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**SOURCE BOOKLET
LIFE SCIENCES
PRELIMINARY EXAMINATION PAPER II**

QUESTION 1

The following information is adapted from research conducted at the University of KwaZulu-Natal into the effects of Antiretroviral drugs in HIV/AIDs affected men.

Introduction to ARVs and HIV

Antiretroviral (ARV) therapy is currently effective in lowering the replication of the Human Immunodeficiency Virus (HIV) in the blood. However, it does not completely remove the virus from the host tissues.

Destination of ARVs

The testes are an example of a hiding place for the HI-virus as many of the ARV drugs cannot move from the blood into the tissues of some organs. This is called the blood tissue barrier. The protected tissue of the testes allows HIV to continue replicating, even if a person is taking ARVs. The testes can then act as an area in which drug-resistant strains of HIV can develop. Some other studies have also shown that the concentration of ARV drugs in the semen and seminiferous tubules is too low to prevent viral replication. The challenge for scientists is to find the correct combinations of ARVs that can get through to the seminiferous tubules.

Effects of ARVs on spermatogenesis

Spermatogenesis is the process that produces mature functional sperm in the testis and this process takes 72 days to complete. The hormones LH, FSH and testosterone are required to control the correct development of healthy sperm cells. ARVs can pass as far as the germinal epithelium layer in the tests where sperm is produced, but cannot enter any further. Recent studies also show that some ARVs significantly lower the sperm count, reduce the sperm movement and increase the amount of abnormal sperm.

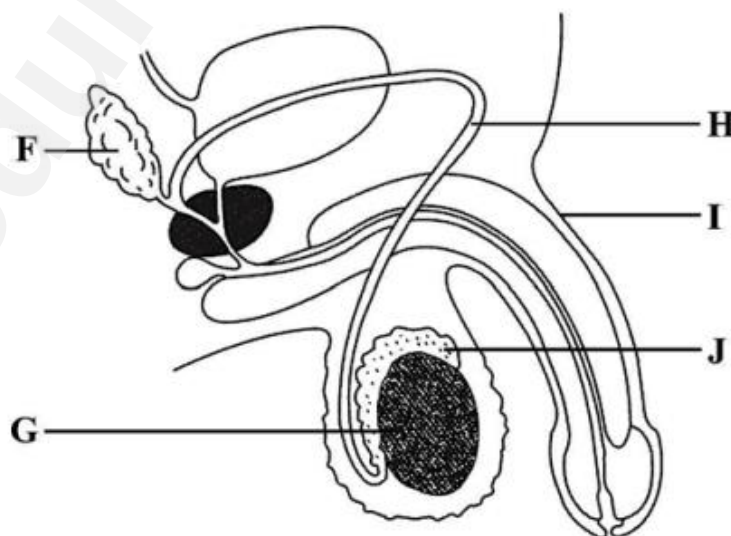
Effect of ARVs on mitochondria

One reason for this is that some ARVs act as mitochondrial toxins. It is believed that these toxins damage some mitochondria and also reduce the amount of mitochondrial DNA. This damage then inhibits the action of their enzymes such as DNA polymerase. Other research studies show that men on ARV treatment show a loss of germinal epithelium cells and their sperm do not mature. Their testosterone levels are also below normal. However, much still needs to be done to determine the exact relationship between ARVs and loss of fertility in men.

Table A: Summary of Studies showing the effects of different ARV treatments (drugs) on tissue of the testes

