10.5 Steroids: Natural and Synthetic

Which of the people in **Figure 1** do you think is using steroids? Most people would assume that it is the weightlifter, not the boy with asthma. The truth is, however, that the only person we know to be using steroids, from these photographs, is the boy using the asthma inhaler. The use of illegal substances in the world of sports has led to a very negative perception of steroids. Yet, the term "steroid" refers to a class of lipids that includes cholesterol and the hormones derived from cholesterol, which act on receptors inside cells. There are many legitimate and helpful uses of steroid hormones, both in medicine and in the natural world.

Figure 1 Was your first thought that the weightlifter was using steroids? We often make false assumptions about the use and abuse of steroids.

In this section, you will learn about natural steroids and their functions in the body, as well as synthetic steroids, their legitimate medical use, and their abuse as performance-enhancing drugs in sports.

Natural Steroid Hormones

Steroid hormones act on specific target tissues in the body. Recall that target tissues are tissues with the appropriate steroid receptor molecules in the cytosol of their cells. Steroid hormones are derived from cholesterol and easily pass through the cell membrane to attach to the receptor molecules inside a cell. The hormone-receptor complex then enters the nucleus and binds to specific regulatory sequences adjacent to the genes whose expression is controlled by the hormone. This binding activates transcription, and proteins encoded by the genes are made rapidly.

All genes that are regulated by a specific steroid hormone have the same DNA sequence that binds to the hormone-receptor complex. This sequence is called a steroid hormone response element. For example, all genes controlled by a glucocorticoid have a glucocorticoid response element associated with them. Therefore, the release of a glucocorticoid into the bloodstream activates the transcription of genes through the glucocorticoid response element.

testosterone the main male sex hormone, which stimulates and controls the development of male secondary sexual characteristics

estrogens predominantly female sex hormones, including estradiol, that trigger sexual development

progestins predominantly female sex hormones, including progesterone, that control the menstrual cycle

One common hormone, **testosterone**, is a steroid that helps to build muscle mass, which is one of the male secondary sex characteristics. By binding to receptors inside the cell nucleus, testosterone controls the metabolic genes that build the proteins used for muscle development. As testosterone increases, the body builds more muscle mass. This increase in muscle mass occurs naturally in the male body during puberty, but it can also be induced by the use of more testosterone.

Other natural steroid hormones include aldosterone, which is produced by the adrenal glands in response to stress, and cortisol, which is produced by the adrenal cortex and raises the blood glucose level. In females, the **estrogens** and the **progestins** are steroid sex hormones that trigger female sexual development and control the female reproductive cycle.

Synthetic Steroids

Synthetic hormones are chemicals that have been designed to mimic the actions of natural hormones. For example, one group of synthetic hormones, called anabolic steroids, mimics many of the muscle-building characteristics of testosterone. There are many synthetic hormones that have been developed for legitimate medical purposes (**Table 1**). Synthetic steroid hormones are an important treatment for transplant patients because they suppress the immune system, reducing the incidence of organ rejection. Many synthetic steroids can reduce pain and inflammation, so they are used to treat inflammatory disorders, such as arthritis and asthma, as well as autoimmune disorders, such as lupus. Many of the prescription inhalers used to treat asthma contain synthetic steroids. Synthetic steroids used for medical purposes are considered safe and effective when used as prescribed, but they should only be used under a doctor's supervision.

synthetic hormone a hormone created by humans that behaves like a natural hormone

Table 1 Some Synthetic Steroids

Drug	Therapeutic use
prednisone	treatment of lupus and following organ transplantation
beclomethasone	treatment of asthma
dexamethasone	treatment of rheumatoid arthritis
hydrocortisone	treatment of inflammatory skin disorders

Performance Enhancement in Sports

The negative perception of steroids comes largely from the illegal use of anabolic steroids and other performance-enhancing substances in the world of sports. A small percentage of athletes are willing to risk their health and reputation to gain even a small competitive edge.

