Pearson Edexcel Level 3 GCE

Biology A (Salters-Nuffield)

Advanced

Paper 3 - Pre-release material

Sample Assessment Material for first teaching September 2015

Paper Reference
9BN0/03

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PEARSON

Cheaters – drug abuse in sport

1 Lance Armstrong was a driven athlete, an American road racing cyclist who won a record number of races. The *Tour de France* is considered to be one of the toughest races, which Armstrong won a record seven consecutive times. However his career was dogged with speculation about doping – taking banned performance-enhancing substances. Although Armstrong strongly denied allegations of doping for many years, he finally admitted – in a televised interview with Oprah Winfrey in 2013 – that a deep flaw in his character, which he described as his "ruthless desire to win", led him to take banned substances throughout his career. He admitted to taking the hormones cortisone, testosterone and erythropoietin (EPO), and also to conducting blood transfusions to boost his oxygen levels. The United States Anti-Doping Agency (USADA) had formally presented evidence against Armstrong in 2012, including laboratory test results and evidence of financial payments. The Chief Executive of the USADA said at the time that this was, "the most sophisticated, professionalised and successful doping programme that the sport had ever seen." The Union Cycliste Internationale (UCI) subsequently disqualified Armstrong from all of his *Tour de France* races, stripping him of the titles and banning him from cycle road racing for life.

2 The media loved this Armstrong story; and sport is filled with similar stories about athletes prepared to use banned substances in their drive to win. George Mitchell named 89 Major League Baseball players in a report released in 2007 and based on 20 months of investigation into performance-enhancing drug use amongst players. "The illegal use of performance-enhancing substances poses a serious threat to the integrity of the game," the Mitchell Report said, and added, "Widespread use by players of such substances unfairly disadvantages the honest athletes who refuse to use them and raises questions about the validity of baseball records". So why do some athletes take banned substances? The risks are high: discovery often results in suspension from the sport we are led to believe they love, which can be career-damaging in itself. But it can be worse – Armstrong has had talks with US Justice Department officials about returning a proportion of the estimated US$40 million in sponsorship funding that his cycling team received. Some athletes have been jailed and others have died prematurely from conditions and complications associated with taking banned substances.

3 It's a cat and mouse game that the media are always keen to play. A game that's complex with high stakes and while the tests become ever more sensitive, the cheaters are always one-step ahead. Athletes understand the rewards of training hard and the elation of standing on the top of the podium. Depending on their discipline, athletes' main aim is to build muscle mass, strength and endurance and to increase the delivery (speed and amount) of oxygen to the working muscles. Training can achieve this for them, but the use of drugs can boost performance further. Additionally, they may also use drugs to mask pain, stimulate the body, relax, lose weight and of course, hide the use of other drugs. This article will look at the substances and techniques used by athletes, how drugs can affect the body, including side-effects, and how those responsible for testing are trying to keep up with the game, whilst always being at least one step behind.

Muscle mass and strength

4 Hypertrophy is the increase in size of an organ due to an increase in size of its component cells, rather than an increase in the total number of cells in the organ. Muscular hypertrophy is an increase in the cross-sectional area of individual muscle fibres, due to an increase in contractile proteins. Muscles adapt in this way when subject to increasing workloads during training sessions. Heart muscle can be developed through training, so that the heart can pump more efficiently, pushing out a greater volume of blood from its chambers with every pump and pumping more quickly. Skeletal muscle can also be developed through training by working faster and for longer periods. This is the aim of the athlete – to increase their strength and speed. Working faster – and for longer – is limited by the time it takes to move oxygenated blood from the heart to the exercising tissues, and so it is this process that is often targeted through drug use. If the speed of movement of oxygen from the heart to where it is needed can be increased, then athletes will be able to work harder over a longer time.

5 Athletes often use performance-enhancing drugs that are naturally-occurring molecules in the body, such as hormones. Taking more of these naturally-occurring substances will increase their effect. Although it is difficult to detect a substance that is found in humans naturally, increasing the levels of substances in the body can cause a range of side-effects, which can range from hardly noticeable effects to adverse or serious ones, and even death.

6 **Hormone-related substances** used by athletes to build mass and strength include:

- Anabolic steroids
- Beta-2 agonists
- Human growth hormones:
  - Human chorionic gonadotropin (HCG)
  - Luteinizing hormone (LH)
  - Human growth hormone (HGH)
  - Insulin-like growth factor (IGF-1)
  - Insulin

Anabolic steroids

7 **Anabolic steroids** build muscle and bone mass, as opposed to catabolic steroids, which break down tissues. Anabolic steroids work primarily by stimulating the muscle and bone cells to make new protein, thereby increasing muscle mass and also decreasing fat. This allows the athlete to train harder and for longer. They are manufactured drugs that mimic the effects of the male hormone testosterone, enhancing male reproductive and secondary sexual characteristics.

8 Anabolic steroids are usually injected into the muscle and often a 'cycling' method is used in order to avoid the undesirable side effects. 'Cycling' means that athletes inject the steroids for a period of time and then stop for a rest period, before starting, often synchronising the rest periods with when they are expecting to be tested, so that the tests do not detect the increased levels of the drugs.

9 Some athletes use additional steroids simultaneously, in the belief that this increases the effectiveness. This method is known as 'stacking'. Some athletes combine cycling and stacking methods, this is known as 'pyramiding'. The drug dosage is gradually increased over a period of weeks and then slowly reduced again to nothing, to allow the body a rest period, before repeating. The idea is to train harder whilst taking the drugs to maximise their effects.