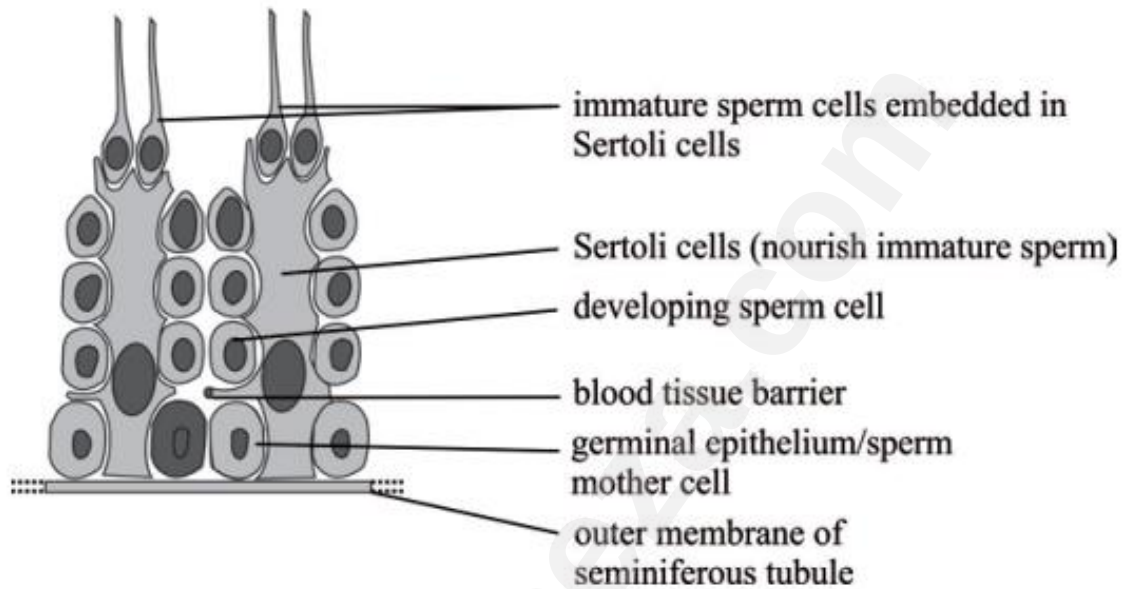
Treatment (drugs used)	Effects	Type of Experimental investigation	Duration of experiment
A Drug 1 and Drug 2	Reduced sperm movement, reduced sperm count and reduced sperm survival. Reduced testosterone.	Animal testing	21 days
B Combination of three or more drugs	Levels of testosterone, FSH and LH not significantly altered.	Analysis of human sperm and tissue in testes	4 years
C Drug 3 and Drug 4	Semen altered, decreased sperm movement, reduces mechanisms essential for fertilization of an ovum.	Trials in test tube samples of sperm	48 weeks
D Drug 5 and Drug 4	Higher percentage of active sperm, increase in healthy sperm.	Semen samples and cross sections of testes	Ongoing
E Drug 6 and Drug 4	Diabetes	Ongoing sperm and testis analysis	4 years
F Drug 7 and Drug 8	Increase in testosterone levels	Sperm and testis analysis	7 days

B: Human male reproductive organs



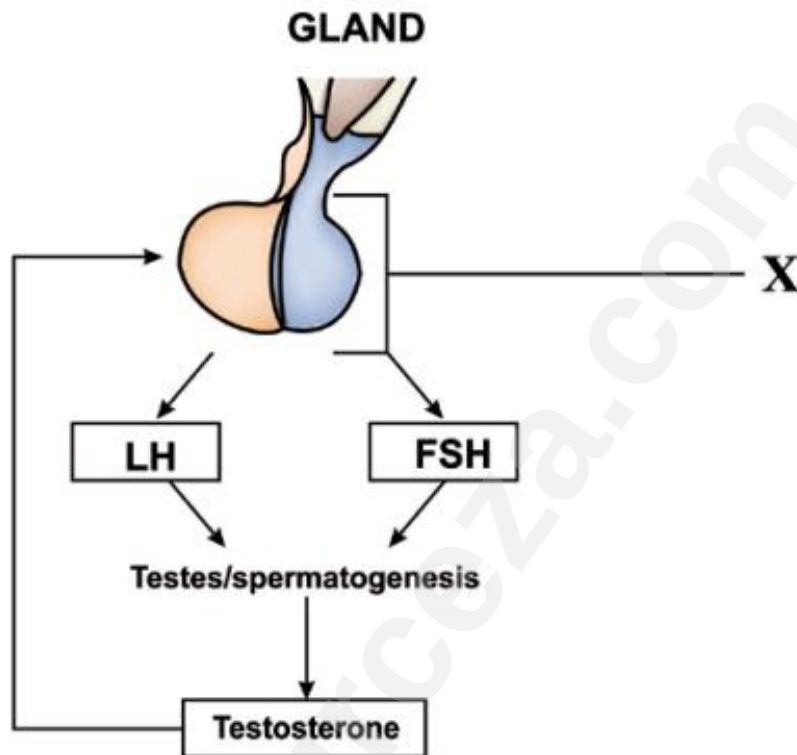
[Source: <www.biologydiscussion.com>]

