give your weekly total. Remember that you will need to keep up the schedule for 9 months, so allow yourself some time off!

<table>
<thead>
<tr>
<th>Day</th>
<th>Mon</th>
<th>Tues</th>
<th>Weds</th>
<th>Thurs</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Given this quantity of study per week, a dedicated study area would be helpful.

3.2 Computer and web-access

S290 is delivered online via a module website. You will need a computer with reliable internet access in order to be able to study the module materials and complete your assignments. You will also be offered online tutorials and you will be able to communicate with your tutor and fellow students in our online forums. You will therefore find studying S290 most straightforward if you are the sole or main user of a computer with internet access.
**Computing requirements**

A computing device with a browser and broadband internet access is required for this module. Any modern browser will be suitable for most computer activities. Functionality may be limited on mobile devices and with some older browsers.

Any additional software will be provided or is generally freely available. However, some activities may have more specific requirements. For this reason, you will need to be able to install and run additional software on a device that meets the requirements below.

A desktop or laptop computer with either:
- Windows 7 or higher
- Mac OS X 10.7 or higher

The screen of the device must have a resolution of at least 1024 pixels horizontally and 768 pixels vertically.

To complete the module assignments, you will also require:
- Word-processing skills and a word processing programme, for example, Microsoft Word or Apache Open Office (available as a free download).
- Basic spreadsheet skills and a spreadsheet programme, for example Microsoft Excel or Apache Open Office equivalent. Skills include data entry, basic manipulation and simple graph generation.
- A means of inputting a digital image of hand-drawn graphs or diagrams into a word-processed file, e.g. a scanner, a digital camera or a mobile phone with a camera.
- A scientific calculator.

It may be possible to join some tutorials via a mobile phone with the Adobe Connect app installed. To participate in online tutorials, you will also require:
- A basic headset (earphones and microphone).
4 Self-assessment questions

These questions are intended to help you find out whether you are ready for S290, or if you need to brush up on your knowledge and skills in advance. Answers to the questions are provided at the end of this document.

You should allow yourself about two hours to work through the questions. This exercise will be useful for all prospective students of S290, even for those of you who have already studied other OU science modules and have completed the suggested prior study; working through this information will serve as a reminder of some of the relevant facts, skills and concepts that you should be bringing with you from earlier study.

Please note that you shouldn’t expect to be able to answer all the questions correctly now but attempting them should allow you to judge: (a) the areas where some reading beforehand would be useful (b) whether you will be able to cope with the demands of the module.

As a guide, if you are prepared you ought to get over 80% of the questions correct. If you get less than this, you are strongly advised to prepare for the module with some directed study in areas in which you struggled to answer questions correctly. This could be through revising the areas from your previously studied modules, or by using the S290 primer materials.

Where questions require some extended writing, you should not be surprised if your answer does not correspond to the model answers provided as these may contain some very specific details. Also, some answers offer some further explanation or relevant discussion which you would not be expected to provide.

The questions cover the following areas:

- Maths and science notation and graphing skills
- Digital and information literacy skills
- Scientific comprehension skills
- Basic chemistry and physical sciences
- Basic cell and molecular biology
- The human immune system
- Investigational and practical

5 Maths skills, scientific notation, probability and graphing skills

S290 will require you to collect, analyse and report data from various sources, including from investigations you will perform. The following questions will help you gauge your skills in these areas. You should note that there is a maths skills book available should you need to study this area further.

Question 1

The decimal number 102.6485 is expressed to four decimal places (i.e. there are four numbers after the decimal point). If 102.6485 is rounded to three decimal places, it becomes 102.649, because the fourth digit after the decimal place (5) is ‘5 or more’ – so the third digit is rounded up from 8 to 9. If the fourth digit had been less than 5, the third digit would not have been rounded up.

(a) Follow the ‘5 or more’ rule to round 102.6485 to:
(ii) to two decimal places,
(iii) one decimal place.