10 The unwanted physiological side effects of steroid use include heart attack or stroke; tumours on liver and kidney; high blood pressure (hypertension); blood clots; fluid retention and high cholesterol. In addition, in men the following effects have been seen: reduced sperm count; infertility; shrunken testicles; baldness and breast development. In women it causes a range of male features, including hair growth on face and body; reduction of breasts; deepening of voice and menstrual problems. In addition, both men and women have experienced the psychological effects of aggressive behaviour, mood swings, manic behaviour, hallucinations and delusions.

11 Anabolic steroids are addictive – athletes may experience cravings. Habitual users will require more and more of the drug to achieve the same effect and if use is suddenly stopped, they will experience withdrawal symptoms, which may include depression and apathy; feelings of anxiety; difficulty concentrating; insomnia; anorexia; decreased sex drive; fatigue (extreme tiredness); headaches; muscle and joint pain. An addict will keep using a drug, despite its side effects.

12 Many people take anabolic steroids in the misguided belief that it will help them become fit and healthy. Adolescent boys and young men often take steroids when they consider their body not to be sufficiently big or strong. Steroid misuse is widespread in many sporting areas. Bodybuilders take them to increase bulk and strength and athletes are under even more pressure to perform, especially those requiring strength and endurance, such as weightlifters.

Beta-2 agonists

13 **Beta-2 agonists** mimic the action of adrenaline and noradrenaline that are secreted by the sympathetic nerves. They are inhaled by asthma patients to relax the smooth muscle in the airways. Asthma is chronic inflammation of the airway. It is an over-reaction to external stimuli, such as dust and pollution and can lead to bronchoconstriction. There is a genetic element to asthma and it is one of the most common chronic disorders, found in about 5% of the adult population. However, it is more common amongst athletes, found in around 10–20% of the population. This may be due, for winter sports athletes, to inhaling cold, dry air; and in the case of swimmers, where it is particularly prevalent, of training in chlorinated atmospheres. Additionally, asthmatic symptoms may be triggered by acute physical exercise, which is described as 'exercise induced asthma' (EIA).

14 If something is described as being 'ergogenic', it is intended to enhance physical performance, stamina, or recovery. In 2006, Kindermann and Meyer published the results of a review that they had carried out and concluded that "there is no ergogenic potential of inhaled beta-2 agonists in non-asthmatic athletes" and went on to recommend that "the inclusion of inhaled beta-2 agonists on the list of prohibited substances should be reconsidered".

15 The USADA Prohibited List for 2014 specifically bans all oral beta-2 agonists. It allows the use of three inhaled beta-2 agonists, but states the exact dosing that must not be exceeded. If these doses are to be exceeded then written medical consent is required, as it is for other beta-2 agonists for therapeutic use.

16 Athletes believe that when beta-2 agonists are injected into the bloodstream they have an anabolic effect (build muscle mass) and a catabolic effect (reduce body fat). They actually act to constrict blood vessels and cause a range of side-effects: constriction of blood vessel in the brain causes feelings of nausea, headaches and dizziness; constriction of blood vessels in muscles causes muscles cramps. They also stimulate heart rate, causing rapid heartbeats or flutters.

Human Growth Hormones

17 **Human chorionic gonadotrophin (HCG)** is a glycoprotein hormone which is produced in large amounts during pregnancy by the developing foetus. It is the substance that most home pregnancy test kits detect. It is not banned for female athletes, who, if pregnant, may have naturally high levels in their body.

18 Some male athletes use manufactured HCG before competition to stimulate testosterone production. It is also used to prevent infertility and testicular shrinkage to counter the effects of prolonged steroid use, ironically, as the side effects are similar to those of steroid use.

19 **Luteinising hormone (LH)** is a peptide hormone which plays an important role in maintaining normal levels of testosterone (in the male) and oestrogen (in the female). Work published by Warren in 1999 evidenced 'exercise induced amenorrhea' (absence of a menstrual period in a woman of reproductive age) in female athletes due to environmental and metabolic stresses, mainly low calorie, low fat diets, which led to the suppression of levels of LH and follicle stimulating hormone (FSH). In male athletes, excess LH or its artificial derivatives increase testosterone levels and possibly cause similar side effects to those of anabolic steroids. They are banned for male athletes.

20 **Human growth hormone (HGH)** is a naturally-occurring protein hormone which is made and secreted by cells in the anterior pituitary gland located at the base of the brain. It is involved with cellular metabolism and is important for normal growth and development.

21 The major role of HGH in body growth is to stimulate the liver and other tissues to secrete insulin-like growth factor (IGF-1), which in turn stimulates production of cartilage cells, resulting in bone growth. It also plays a key role in muscle and organ growth.

22 HGH has ergogenic, (performance-enhancing) anabolic (increasing muscle mass and bone growth) and catabolic (breakdown of fat cells) effects. Additionally, it enhances the anabolic power of steroids. HGH was difficult to detect and thus was becoming more and more popular, despite its side effects, which include acromegaly. This is the name given to enlarged face, hands and feet and enlarged internal organs, particularly the heart, kidneys, liver and tongue. In 2010, there was a blood-testing innovation that led to the suspension of a British rugby player who tested positive for HGH.

23 **Insulin-like growth factor (IGF-1)** also known as somatomedin-C, is an important protein growth hormone. It has an independent growth-stimulating effect on cartilage cells and Laron (2001) reported a possibility that this effect may be optimised by a synergistic action with HGH. Again, it also has anabolic and catabolic effects. Side effects are similar to those seen with HGH and also include hypoglycaemia (low blood sugar).

24 **Insulin** is a naturally-occurring peptide hormone produced by beta cells in the pancreas. It is vital in the regulation and metabolism of sugars, starches, fats and proteins, as it controls absorption of glucose from the blood. This absorbed glucose is stored in the liver and muscle as glycogen and stops the body from using fat as a source of energy.