C: Cross section of a section of a seminiferous tubule found in structure G in diagram B



pted from: *Highly Active Antiretroviral Therapy (HAART) and Testicular Morphology*,
Onyemaeychi O, Azu; UKZN – 2012]

D: Negative feedback between male reproductive hormones



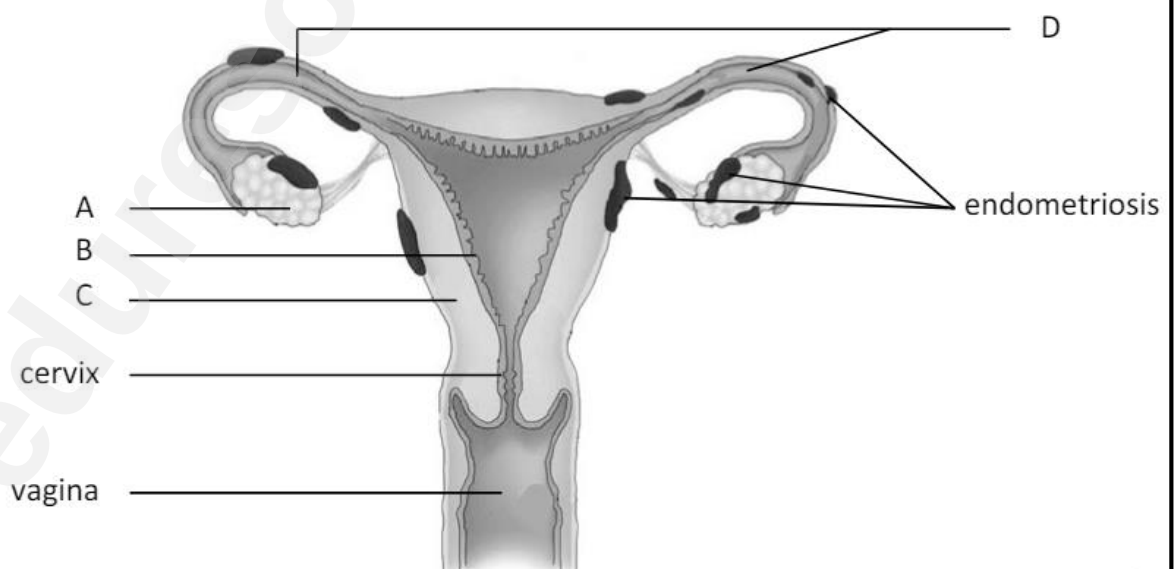
QUESTION 2

2.1.

Endometriosis is an often painful disorder in females in which tissue that normally lines the inside of the uterus- the endometrium- grows outside the uterus. Endometriosis most commonly involves the abdomen and ovaries, fallopian tubes, and ligaments that support the uterus; the area between the vagina and the rectum; the other surface of the uterus; and the lining of the pelvic cavity. Other sites for these endometrial growths may include the bladder, bowel, vagina, cervix, vulva, and in abdominal surgical scars. Less commonly they are found in the lungs, arms, thighs, and other locations.

In endometriosis, displaced endometrial tissue continues to act as it normally would – it thickens, breaks down and bleeds with each menstrual cycle. Because this displaced tissue has no way to exit the body, it becomes trapped. When endometriosis involves the ovaries, cysts may form. Surrounding tissue can become irritated, eventually developing scar tissue and adhesions – abnormal tissue that binds organs together. Endometriosis can cause pain – sometimes severe – especially during the menstrual period. Fertility problems also may develop. Fortunately, effective treatments are available.