Numbers can also be expressed according to significant figures. It is frequently more reliable to quote answers from calculation to a specified number of significant figures where, in straightforward cases, the number of significant figures is found simply from counting the number of digits. So, a temperature of 16.472 °C could be quoted to five significant figures as 16.472 °C, to four significant figures as 16.47 °C, to three significant figures as 16.5 °C and to two significant figures as 16 °C.

(b) Follow these rules to express 102.6485 to:
(ii) 4 significant figures,
(iii) 3 significant figures.

(c) To how many significant figures are each of the following measurements given?
(i) 5.63 m
(ii) 3.567 kg
(iii) 0.082 m
(iv) 50.6 m

Question 2

Large numbers (and small numbers) are expressed using powers of 10 rather than writing out all the zeros. If you write 100 as 10², the ten (10) is known as the base number and the superscript two (²) is called the power (or exponent). So, 10² can also be referred to as ‘ten to the power two’.

In scientific notation, a number is written in the form m \times 10^n, where m, the multiplier, is between 1 and 9. So, 100 (10²) can be written as 1 \times 10² using scientific notation and a large number such as 2 million (2000000) therefore can be written as 2 \times 10^6.

(a) Express the following numbers in scientific notation: (i) 100 000 000, (ii) 35 000, (iii) 95 \times 10^5, (iv) 0.0035, and, (v) 0.51 \times 10^3.

(b) Scientists use units of measurement that have been agreed internationally called SI units.
(i) What is the SI unit (and symbol) for the following quantities: length, mass and time?
(ii) Express 1 gram using scientific notation for the appropriate SI unit of mass.

(c) An inferential statistical test to calculate the probability that a difference between drug treatment and no drug treatment arose by chance returns a calculated p value of 0.38.
(i) What is this probability expressed as a percentage and a fraction?
(ii) Is this difference significant when assessed against a critical p value of 0.05?
**Question 3**

The pie chart shown in Figure 1 shows the relative proportions of different categories of DNA in the human genome.

![Pie chart](image)

**Figure 1** A pie chart representing proportions of DNA sequences in the human genome.

(a) Which category of DNA in the human genome is the largest?

(b) Which category of DNA in the human genome is the smallest?

(c) Based upon Figure 1, are these statements true or false?
   (i) Dispersed repetitive DNA makes up over half of the human genome,
   (ii) There are more sequences supporting gene structure and function than there are genes, and
   (iii) The function of 95% of the human genome is known.
Question 4
The bar chart shown in Figure 2 shows the number of books read by students.

![Bar chart showing numbers of books read for seven students.](image)

**Figure 2** Chart showing numbers of books read for seven students.

(a) How many books have Anna and Hala read between them?
(b) How many books have the whole group read?
(c) What is the mean number of books read by the group?
**Question 5**

Scatter diagrams are very useful for seeing whether two variables are associated, i.e. when one variable changes does the other also change? Figure 3 is a scatter diagram showing the relationship between deaths among children aged under five years and their access to so-called ‘improved’ sanitation.

![Figure 3](image)

**Figure 3** Scatter diagram showing relationship between mortality and sanitation in various countries.

(a) In Sierra Leone, where fewer than 20% of under-fives have access to improved sanitation, what is the mortality?

(b) How would you describe the pattern made by the data points (the dots) in Figure 3?

(c) Is access to improved sanitation high or low in countries with high under-five mortality rates? Pick a country to illustrate your answer.

**Question 6**

The association between two variables is often shown graphically using simple data points. How would you describe the relationship between predators and their prey in the three data sets shown in Figure 4a-c?

![Figure 4](image)

**Figure 4** Graphs illustrating three relations between two variables (a-c).
6 Digital information skills

You should have completed the OU library skills activities in your previous Open University studies. An important OU Level 2 skill involves being able to critically evaluate information. PROMPT provides a toolset for evaluating the usefulness and validity of a source of information. The PROMPT criteria are outlined below:

**Presentation**
Given the age, condition and format of the information, is it as readable as it could be? Is the information clearly laid out and easy to navigate? Is it obscured by busy designs, animations or images?

**Relevance**
Does the information you have found meet the need you have identified? Does it make sense in the context in which you are working?