There are several ways for athletes to gain an unfair advantage. One of the most common ways is the use of anabolic steroids. These are synthetic steroids that, much like testosterone, build muscle mass. Anabolic steroids provide an advantage only in sports where muscle mass is important. In primarily aerobic sports, where greater muscle mass is less of an advantage than greater aerobic capacity, different performance-enhancing substances are used. Erythropoietin (EPO) is a protein hormone that can stimulate red blood cell production. With more red blood cells, the blood can carry more oxygen, providing longer endurance and more energy.

All of these performance-enhancing drugs have potential side effects. Anabolic steroids, in particular, have a variety of well-known negative effects, including acne, bad breath, high blood pressure, liver disease, and cancer. In men, anabolic steroids can reduce the size of the testes and enlarge the breasts. In women, they can cause irregular menstrual cycles and the growth of facial hair (**Figure 2**).

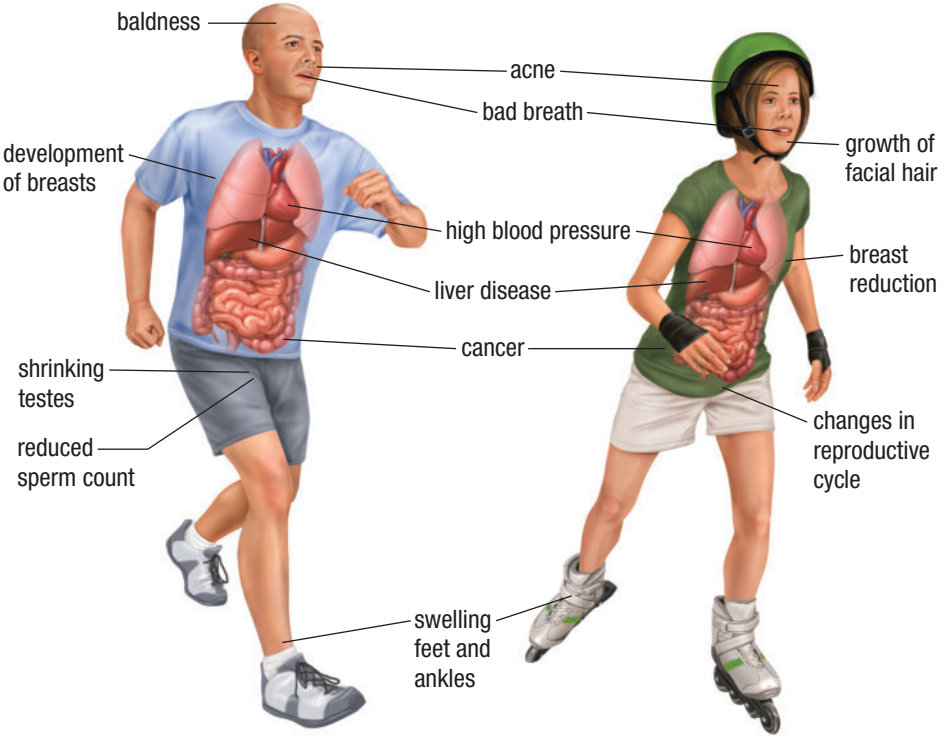

Figure 2 Negative effects of the long-term use of anabolic steroids in males and females

Some performance-enhancing drugs have a mood-altering effect. For example, anabolic steroids increase levels of aggressiveness. This "roid rage," as it is sometimes called, can lead a person to uncharacteristically violent or dangerous actions. Other drugs cause anxiety, depression, paranoia, or addiction.

Despite all the risks, there have been many high-profile cases of professional and Olympic athletes using performance-enhancing drugs. In 1988, Canadian sprinter Ben Johnson was stripped of his Olympic gold medal because of his use of unapproved substances. Baseball star Mark McGwire gained fame for hitting a record number of home runs during the 1998 season, but he later admitted to having used banned steroids to improve his hitting power. Even high school and university athletes can run into trouble by trying to unfairly enhance their performance. In June 2010, the University of Waterloo Warriors football program was suspended for a year because of the use of performance-enhancing drugs by a few of its players. Some of the players were suspended for two years.

The detection of banned substances among amateur and professional athletes is difficult, but the detection methods are continually being refined. The International Olympic Committee, for example, frequently updates its lists of banned drugs and the substances that may be used as masking agents (**Table 2**).