Diagram A. Female Reproductive System Showing Areas of Endometriosis



This painful, chronic disease affects at least 6,3 million women and girls in the United States of America, and millions more worldwide. The cause of endometriosis is unknown. One theory suggests that during menstruation some of the menstrual tissue extends into the fallopian tubes, implants in the abdomen, and grows.

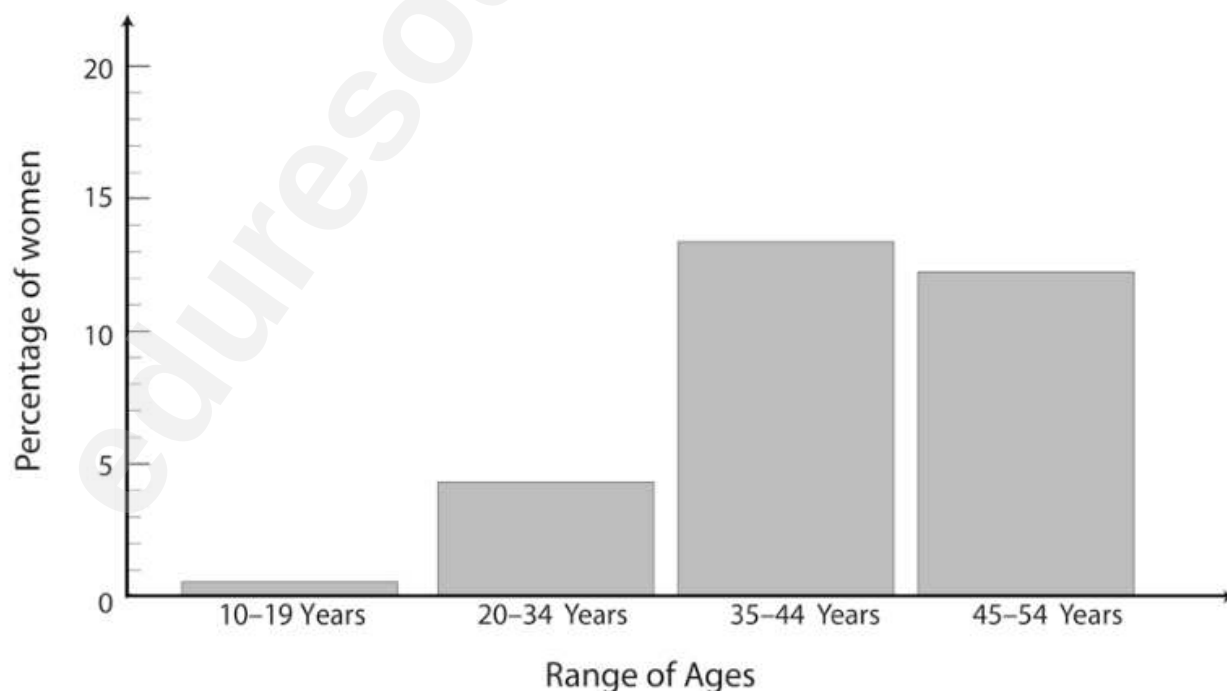
Hormones may also play a role. Endometriosis affects about one in 10 women of reproductive age, which is the time between a female's first menstruation and menopause, when she can no longer become pregnant. These childbearing years are when a woman's oestrogen levels are at their highest. After menopause, a female's oestrogen levels significantly drop and symptoms of endometriosis typically subside.

Research by the Endometriosis Association (EA) revealed a startling link between dioxin exposure and the development of endometriosis. Dioxin is a toxic chemical by-product of pesticide manufacturing, bleached pulp and paper products, and medical and municipal waste burning. The EA discovered a colony of rhesus monkeys that had developed endometriosis after exposure to dioxin. A total of 79% of the monkeys exposed to dioxin developed endometriosis, and, in addition, the more dioxin exposure, the more severe the endometriosis.