25 When there is very little insulin in the blood, or none at all, glucose is not taken up and so our body uses fat as a source of energy. Athletes take insulin in combination with anabolic steroids or HGH to increase muscle mass by stimulating protein synthesis. Side effects are mainly associated with low blood sugar levels – shaking, nausea and weakness, however, excessive hypoglycaemia can lead to coma and even death.

Oxygen Delivery

26 The three main methods to increase the amount of oxygen in the tissues are the use of protein hormones, artificial oxygen carriers or blood doping.

Protein hormones

27 **Erythropoietin (EPO)** is a glycoprotein hormone, made in the kidney, that controls red blood production (erythropoiesis) in the bone marrow. EPO is released when blood oxygen levels are low to stimulate the production of red blood cells, which increase the delivery of oxygen to the tissues and organs, including the kidney. The use of EPO by endurance athletes (e.g. cross-country skiers, marathon runners and cyclists) can significantly increase their oxygen supply and its use is difficult to detect.

28 The use of EPO by athletes causes increases to their blood density, so that their blood has a constituency more like honey than water. This 'thick' blood does not flow easily and the heart must work much harder to pump the blood around the body, thereby increasing the risks of heart attack and stroke.

29 The first test for EPO was introduced at the Sydney Olympics in 2000. Synthetic EPO produces smaller than normal red blood cells, which bind more iron than natural EPO. By looking at the size of the red blood cells and their iron content, it can be established whether an athlete has taken EPO.

Artificial Oxygen Carriers

30 These are manufactured substances that mimic the role of haemoglobin. They are used legitimately by medical professionals to treat people experiencing breathing difficulties, such as premature babies, deep-sea divers and casualties with severe lung injuries. They are based around substances such as perfluorocarbons (PFCs), synthetic or modified haemoglobins and liposome-encased haemoglobins, and have the ability to carry oxygen in the body.

31 Schumacher *et al* (2001) investigated the effects of "solutions based on recombinant, bovine or human haemoglobin and perfluorocarbon-emulsions" and their tests on animals and humans demonstrated improved oxygen delivery to the muscle and thus improved aerobic exercise capacity. However, side effects are serious and can be lethal, including nephrotoxicity (kidney damage that result in the kidney no longer being able to eliminate urine and wastes); high blood pressure and problems associated with the immune system.

Blood doping

32 **Homologous blood transfusion (HBT)** is storing someone else's blood (with the same blood type), which is then injected into you when required. By contrast, autologous blood doping is the transfusion of your own blood, which has been stored (refrigerated or frozen) until needed.

33 Athletes have been using blood doping techniques to cheat for several decades and a test for homologous blood was implemented at the 2004 Summer Olympic Games in Athens. The World Anti-Doping Agency (WADA) is currently funding research projects to develop a test for autologous transfusions.

34 Unofficial blood transfusions can have serious medical consequences. Without proper screening, another person's blood may contain a virus, such as HIV. Blood also needs to be handled and stored correctly and the transfusion procedures carried out in a proper manner, in order not to put the recipient at significant health risks. Increased blood volume causes high blood pressure and increases the risk of heart attack, stroke, and pulmonary or cerebral embolism.

Pain

35 Injuries are an inevitable part of training, especially at high intensities for prolonged periods, such as undertaken by top athletes. Careers can be plagued with and hampered by injuries, which can also end careers prematurely. The sensation of pain is usually a signal for us to stop what we are doing, because something is wrong with our body: continuing may cause further damage. Athletes sometimes try to mask their injury pain with drugs, including narcotics, adrenal cortex hormones and local anaesthetics, in order to continue competing and performing beyond their normal pain threshold.

36 **Narcotics** use in sport is banned because this class of drugs impair athletes' judgment in potentially dangerous situations. Athletes have been known to use morphine, methadone and heroin. Narcotics are highly addictive and cause mental impairment, including judgement, balance and concentration as well as potentially long-term mental health issues.

37 **Adrenal cortex hormones**, such as adrenocorticotropic hormone (ACTH) are protein hormones that work to reduce injury-related inflammation and allergic reactions. ACTH is secreted by the pituitary gland and stimulates the production of hormones from the adrenal cortex. They are used by athletes to increase the production of androgens by the adrenal glands to mask injury pain. However, this also raises cortisol levels, which increases the production of glucose and which in turn raises blood glucose levels. Common side effects include stomach pains, nausea and vomiting; indigestion and weight gain; skin problems and facial swellings; irregular heartbeat, menstrual problems, muscle cramps and irregular bruising and poor healing as well as mental health problems including tiredness, hallucinations, confusion, excitement, restlessness and mood swings.

38 **Local anaesthetics** mask pain in just one area of the body, such as a dentist would use to numb an area of the mouth, without mental impairment (the dentist's patient is conscious). The main issue with their use is that, in masking pain, the athlete may further aggravate an injury. Although WADA currently does not ban the use of local anaesthetics in sport, there is the question of whether reducing or eliminating pain constitutes a performance-enhancing intervention.

Coping with stress

39 **Stimulants** are used by athletes living within strict social rules and training regimes to cope with general fatigue, to help keep them alert, to reduce tiredness and maintain aggressiveness. Commonly used stimulants include caffeine, amphetamines and cocaine, which cause the heart to beat faster, breathing rate to increase and give an increase in mental alertness. There are, of course, the inevitable side effects, including shaking, nervousness, irregular heartbeats, high blood pressure, convulsions and even death.