**Objectivity**
Does the author or owner of the information make clear their own and/or alternative views?

**Method**
Is it clear how the research was carried out? Were the methods appropriate? Does it permit the author to come to a sound and reasonable conclusion? Note that these criteria are particularly important when evaluating scientific and historical information.

**Provenance**
Can the author or source of the information be considered a reliable authority on the subject?

**Timeliness**
When was the information produced? Is it recent or dated? Is it obsolete? Does the age of the information matter on this occasion?

If you haven’t completed the relevant skills activities, there will be links to the relevant materials in the S290 preparatory materials.

7 Scientific comprehension skills

As a part of S290, you will be reading scientific reports and using scientific information from web-based resources. Whilst you do not need to be familiar with these at the start of the module, a reasonable level of scientific comprehension is required. These questions will allow you to assess areas of your ability to comprehend a piece of scientific writing.

Read the following article:

**Stem cells appear to repair tissue damage caused by bowel disease**

Gut stem cells appear to be able to repair tissue damage due to inflammatory bowel disease in tests on mice, according to a team of researchers from the Cambridge Stem Cell Institute at the University of Cambridge, and BRIC, the University of Copenhagen, Denmark. The findings may pave the way for patient-specific regenerative therapies for inflammatory bowel diseases such as ulcerative colitis.
Writing in the journal Cell Stem Cell, the team described looking at developing intestinal tissue in a mouse embryo and finding a population of stem cells that were quite different to the adult stem cells that have been described in the gut. The cells were actively dividing and could be grown in the laboratory over a long period without becoming specialized into the adult counterpart. Under the correct growth conditions, however, the team could induce the cells to form mature intestinal tissue. When the team transplanted these cells into mice with a form of inflammatory bowel disease, within three hours the stem cells had attached to the damaged areas of the mouse intestine and integrated with the gut cells, contributing to the repair of the damaged tissue.

“We found that the cells formed a living plaster over the damaged gut. They seemed to respond to the environment they had been placed in and matured accordingly to repair the damage,” observed R. Kim Jensen, a Wellcome Trust researcher and Lundbeck Foundation fellow, who led the study. “One of the risks of stem cell transplants like this is that the cells will continue to expand and form a tumour, but we didn’t see any evidence of that with the immature stem cell population from the gut.”

Cells with similar characteristics were isolated from both mice and humans, and the team were also able to generate similar cells by reprogramming adult human cells (induced pluripotent stem cells) and grown them in the appropriate conditions.

“We’ve identified a source of gut stem cells that easily expanded in the laboratory, which could have huge implications for treating human inflammatory bowel diseases. The next step will be to see whether the human cells behave in the same way in the mouse transplant system, and then we can consider investigating their use in patients,” added Dr. Jensen.


Question 7
(a) Where do the cells under discussion come from?
(b) What do the researchers observe when cells are transplanted into mice with a form of inflammatory bowel disease?
(c) In which journal was the original research published?
(d) What is the risk of stem cell transplants identified by Dr Jensen?
8 Biological and health knowledge and understanding

These questions will allow you to assess areas of your core knowledge and understanding of underlying principles important for S290.

Question 8

(a) How many hydrogen atoms are there in a molecule of ethanol, C₂H₅OH?

(b) Hydrogen gas and oxygen gas are examples of molecules where the atoms in the molecule are from the same element: a molecule of hydrogen gas consists of two atoms of hydrogen, and a molecule of oxygen consists of two atoms of oxygen held together by chemical bonds, as shown in Figure 5.

How do the bonds between the hydrogen and oxygen atoms in each of these molecules differ?

Figure 5 Hydrogen gas consist of two atoms of hydrogen and oxygen gas consists of two atoms of oxygen.

(c) Which one of the following types of bond does not involve a sharing or transfer of electrons? Ionic bond Covalent bond Hydrogen bond

Question 9

Electromagnetic radiation is a form of energy that can be described as either a wave or as a flow of ‘packets’ of energy. It includes gamma rays, X-rays, ultraviolet, infrared, microwaves and radio waves. The different types of radiation are distinguished by their wavelength and frequency.