[Adapted: www.endometriosisassn.org & www.mayoclinic.org]

Diagram B. Endometriosis among Women aged 20 to 54 years (Survey 2005 – 2006)

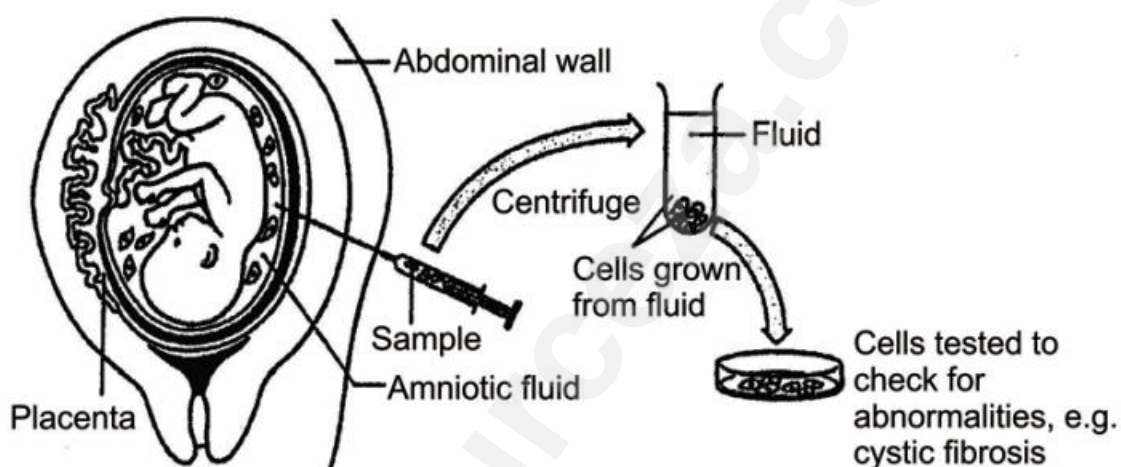
Adapted: [U.S. Department of Health and Human Services, 2009]



2.2.

The information below describes amniocentesis which is used to check whether a foetus has any genetic abnormalities.

A syringe is inserted through the abdominal wall into the amniotic fluid. Fluid containing foetal skin and digestive tract cells is collected. These cells are grown and then checked for genetic abnormalities. Pregnant women aged 38 – 45 are usually tested. This procedure does have risks. The test is done between 16 and 18 weeks after which the pregnancy can be legally terminated if necessary.



[Adapted from Pickering]

QUESTION 3

SOURCE A DOPING IN SPORTS

'Doping' refers to an athlete's use of prohibited drugs or methods to improve training and sporting results.

[<<https://www.unesco.org>>]

The use of performance enhancing drugs in modern sporting events is on record as early as the games of the third Olympic Games, when Thomas Hicks won the marathon after receiving an injection of strychnine in the middle of the race. Even though strychnine is a deadly poison, small doses can act as a muscle stimulant. However, it is extremely dangerous.

[Adapted: Hermann, A., Henneberg, M. 2014. Long term effects of doping in sporting records: 1886–2012. *Journal of Human Sport and Exercise* 9 (3): 727]

Athletes have used a variety of performance enhancing chemicals ever since competitive sport began:

Growth Hormone (GH)

Increases muscle mass, increases use of nutrients in cells, causes fat breakdown, accelerates recovery from injury.

Erythropoietin (EPO)

Stimulates bone marrow to produce more red blood cells to enable more oxygen to be carried.

HORMONES USED FOR SPORTS PERFORMANCE

Insulin

Boosts glucose uptake by cells to allow more glycogen storage.

Testosterone

Increases protein synthesis, muscle fibre development, red blood cell manufacture, prevents muscle cell breakdown.