40 **Relaxants** are taken by some athletes to cope with a stressful timetable, strict social and dietary guidelines and the pressures of competition. **Alcohol** reduces activity in the brain and nervous system and is regularly used by many people to help them relax. It can significantly impair mental functions (judgement, balance, coordination), especially in excess and is restricted by the International Olympic Committee (IOC) and banned altogether in certain events. Meanwhile **beta-blockers** are permitted, by prescription, for athletes competing in archery and shooting competitions and other sports that require a steady hand. They are used to treat high blood pressure and work by slowing down the heart and relaxing the blood vessels. Not surprisingly, side effects include a slow heart rate, leading to fatigue and hypotension (low blood pressure).

41 The clinical value of **cannabinoids**, such as marijuana, still has to be proven, but they are said by some people to relieve pain and are used as a relaxant. Side effects include hallucinations, drowsiness, increased heart rate, impaired judgement, balance, coordination and memory.

Drug testing

42 Urine tests can detect many of the drugs used by athletes. Collecting urine samples from athletes is the responsibility of a drug control officer, who sends the sample for laboratory analysis. The test results are sent directly to the governing sports agency. Blood samples are also sometimes required for detection of certain drugs. Athletes often take additional substances to mask the use of banned drugs, although these are often banned themselves because of their masking effects.

One of the difficulties of drug testing is that the governing bodies and testing technicians have to know what to look for to be able to devise detection tests. This means that when new or different drugs start being used, a new test has to be developed to detect it and this takes time.

Masking drugs in the urine

43 **Diuretics** increase the rate of urine flow and sodium excretion to regulate the volume and composition of body fluids and are a prescribed drug for high blood pressure. They can mask the presence of other banned substances in the urine because they act on the kidneys, increasing the amount of urine produced and thereby diluting the concentration of other drugs. Diuretics are particularly favoured by athletes who are subject to weight restrictions, including jockeys, weightlifters and rowers, because urine excretion results in rapid weight loss: a convenient trick just before your weigh-in.

44 **Secretion inhibitors** prevent certain proteins from being secreted in urine and thus not be detected in urine tests. Side effects include nausea, vomiting, kidney problems and allergic reactions.

Masking drugs in the blood

45 **Epitestosterone** is a natural steroid, which is used to mask the use of testosterone and has been banned for this reason by many sporting authorities, even though it has not been shown to enhance performance itself. Testosterone is tested for by determining the ratio of testosterone to epitestosterone in the blood (T/E ratio). By injecting epitestosterone, the T/E ratio is lowered from the 1:1 ratio expected in healthy male adults.

46 **Plasma expanders** are injected by athletes to increase the volume of the fluid component of their blood and thus reduce the concentration of drugs in their system. They are used by medical professionals in the treatment of victims of shock, trauma and surgery. Side effects are mainly limited to allergic reactions.

Gas chromatography and mass spectrometry tests

47 Gas chromatography (GC) and mass spectrometry (MS) together provide powerful chemical analysis. Urine and blood samples given by athletes are subjected to these methods to detect numerous drugs.

48 **The gas chromatography test** separates all of the components in a sample. This is done by first injecting the sample into the GC machine, where the sample is vaporised in a gaseous solvent. Each substance dissolves differently in the gas and stays in the gas phase for a different length of time. This period is called the 'retention time' and is unique and specific to each substance, helping to differentiate and identify each component. The different retention times are due to different chemical and physical characteristics of the molecules, causing them to travel through the GC column at different speeds. Small, low mass molecules may travel more quickly that larger, heavier molecules. The shape of the molecules will also affect the speed at which they travel through the column, as will interaction between substances, which can increase or decrease their speed. Each component of the sample is absorbed onto a solid or liquid when it comes out of the gas phase and is analysed by a detector in the GC machine, which then provides a print out or digital image of the retention times, called a chromatogram. The location of the peaks in the sample's chromatogram are compared with standard chromatograms of known substances in order to identify and quantify the specific drugs in the athlete's sample. The size of the peaks is proportional to the quantity of the substance in the sample being analysed.

49 **Mass spectrometry** identifies substances by electrically charging the sample molecules with an electron beam and accelerating them through a magnetic field. This blows apart the molecules into charged fragments and these different charges are detected. A spectral plot displays the mass of each fragment, which is unique to that substance and can be identified against plots for known substances. These fragment masses are used to determine the mass of the original molecule, and hence its quantity.

Immuno-assays

50 These are quick and accurate tests that can be carried out on-site to detect specific molecules. The sample is mixed with a solution containing antibodies specific to the target substance and relies on the capacity of the antibodies to bind to the specific structure of a molecule. The antibodies in the test are usually labelled – either with a fluorescent dye or a radioactive substance. In this way the amount of the target substance in the sample can be determined by measuring the level of fluorescence or radioactivity.

51 **WADA is pioneering a new approach to drug detection** in the development of the Athlete Passport. This strategy moves away from individual substance detection, by instead monitoring athletes over time to gain a profile of their system, by recording selected variables. The effects of doping can then be revealed through the detection of abnormal variations. New WADA guidelines came into effect on 1st January 2014 to detect steroid doping by monitoring selected urinary steroid concentrations over time. Others are planned to be introduced as soon as they are ready.

All sporting governing bodies and anti-doping agencies have a hard task ahead of them in trying to keep sports clean; despite athletes, coaches and managers insisting that most competitors do not take drugs. Nevertheless drug testing is now an integral part of competition with routine testing of winners and random testing of others. The pressure on athletes to perform and achieve is huge and the rewards can be equally sizeable – not least through financial rewards or celebrity status – although careers can be very short.

52 The pressure has always been there and even athletes in ancient Greece were willing to take medicinal preparations that gave promises of improved performance. In 1967, Dr Gabe Mirkin asked 100 runners a question that has now also become known as 'Goldman's dilemma'. Goldman repeated the question to athletes in combat and power sports, and observed similar results i.e. over half of athletes replied in the affirmative. What was that question? "If I could give you a pill that would make you an Olympic champion – and also kill you in a year – would you take it?"