(a) What is the name given to the form of electromagnetic energy detected by the human eye?

(b) Place these forms of light in order of increasing wavelength: infra-red, UV, green, orange, blue and red.

The cell stores information to synthesise proteins in the base sequence of DNA. A good understanding of the basics of the processes by which this occurs is required to study S290.
Question 10

Although DNA has a relatively simple structure, its four nucleotides provide a powerful coding language – a means of storing and passing on information. The key to understanding the structure of DNA and how it functions in the cell lies in the interaction between the bases in each strand at the core of the molecule. Along the length of a strand within the double helix, each base makes a specific pairing with a corresponding base in the other strand. These interactions are known as base pairing.

On Figure 6 below, which of the bases on the right would pair with the bases in the DNA strand on the left to form a double stranded segment of DNA?

![Figure 6](image) 

Figure 6 (right) DNA strand with nine nucleotides, with bases indicated as boxes on the right of each nucleotide coloured pink (T), yellow (A), blue (G) and green (C) in random order.
**Question 11**

Complete the following description of how genetic information in DNA is copied and used to synthesize protein by inserting the appropriate word or phrase into [a]-[f].

The DNA base sequence of a gene is copied into RNA during the process of [a]. During this process, the bases pair between DNA and RNA along similar lines to the process that occurs in double-stranded DNA, with the exception that the thymine base (T) in DNA is replaced by a [b] base in the messenger RNA (mRNA). Once complete, the mRNA is then exported from the nucleus to the cytoplasm to be used as a template to synthesize proteins. The synthesis of proteins is called [c] and occurs on specialist components within the cell that are called [d]. Each amino acid incorporated during synthesis is coded by three RNA bases that together are referred to as a [e]. Amino acids are joined together covalently into a chain by a covalent bond often referred to as a [f] bond.

**Question 12**

Complete each of statements A-C about protein structure by selecting a definition from the list (1–3) and a diagram of its structure from Figure 7 below.

A  The primary structure of a protein is (choose from 1–3)

B  The secondary structure of a protein is (choose from 1–3) and is commonly drawn as (choose from a or b)

C  The tertiary structure of a protein is (choose from 1–3) and is commonly drawn as (choose from a or b)

1  formed by the folding of the alpha helices and beta pleated sheets to form a 3D structure

2  a polypeptide chain of amino acids

3  the formation of alpha helices and beta pleated sheets

![Figure 7](From PDB3NI3 and PDB1H97).
Question 13

The cycle of growth and division whereby one cell becomes two, involving the replication and exact partitioning of the chromosomes, duplication of all cell constituents and transmission of cellular organisation to the two new cells.

(a) The two main phases of the cell cycle are known as [select two from list below]:
   - Interphase
   - Cytokinesis
   - Mitosis
   - Mitotic phase

(b) Interphase consists of three subphases - G1, S, and G2. Which one of the following statements describes the events that occur during S phase?
   A The cell divides into two daughter cells.
   B The DNA within the cell is replicated producing two complete copies.
   C The cell enters a state of quiescence.

(c) Name the two processes that occur during the mitotic phase of cell division:
   (i) the division of the nucleus.
   (ii) the division of the cytoplasm.
Question 14

Identify the components of a human cell labelled A-G, shown on Figure 8 and described below:

Figure 8 The internal structure of an animal cell.

A  This structure surrounds G, separating it from all of the other cellular material. It has many small holes, or pores, that allow certain substances to move between the two compartments of the cell.

B  This gel-like liquid surrounds all the organelles and other sub-cellular structures. All the material outside G and bounded by F (including B and all the organelles and structures within it) is referred to as the cytoplasm.

C  These small, roughly spherical particles are where protein synthesis takes place. Some are free in the gel-like liquid B while others are attached to membranous structures (E).

D  Within this organelle, energy is derived from nutrients is converted to a usable form of chemical energy that drives various processes in the cell. This organelle carries its own genetic material.