[Adapted: Baumann, G. P. 2012. Growth Hormone Doping in Sports: A critical review of use and detection strategies. *Endocrine Reviews* 33(2):155–186]

[Adapted: De la Torre, X., Brito, M. & Botré, D. *Thyroid hormones in sport: use or abuse?* Federazione Medico Sportiva Italiana, Italy]

[Adapted: Saudan, C., Baume, N., Robinson, N., Avois, L., Mangin, P. & Saugy, M. 2006. Testosterone and doping control. *British Journal of Sports Medicine* 40(1): 21–24]

[Adapted: <<https://www.medicinenet.com>>]

[Adapted: <<https://www.theguardian.com>>]

SOURCE B

RULES OF SPORTSMANSHIP



[Adapted: <<https://www.olympic.org>>]

SOURCE C

RIGHT OR WRONG?

Those who oppose the use of steroids and other performance-enhancing drugs say that the athletes who use them are breaking the rules and getting an unfair advantage over others. The athletes are endangering not only their own health, but also indirectly encouraging youngsters to do the same. Others maintain that it is hypocritical for society to encourage consumers to seek drugs to treat all sorts of illnesses and conditions, but to ban drug use for sports.

When athletes train for competitions, they choose what type of training to use, what diet to follow and what equipment and supplements to choose. There is a huge range of different supplements and sporting equipment to choose from. Hormones are simply another one of these. Far from being against the spirit of sport, biological manipulation embodies the human spirit – the capacity to improve athletes on the basis of reason and judgment. The result will be that the winner is not the person who was born with the best genetic potential to be strongest. Sport would be less of a genetic lottery.

Classical musicians commonly use beta blocker drugs to control their stage fright. These drugs lower heart rate and blood pressure, reducing the physical effects of stress, and it has been shown that the quality of a musical performance is improved if the musician takes these drugs. No one complains about the use of these drugs. We do not think less of the violinist or pianist who uses them. If the audience judges the performance to be improved with drugs, then the drugs are enabling the musician to express him or herself more effectively.

[Adapted: Matei, R. & Ginsborg, J. 2017. Music performance anxiety in classical musicians – what we know about what works. *British Journal of Psychology International* 14(2): 33–35]

[Adapted: Savulescu, J. & Foddy, B. 2010. *Le Tour and Failure of Zero Tolerance: Time to Relax Doping Controls*. In Savulescu, J., Kahane, G. & Ter Meulen, R. Enhancing Human Capacities. (eds), Blackwell]

The difference between gold medallists and making second place may be measured in fractions of seconds or millimetres. A tiny advantage can make all the difference. What if that advantage comes from using a performance-enhancing drug? For athletes who want to compete clean, the threat that they may be beaten by a competitor who is not faster, stronger, or more dedicated, but who takes a drug to gain the edge, is very personal. Performance-enhancing drugs affect the individual athlete psychologically – when an athlete wins by using a performance-enhancing drug, what does that mean for the athlete's own understanding of what happened? Am I the world's best? Or was my supposed victory affected by the drug's effects? We expect the winning athlete to combine extraordinary natural talents with effort, training, and technique. Natural talents should be respected for what they are: the occasionally awesome luck of the biological draw. Courage, strength, competitiveness, and other virtues rightfully demand our moral admiration. The other factors – equipment, coaching, and nutrition – contribute to an athlete's success but don't induce the same appreciation.

Allowing drugs in the sports world ultimately takes away from the true purpose of playing and watching sports because we love them. Doping centres everything around just the opposite: winning and losing. It diminishes the values that should drive an athlete, including character, integrity, sportsmanship, skill and talent.

[Adapted: Haisma, H. J. & de Hon, O. 2006. Gene Doping. *Int. J. Sports Med.* 27: 257–266]

SOURCE D

A LESSON FROM HISTORY?

Sporting authorities have adopted a policy of prohibition for performance-enhancing drug use in sport, but history dictates that this is a strategy doomed to fail. This was seen to good effect in America when in January 1920 the sale and use of alcohol was prohibited (banned) in order to prevent alcoholism and the associated crimes. This was the period known as 'Prohibition'. Prohibition was difficult to enforce. Far from its proposed effect, alcohol consumption increased as people found ways to brew their own liquor, and sell it in illegal nightclubs. Organised crime therefore thrived, and corruption among government officials soared as they were paid to 'look the other way'. The quality of the alcohol was often very poor, contaminated with toxic levels of methanol and other waste products. As the quality of the alcohol was unregulated, the incidence of death from poisonous alcohol rose fourfold in five years. In early 1933, Congress adopted a resolution proposing an end to 'Prohibition'.