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Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Biology A (Salters-Nuffield)

Advanced

Paper 3: General and Practical Applications in Biology

Sample Assessment Material for first teaching September 2015

Time: 2 hours

Paper Reference

9BN0/03

You may need a ruler, pencil and a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You may use a scientific calculator.
- In questions marked with an asterisk (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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PEARSON

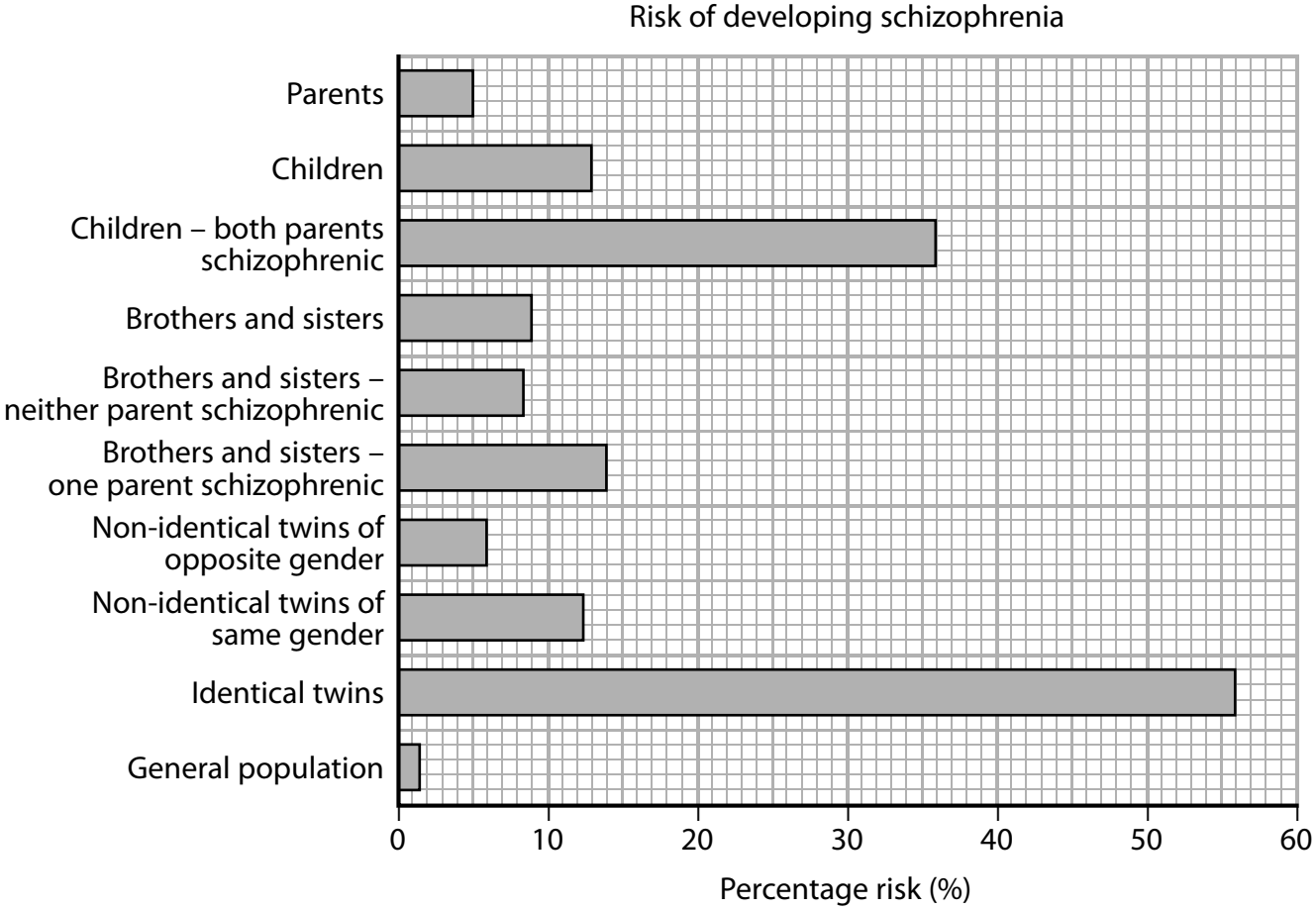
Answer ALL questions.

Write your answers in the spaces provided.

1 Schizophrenia is a disorder that affects brain structure and function and has a variety of symptoms.

The bar graph shows how the relationship to a family member suffering from schizophrenia affects the risk that the individual will also develop schizophrenia.

The percentage risk of schizophrenia in the general population is included for comparison.



(a) Explain the difference between the percentage risks of developing schizophrenia in identical twins and non-identical twins of the same gender.

(2)

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.....

(b) Some early studies of schizophrenia included identical twins raised in separate families.

(i) Explain how the design of these studies allows the influence of environmental factors on the development of schizophrenia to be investigated.

(2)

(ii) The conclusions based on these early studies of identical twins raised in separate families are said to lack validity.

Give **two** reasons why these studies may lack validity.

(2)

(c) Schizophrenia has been linked to abnormally high levels of a neurotransmitter in the brain.