E  This organelle is composed of membranes organised into sack-like or sheet-like structures. Part of this organelle is ‘rough’ in appearance because there are many C particles stuck to its surface, which gives it a grainy appearance. Its purpose is to sort proteins and ensure they are transported to the correct part of the cell.

F  This structure surrounds the cell. It is composed of fats and proteins and is selectively permeable, meaning that some substances, including gases like oxygen, can move freely across it while others, including large molecules like sugars and proteins, can only cross via special channels.

G  This is the most prominent organelle present in most human cells, being absent in mature red blood cells. It contains the genetic material, DNA (deoxyribonucleic acid), which carries the information necessary for the cell to synthesise proteins. Within it, DNA is tightly coiled and attached to proteins to form 46 chromosomes arranged in 23 matching pairs.
Question 15

The cell membrane forms a boundary of living cells and among its functions is the control of substances passing into and out of the cell. Define the following terms:

(a) Concentration gradient,
(b) Diffusion,
(c) Active transport.

For neurons, the key substances that are prevented from moving across the cell membrane are sodium (Na⁺) and potassium (K⁺) ions.

(d) Define the term ion.

(e) What is the relative distribution of Na⁺ and K⁺ ions either side of a resting neuronal membrane?

(f) What is the effect of this difference across the resting neuronal membrane?

Question 16

Insert the appropriate words/phrases:

Our bodies are constantly exposed to a range of potentially harmful invaders. These invaders, which include viruses, bacteria and other harmful microbes are collectively called [a]. To protect ourselves against these risks, our bodies have developed several layers of defence, which are collectively called our [b].
Question 17

The three types of human immune system cells (leukocytes) derive from haematopoietic stem cells in bone marrow (Figure 9). These leukocytes consist of three specialised type of cell (A-C) that have specific defensive functions and cooperate to recognise and eliminate pathogens and cancer cells. Name each of the cell types A-C, based upon the descriptions below:

A These white blood cells are characterised by the presence of secretory granules in their cytoplasm.

B These large phagocytic white blood cells have a simple oval nucleus and clear, greyish cytoplasm.

C These cells spend most of their lifespan in the body’s lymphatic system (bone marrow, thymus, lymph nodes, spleen and tonsils)- they include T cells, B cells and killer cells.

Figure 9 Origin of the three types of immune system cells (leukocytes) from haematopoietic stem cells.
Question 18
Clinical trials take part in four phases. Identify the phase (column A) with the appropriate description (column B).

<table>
<thead>
<tr>
<th>Preclinical Phase</th>
<th>involves testing for both efficacy and safety, often takes place over several years, at multiple centres and involves thousands of participants.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 2</td>
<td>involves expanded testing for safety, which takes weeks or months and involves hundreds of participants. involves laboratory studies and often takes several years of basic cell and molecular research.</td>
</tr>
<tr>
<td></td>
<td>involves the first stages of testing for safety in humans. It often uses quite small numbers.</td>
</tr>
</tbody>
</table>

Question 19
Define the following terms when used in the context of the various phases of clinical trials and research.
- Controls
  - Randomised controlled trial
- Experimental study
- Hypothesis
- Null hypothesis.

Question 20
Experimental and observational studies are both important in the health sciences, so it is necessary to have an appreciation of the way in which these types of study differ. What is meant by the terms experimental and observational studies?

Question 21
Define the following terms that refer to organisms that can live on or in the human body.
- (a) Parasite
- (b) Protist
- (c) Pathogen
- (d) Commensal bacteria.
9 Answers to Self-Assessment Questions

Question 1
(a) (i) 102.65 (ii) 102.6
(b) (i) 102.6, (ii) 103
(c) (i) Three significant figures (ii) Five significant figures (iii) Here there are only two significant figures because initial zeros do not count. These initial zeros tell you only about the size of the number, and not about the precision to which it is known. The first significant digit in this value is the 8. (iv) There are three significant figures here, since the zero in the middle of a number does count as a significant figure in the same way as the other digits.