Party serving illegal liquor during Prohibition

[<<https://images.squarespace-cdn.com>>]

[Adapted: Dawson, R. T. 2009. Hormones and Sport. Drugs in Sport – The role of the physician. Drugs In Sport Clinic and User's Support (DISCUS)]

SOURCE E NATURAL EPO LEVELS, GENETICS

There are other legal ways to increase the number of red blood cells. EPO is a hormone produced in response to anaemia, haemorrhage, pregnancy, or living at high altitudes where there is less oxygen. More recently, hypoxic air machines have been used to simulate altitude training. The body responds by releasing natural EPO and growing more red blood cells, so that it can absorb more oxygen with every breath.

There is no difference between elevating your blood count by altitude training, by using a hypoxic air machine, or by taking EPO. But the last method is illegal. Some can afford hypoxic air machines and altitude training while others cannot.

High Altitude training Camp – Flagstaff Arizona

Location: Flagstaff, AZ

Elevation: 2134 m above sea level

Duration: 7 days

What you get: 10 guided trail runs, 1 long run, 2 track workouts, airport transportation, lunch daily, one-on-one coaching, 5 Classroom sessions

Costs:

Training Camp Registration Cost: R 12 040

Cost of Flights (Toronto to Flagstaff Round trip): ~R13 097

Accommodation (Watson Lake Inn): R28 016

Food/Extras: R10 000

Total Cost: ~R 62 060

[Adapted: <<https://altitudeathletictraining.com>>]



R 350

[<<https://www.peptides.co.za>>]

[Adapted: Browne, A., LaChance, V. & Pipe, A. 1999. The ethics of blood testing as an element of doping control in sport. *Med. Sci Sports Exercise* 31:497–501]

[Adapted: House of Commons, Select Committee on Culture, Media and Sport. 2004. Seventh Report of Session 2003–2004, UK Parliament, HC 499]

Olympic swimmer Ian Thorpe has enormous feet which give him an advantage that no other swimmer can get, no matter how much they exercise. Some gymnasts are more flexible, and some basketball players are seven feet tall. By allowing everyone to take performance enhancing drugs, we level the playing field. We remove the effects of genetic inequality. Far from being unfair, allowing performance enhancement promotes equality.

The Finnish skier Eero Mäntyranta won three gold medals in 1964. Subsequently it was found he had a genetic mutation- primary familial and congenital polycythaemia (PFCP) causing an increase in red blood cell number and haemoglobin due to a mutation in the EPO receptor gene. This condition results in an increase of up to 50% in the oxygen carrying capacity of the blood, a large advantage when participating in endurance events.

Sport discriminates against the genetically unfit. Sport is the province of the genetic elite.



Ian Thorpe's feet – size 17
[<<https://www.abc.net.au>>]



Eero Mäntyranta
[<<https://upload.wikimedia.org>>]

[Adapted: Browne, A., LaChance, V. & Pipe, A. 1999. The ethics of blood testing as an element of doping control in sport. *Med. Sci. Sports Exercise* 31:497–501]

[Adapted: House of Commons, Select Committee on Culture, Media and Sport. 2004. Seventh Report of Session 2003–2004, UK Parliament, HC 499]

[Adapted: Shahmoradi, S., Ahmadalipour, A. & Salehi, M. 2014. Evaluation of ACE gene I/D polymorphism in Iranian elite athletes. *Adv. Biomed. Res.* 2014(3): 207]

SOURCE F HEALTH EFFECTS

Raising the number of red blood cells can cause health problems such as risk of stroke or heart attack. Because the effect of drugs is profoundly different between people, sports events would be determined in large part by whose body responds best to chemicals. Training is active, you have to do the work to earn the benefit. Doping is not, so it fundamentally changes the outcome of the sport without changing the input. The most ambitious person would be the most reckless person- the one to take the most drugs possible without killing or harming themselves. If most athletes are deciding to use steroids, then many of the players who do not wish to suffer from the long-term effects will feel pressurized into using illegal substances themselves.