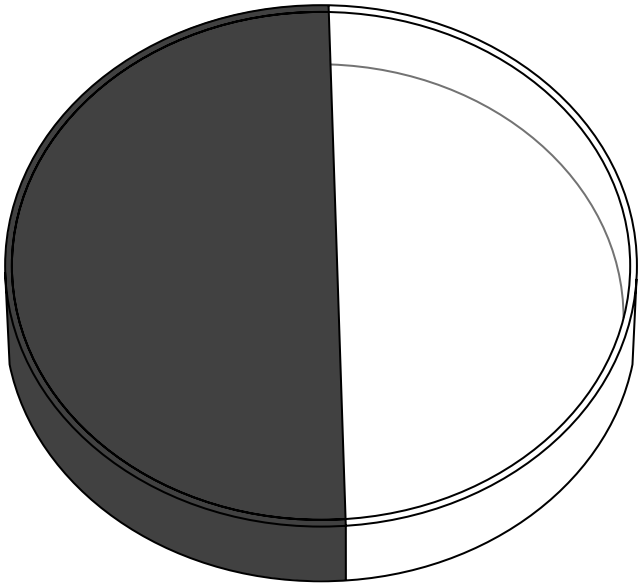
Explain how the action of the drugs used to treat schizophrenia may lead some patients to experience symptoms similar to those of Parkinson's disease.

(5)

(Total for Question 1 = 11 marks)

2 Blowfly larvae can be used by a forensic scientist to help determine the time of death of a body.

The diagram shows a Petri dish used by a student to investigate whether young and old blowfly larvae show a preference for light or dark conditions.



In the first trial, the left side was dark and the right side was light.

Five blowfly larvae were added to each side of the chamber.

After five minutes, the number of larvae on each side of the Petri dish was recorded.

In the second trial, the same experiment was repeated but this time the right side was dark and the left side was light.

The table shows the results of the trials.

Trial	Number of young blowfly larvae		Number of old blowfly larvae	
	Left side dark	Right side light	Left side dark	Right side light
1	9	1	2	8
2	2	8	9	1

(a) Give a null hypothesis for this investigation.

(1)

.....

.....

(b) The Chi squared test can be used to determine whether the results of this investigation indicate a significant difference in the distribution of young larvae between the light and the dark side.

(i) Use the formula to calculate the Chi-squared value for young larvae.

(3)

$$\chi^2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

Answer .....

(ii) The table below gives some critical values for Chi-squared.

p value			
0.15	0.1	0.05	0.025
2.07	2.71	3.84	5.02

Use your calculated value to determine whether the difference between the observed and expected results is significant.

(1)

.....

.....

(c) Forensic scientists measure the length of larvae found in the tissues of a dead person to help them determine time of death. Older larvae are longer than younger larvae.

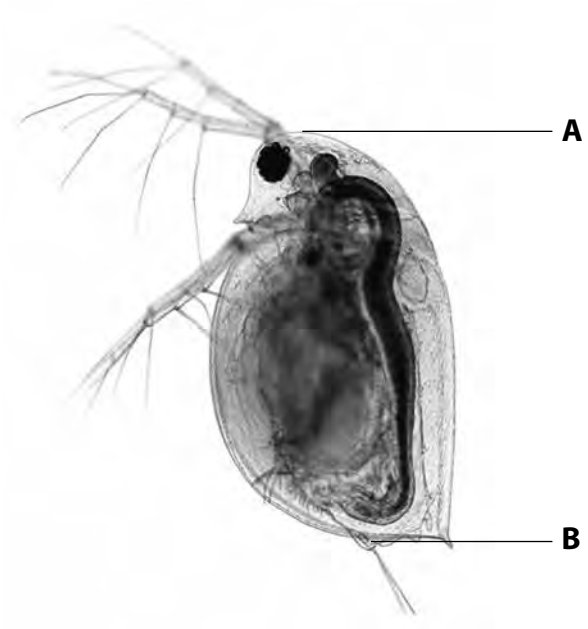
The growth of insect larvae can be affected by a number of factors including toxins.

Explain a procedure that you could use to find out if the presence of a toxin in a sample of dead tissue could affect the accuracy of estimating time of death.

(5)

(Total for Question 2 = 10 marks)

3 A student investigated the effect of temperature on the heart rate of *Daphnia*.



Magnification ×60

(Source: http://www.nature-education.org/water-life.html)

(a) Use the lines A to B to calculate the actual length of this *Daphnia*.

(2)

Answer .....

(b) The student used five *Daphnia* in the investigation.

The *Daphnia's* heartbeats were counted over a 20-second period.

A stopwatch was used and a pencil mark made on a piece of paper while observing the *Daphnia* through a low powered microscope.

The number of heartbeats was counted three times for each *Daphnia*.

This was repeated at five different temperatures using the same *Daphnia* each time.

This was then repeated using the four other *Daphnia*.

The results obtained are shown in the table below.

Daphnia	**Heart rate / beats in 20 seconds**														
	5 °C			**10 °C**			**15 °C**			**20 °C**			**25 °C**		
1	20	18	19	30	26	29	36	35	36	42	45	44	53	47	53
2	22	23	19	36	32	29	36	39	34	42	46	42	50	51	63
3	16	18	20	26	30	27	35	33	36	39	41	40	58	52	50
4	19	22	21	30	32	35	38	36	37	45	46	42	62	62	58
5	20	25	21	35	32	34	36	39	38	44	48	42	52	55	59

(i) Explain why the number of heartbeats was measured in 20 seconds rather than in one minute.

(2)

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(ii) The mean heart rate at 5 °C is 20.2 beats in 20 seconds. Calculate how many times faster the mean heart rate is at 25 °C than at 5 °C.

(2)

Answer .....

(iii) The student concluded that temperature increased the heart rate of *Daphnia*.

Analyse the data to explain how this investigation could be modified to improve the validity of this conclusion.

(3)

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(c) Discuss the ethical issues that might arise from the use of invertebrates in investigations.