Question 2
(a) (i) 1x10^8, (ii) 3.5 x 10^4, (iii) 9.5x 10^6, (iv) 3.5 x 10^{-3} (v) 5.1 x 10^2.
(b) (i) Length (metre, m), mass (kilogram, kg) and time (second, s).
   (ii) The kilogram (kg) is the SI units of mass. As 1 kilogram contains 1000 g, 1 gram = 1x10^{-3} kilograms i.e. one thousandth of a kilogram. Therefore, 1 g = 1x10^{-3} kg.
(c) (i) 0.38 is the same as 38% or 38/100. So, the probability that the difference between drug treatment and no drug treatment arose by chance would be 38 in 100 (or 8/25).
   (ii) No; to be significant, the calculated p value would need to be lower than 0.05, that is, to have a probability of arising by chance of less than 1 in 20.

Question 3
With pie-charts, the sizes of the areas for each category (‘slice’) is used to represent the relative quantities, so using this guide, the largest and smallest can be determined visually.
(a) Dispersed repetitive DNA.
(b) Genes.
(c) (i) False, (ii) True, (iii) False.

Question 4
The height of each of the vertical bars for each student indicates how many books read, which is indicated using the scale on the vertical axis.
(a) Anna has read 2 books and Hala 5 books, so between them they have read 7 books.
(b) 35 books have been read by the whole group.
(c) The mean value is obtained by dividing the total number of books read by the number of students, so 35/7= 5 books.
Question 5
(a) By reading the vertical axis, you can record a value of 190 deaths per 1000 live births. It is important to have also noted the ‘per 1000 live births’ as this is a component of the rate.
(b) You may have said something like ‘the data points slope downwards, from top left to bottom right of the diagram’.
(c) Access to improved sanitation is low in countries with high under-five mortality rates. We picked Sierra Leone, which has the highest under-five mortality rate and the lowest access to improved sanitation – but you could have chosen other examples. The reverse is also true: access to improved sanitation is high in countries with low under-five mortality rates; for example, the UK, USA, Australia and Japan all have very low under-five mortality and very high (almost 100%) access to improved sanitation.

Question 6
(a) There is a positive association between predator number and prey- the increase in one variable is associated with an increase in the other.
(b) There is a negative association between predator number and prey- the number of prey increases as the number of predators decreases.
(c) There appears to be no relationship or association between the two variables.

Question 7
(a) Mouse embryo developing intestinal tissue.
(b) The stem cells attached to the damaged areas of the mouse intestine, integrate with the gut cell and contribute to repair of the damaged tissue.
(c) Cell Stem Cell.
(d) Formation of a tumour from the transplanted stem cells.

Question 8
(a) There are six atoms of hydrogen in ethanol. You can tell that there are six hydrogen atoms in a molecule of ethanol because the subscript 5 is to the right of the chemical symbol H indicates 5 atoms that are associated with the two carbon (C₂) atoms and the single H after the oxygen symbol (O) has no subscript, indicating only a single atom of hydrogen.
(b) The bond between the hydrogen atoms is a single bond- it is a covalent bond in which one pair of electrons is shared between the two hydrogen atoms. The bond between the oxygen atoms is a double bond in which two pairs of electrons are shared between two atoms.
(c) The hydrogen bond does not involve the sharing or transfer of electrons between atoms. This form of bond involves the attraction between two polar molecules in which a hydrogen attached to an electronegative atom in one molecule is attracted to an electronegative atom in another molecule.
**Question 9**

Figure 10 below shows the full spectrum of electromagnetic radiation.

![Figure 10 The electromagnetic spectrum.](image)

(a) The form of energy detected by the human eye is called visible light. The order of colours in the visible spectrum, starting from the low-wavelength end is: violet, merging to blue, then green, yellow, orange, red.

(b) UV has a shorter wavelength (shorter than visible violet) and infrared a longer wavelength (than visible red), so the order of *increasing* wavelength is UV, blue, green, orange, red and infra-red.
Question 10
Along the length of a strand within a double helix of DNA, each base makes a specific pairing with a corresponding base in the other strand. These interactions are known as base pairing, for which there are very precise rules:

- T pairs only with A
- C pairs only with G

These pairs are called complementary base pairs, so applying these rules the double stranded segment of DNA would be as shown in Figure 11.