Effects of testosterone on the body

- Severe acne
- Increased risk of tendinitis and tendon rupture
- Liver abnormalities and tumours
- Increased cholesterol
- High blood pressure
- Heart and blood circulation problems

[Adapted: <<https://www.mayoclinic.org>>]

SOURCE G TECHNOLOGY

Athletes already radically change their bodies through advanced, technologically driven training regimes. Tour de France cyclists receive intravenous artificial nutrition and hydration overnight because their bodies cannot take on enough food and fluid naturally. Ben Johnson, stripped of his 100 metres Olympic gold at the 1988 Games, said that the human body was not designed to run the speeds it is called upon to run now, and steroids were necessary to recover from the gruelling training and injuries.

[Adapted: Savulescu, J. & Foddy, B. 2010. *Le Tour and Failure of Zero Tolerance: Time to Relax Doping Controls*. In Savulescu, J., Kahane, G & Ter Meulen, R. *Enhancing Human Capacities*. (eds), Blackwell]

[Adapted: <<https://sportsscientists.com>>]

[Adapted: <<https://www.npr.org>>]

The United States Bobsled team has teamed up with German car manufacturer BMW to help design their Bobsleds. BMW has completely redesigned it and has built the thing entirely out of carbon fibre. It is a certainty that the American Bobsleds will be quicker and more aerodynamic.

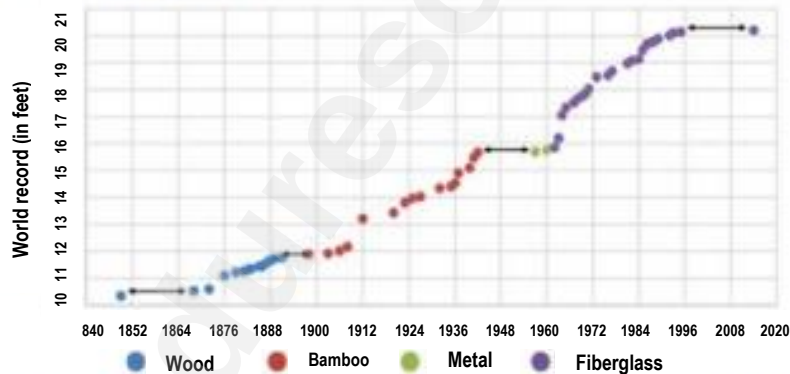


Bobsled [<<https://mabuhaynews.ca>>]

Reduced skin friction drag



23 out of 25 world records in Olympics 2008 were made by swimmers wearing his swimsuit.



Graph showing improvement pole vaulting records between 1840 and 2012

[Adapted: <<https://business.uoregon.edu>>]

Eliud Kipchoge, who holds the world marathon record, donned a Vaporfly prototype in October when he ran the first sub-2-hour marathon ever. Both independent and Nike-sponsored studies have confirmed that the shoes increase athletes' energetic efficiency by 4% or more, which yields significant dividends in marathon-length distances.



[Adapted: <<https://jursoutblog.wordpress.com>>]

[Adapted: <<https://www.washingtonpost.com>>]

SOURCE H

FAMOUS ATHLETES CAUGHT DOPING



**Diego Maradona –
footballer- ephedrine**



**Linford Christie – sprinter
- Nandrolone**



**Marion Jones – sprinter/
Long jump- THG**



**Ben Johnson – sprinter -
testosterone**



**Lance Armstrong – cyclist
- EPO, testosterone, GH,
cortisone**



**Mary Decker – middle
distance athlete-
testosterone**



**Carl Lewis – sprinter/ long
jump- pseudoephedrine**



**Tyson Gay – sprinter -
testosterone**

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