(4)

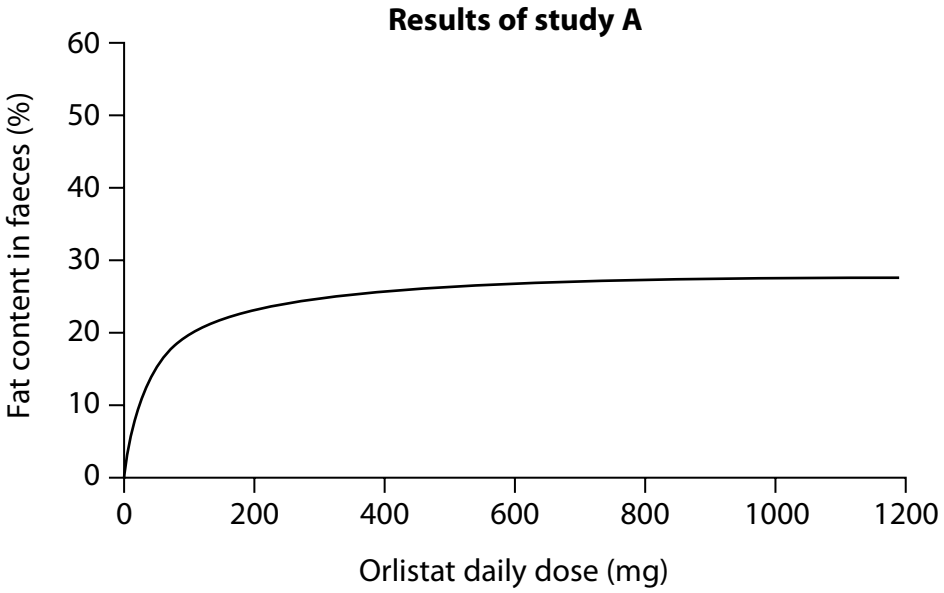
(Total for Question 3 = 13 marks)

4 Obesity is a risk to health.

There is a drug called Orlistat that can help obese people to lose weight. This drug works by permanently attaching to the enzyme lipase.

Two studies, A and B, were carried out to investigate the effectiveness of the drug.

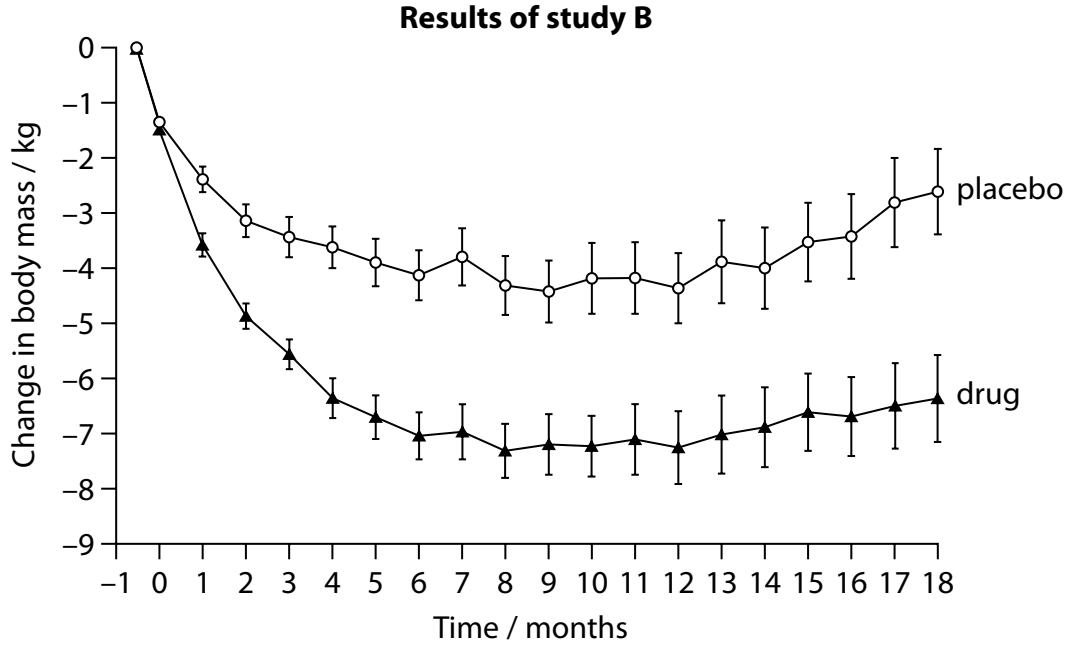
In study A, 20 people were given different concentrations of the drug and the fat content of their faeces was measured. The graph below shows the results.



(a) Analyse the data in the graph to explain how the drug helps obese people to lose weight.

(5)

(b) Study B was a placebo-controlled study. The change in body mass of 300 patients was measured over a period of 18 months. The graph below shows the results.



Explain how the data in study B show that the design of study B is better than the design of study A.

(4)

(c) (i) A high body mass index (BMI) is an indicator of obesity. Use the formula for BMI to calculate the height of a person with a mass of 80 kg and a BMI of 31.25.

(3)

$$\text{BMI} = \frac{\text{mass in kg}}{(\text{height in m})^2}$$

Answer .....

(ii) The table shows the percentage decrease in the BMI of 350 people who took the placebo and a group of 350 people who took the drug daily for a period of 12 months.

Treatment	Percentage decrease in BMI (%)	Percentage decrease in body mass (%)
Drug	26.5	19.0
Placebo	15.7	11.7

Give **one** reason why the percentage of people with a decrease in BMI is higher than the percentage of people with a decrease in body mass.

(1)

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(iii) Explain the health risks of having a very high BMI.