![Figure 11: Segment of doubles-stranded DNA showing base-pairs.](image)

Question 11
(a) transcription
(b) Uracil (U)
(c) translation
(d) ribosomes
(e) codon
(f) peptide

Question 12
A= 2, B= 3 & a and C= 1 and b.

Question 13
(a) Interphase and mitotic phase,
(b) B
(c) (i) mitosis and (ii) cytokinesis.
**Question 14**
A  Nuclear membrane,  
B  Cytosol,  
C  Ribosomes,  
D  Mitochondrion,  
E  Endoplasmic reticulum,  
F  Cell membrane,  
G  Nucleus.

**Question 15**
(a) A difference in the concentration of a substance between two areas, for example, the inside and outside of a cell.
(b) The net (overall) movement of a chemical substance down a concentration gradient (from an area where it is at high concentration to an area where it is at low concentration).
(c) The movement of a chemical substance across a cell membrane up a concentration gradient (the opposite to diffusion) and which requires the cell to expend energy.
(d) An ion is produced when an atom loses or gains an electron in a process called ionisation. This loss or gain of electrons means that ions are charged particles.
(e) The cell membrane keeps the concentration of $K^+$ much higher inside the neuron than outside, and the concentration of $Na^+$ much lower inside the neuron than outside. Inside the neuron these are 10 millimoles per litre $Na^+$ and 140 millimoles per litre $K^+$, whereas outside the neuron they are 142 millimoles per litre $Na^+$ and 4 millimoles per litre $K^+$.
(f) An electrical difference, or membrane potential is created across the membrane due to this unequal concentration of ions/charge on either side. In a resting neuron the inside is slightly more negative than the outside, so the membrane potential of a resting neuron is by convention given a negative value, typically around $-70$ millivolts (mV).

**Question 16**
(a) pathogens,  
(b) immune system.

**Question 17**
A  Granulocytes,  
B  Monocytes,  
C  Lymphoid cells- or lymphocytes.
Question 18

The four phases of clinical trials are detailed below.

![Figure 12: Phases of clinical trial indicating their main objective and participant numbers. Source: IPM Global – International Partnerships for Microbicides](image)

Question 19

**Controls**: A group of individuals or experimental samples that are not exposed to the experimental condition or intervention being examined.

**RCT**: A type of study design that offers the scientist a means to control other influences that might affect the study results in their experimental study.

**Hypothesis**: A statement proposing an explanation for an observation, made based on limited evidence, as a starting point for further investigation or experiment.

**Null hypothesis**: A statement that predicts that no difference will be observed in the dependent variable as the independent variable changes. It is a hypothesis of ‘no change’ or ‘no difference’ between experimental conditions – hence the use of the word ‘null’.

Question 20

Experimental studies are where the scientist can directly intervene to manipulate what he or she is interested in. This can be directly upon on human participants but is more commonly how health science research is undertaken in the laboratory through the experimental manipulation of cells and tissues.

Observational studies are where the scientists do not intervene directly to control the events– they just observe everything as it occurs naturally. This can be on human participants (behaviour, physiology etc.) or can be on materials derived from human participants, such as on tissues and body fluids etc.

Both types of study still allow scientists to test a hypothesis, it’s just that the process of testing the hypothesis is conducted in a different way (either with or without direct scientist intervention).
Question 21

(a) A parasite is an organism that lives in or on the body of another organism (its host) and benefits at the host’s expense.

(b) A protist is a single-celled organism that shares the basic features of animal cells.

(c) A pathogen is an infectious agent such as a parasite, protist, bacterium, fungus, virus or prion that causes infectious diseases.

(d) Commensal bacteria are often called ‘friendly’ bacteria that live in or on the human body without causing harm and sometimes benefiting their host.

Acknowledgements

Grateful acknowledgement is made to the following sources:

Figure 7: From PDB3NI3 and PDB1H97;

Figure 12: IPM Global – International Partnerships for Microbicides.