Table 2 International Olympic Committee List of Banned Performance-Enhancing Drugs

Drug	Advantage	Side effects
Anabolic steroids		
stanozolol, androstenediol, and nandrolone	increases muscle mass and strength	causes decreased growth, kidney problems, hair loss, oily skin, acne, shrinking testes, infertility, and cancer
Peptide hormones		
growth hormone	decreases fat and improves muscle mass	causes diabetes; abnormalities of the bones, liver, heart, and kidneys; liver disease; and high blood pressure
erythropoietin (EPO)	increases red blood cells, which carry more oxygen	thickens the blood, increasing the chance of stroke; causes heart problems
Masking agents		
bromantan	makes steroids difficult to detect	unknown
probenecid	stops the excretion of steroids for a few hours	causes headaches, tissue swelling, and nausea

The World Anti-Doping Agency (WADA) promotes and coordinates efforts against doping in all types of sports. Begun in 1999 in Switzerland, it is led by the International Olympic Committee. Canadian lawyer Richard (Dick) Pound is a former president of WADA. Because the problem of doping in sports is so serious, WADA guidelines require athletes to be available one hour each day for possible random testing for banned substances. WADA uses some very refined laboratory methods to detect banned substances. For example, the human body makes its own supply of EPO, but there is a slight chemical difference in the body's EPO and the EPO injected as a performance enhancer. WADA's sophisticated laboratories can detect the difference.

10.5 Review

Summary

- Steroids belong to a category of lipids that includes several hormones that act on receptors inside cells.
- Natural steroid hormones occur in the human body and control both male and female sexual development and reproduction, the adrenal fight-or-flight response, and the blood glucose level.
- There are many legitimate medical uses of synthetic steroids, including as painkillers and as anti-inflammatories such as those found in asthma inhalers. They should be used for a valid medical reason and must be supervised by a physician.
- There are many illegal uses of synthetic steroids, particularly in the world of sports, where some athletes are looking for any competitive edge.
- The long-term use of synthetic steroids can lead to baldness, shrinking testes, irregular reproductive cycles, and many other physical and psychological side effects.
- Many competitive sports organizations at all levels now keep lists of banned substances and conduct frequent testing to prevent athletes from using performance-enhancing drugs.

Questions

1. What are steroid hormones? K/U
2. How do steroid hormones affect DNA? K/U
3. What are synthetic hormones? K/U
4. What do the names of many steroid hormones have in common, which might allow you to recognize a steroid hormone from its name? T/I
5. Name a steroid hormone and a non-steroid hormone that affect the blood glucose level. K/U
6. Use the Internet and other sources to research the steroid called cortisone. What are some common medical uses of cortisone? What are some potential side effects of cortisone? T/I
7. Why would it be difficult to detect the use of some banned performance-enhancing drugs, such as growth hormone, testosterone, and EPO? T/I
8. Do you think it is fair to punish an entire sports team for the actions of a few team members who used banned substances? Why or why not? T/I
9. Given what you know about negative feedback loops, what might the administration of extra testosterone do to the body of an adult male? K/U T/I
10. Anabolic steroids are sometimes used in AIDS and end-stage cancer patients. What might be the reasoning for this use? T/I
11. Choose a sport that interests you. Use the Internet and other sources to investigate examples of drug abuse associated with the sport. Write a letter to the organizing body for the sport, outlining your findings and presenting your recommendations for fixing the problem. T/I C
12. Use the Internet and other sources to research other substances and methods that have been used in sports to provide a competitive advantage. Summarize your findings in a brief report. T/I C
13. Proviron is a synthetic steroid hormone that has been used for performance enhancement. Using the Internet and other sources, research the medical benefits of this hormone. T/I
14. The drugs used in inhalers to treat asthma can be grouped into relievers (short-acting broncho-dilators), preventers (steroid inhalers), and long-acting bronchodilators. Using the Internet and other sources, find out how these drugs work. Create a poster or other visual presentation that explains the differences in the actions of these drugs. T/I C