(5)

(Total for Question 4 = 18 marks)

5 There have been several studies into the relationship between cigarette smoking and deaths from lung cancer. The data in the table comes from a review of these studies.

Country	Size of study	Number of deaths from lung cancer	Ratio of smokers to non-smokers dying from lung cancer
UK	34000 males	441	14.00
	6194 females	27	5.00
Sweden	27000 males	55	7.00
	28000 females	8	4.50
Japan	122000 males	940	3.76
	143000 females	304	2.03
Canada	78000 males	331	14.20
USA	358000 males	2018	8.53
	483000 females	439	3.58
USA	290000 males	3126	11.28
USA	188000 males	448	10.73
USA	68000 males	368	7.61

(a) Give **two** reasons why the ratios of smokers to non-smokers who die from lung cancer are different for males compared with females.

(2)

(b) These studies suggest that there is a correlation between smoking and lung cancer.

State what is meant by correlation.

(1)

(c) Smoking tobacco can result in the development of a variety of other health problems including atherosclerosis.

Explain how smoking increases the risk of developing atherosclerosis.

(3)

*(d) Cancer is the result of the abnormal growth of cells in an organ. These cells develop into a tumour which does not carry out the function of the tissues in the organ.

An article states:

"Tobacco smoke is the cause of kidney cancer!"

Evaluate the claim that tobacco smoke is the primary cause of kidney cancer.

(9)

(Total for Question 5 = 15 marks)

6 The scientific article you have studied is adapted from 'How Performance-Enhancing Drugs Work.'

Use the information from the article and your own knowledge to answer the following questions.

(a) (i) The population of the UK is 63 182 000 of which 49 182 000 are adults (paragraph 13).

Calculate the number of adults who have asthma.

(2)

Answer .....

(ii) People with asthma sometimes have difficulty breathing (paragraph 13).

Explain how beta-2 agonists may help to relieve their symptoms.

(2)

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(iii) Explain how beta-2 agonists can increase the heart rate (paragraph 13).

(4)

(b) Explain how human growth hormone (HGH) is able to stimulate cells to secrete IGF-1 (paragraphs 20 and 21).

(4)

(c) Explain why it is difficult to identify athletes who are using banned substances such as HGH (paragraphs 17, 20 and 22).

(2)

(d) Explain one benefit of using substances developed from perfluorocarbons (PFCs) to treat patients with breathing difficulties (paragraphs 30 and 31).

(2)

(e) Local anaesthetics mask pain by binding to protein channels in the membranes of neurones (paragraph 38).

Explain how binding to protein channels will prevent pain being sensed by the pain centre of the brain.

(4)

(f) Explain why diuretics are a prescribed drug for high blood pressure (paragraph 43).

(2)

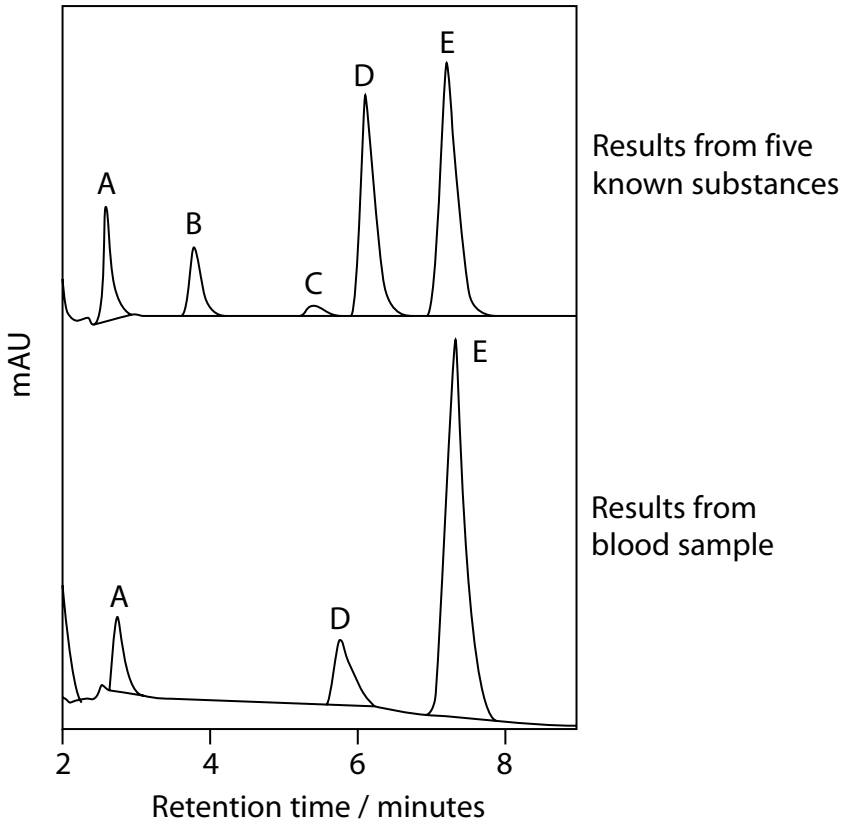
(g) A test for the T/E ratio can help to identify athletes who have injected testosterone into their body (paragraph 45).

Explain the limitation of this test.

(3)

(h) Gas chromatography (GC) can be used to detect athletes who have taken banned drugs (paragraph 48).

The chromatogram shows the GC results for five known banned substances, A, B, C, D and E.



Explain why the peak for drug E is different from the peak for drug A (paragraph 48).

(2)

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(i) Explain how the blood passport may result in more effective monitoring of athletes (paragraph 51).

(2)

(j) Comment on the ethical viewpoints for and against the use of performance-enhancing drugs by athletes.

(4)

(Total for Question 6 = 33 marks)

TOTAL FOR PAPER = 100 MARKS

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