Option D: Medicines and drugs (15/22 hours)

SL students study the core of these options and HL students study the whole option (the core and the extension material).

The aim of this option is to give students an understanding of how medicines and drugs can influence the functioning of the body. Students should be able to recognize the fundamental structures and relevant functional groups of several classes of drugs and medicines (as listed in this option or in topic 10), and should be able to distinguish between them. Memorizing of complex formulas is not required. Throughout the option, the contribution that science has made (and continues to make) towards maintaining and improving the health and well-being of the world's population should be stressed. Aim 8 discussions are central to this option.

Core material: D1–D7 are core material for SL and HL (15 hours).
Extension material: D8–D10 are extension material for HL only (7 hours).

D1 Pharmaceutical products

2 hours

	Assessment statement	Obj	Teacher's notes
D.1.1	List the effects of medicines and drugs on the functioning of the body.	1	Generally, a medicine or drug is any chemical that does one or more of the following. • Alters the physiological state, including consciousness, activity level or coordination • Alters incoming sensory sensations • Alters mood or emotions The importance of the body's natural healing processes and the placebo effect should be stressed.
D.1.2	Outline the stages involved in the research, development and testing of new pharmaceutical products.	2	An example of what can go wrong is the Thalidomide case. The use of combinatorial chemistry will not be assessed. A discussion of specific techniques will not be assessed. **TOK:** Should scientists be held morally responsible when drugs have adverse effects?
D.1.3	Describe the different methods of administering drugs.	2	Methods should include oral, parenteral (by injection), inhalation and rectal. Injections may be intravenous, intramuscular or subcutaneous.
D.1.4	Discuss the terms therapeutic window, tolerance and side-effects.	3	

D2 Antacids

1 hour

	Assessment statement	Obj	Teacher's notes
D.2.1	State and explain how excess acidity in the stomach can be reduced by the use of different bases.	3	Examples should include aluminium and magnesium compounds and sodium hydrogencarbonate. Students should be able to write equations for neutralization reactions and know that antacids are often combined with alginates (which produce a neutralizing layer, preventing acid in the stomach from rising into the esophagus and causing heartburn), and with anti-foaming agents (such as dimethicone).

D3 Analgesics

3 hours

	Assessment statement	Obj	Teacher's notes
D.3.1	Describe and explain the different ways that analgesics prevent pain.	3	Mild analgesics function by intercepting the pain stimulus at the source, often by interfering with the production of substances (for example, prostaglandins) that cause pain, swelling or fever. Strong analgesics work by temporarily bonding to receptor sites in the brain, preventing the transmission of pain impulses without depressing the central nervous system. **TOK:** A discussion of pain perception could be linked to the more general discussion of perception as a way of knowing in TOK.
D.3.2	Describe the use of derivatives of salicylic acid as mild analgesics, and compare the advantages and disadvantages of using aspirin and paracetamol (acetaminophen).	2	Aspirin has been found to be useful in preventing the recurrence of heart attacks and strokes. The disadvantages of aspirin include ulceration and stomach bleeding, allergic reactions and Reye's syndrome in children (a potentially fatal liver and brain disorder). Paracetamol is very safe in the correct dose but can, in rare cases, cause blood disorders and kidney damage. Overdosage can lead to serious liver damage, brain damage and even death.
D.3.3	Compare the structures of morphine, codeine and diamorphine (heroin, a semi-synthetic opiate).	3	Stress the functional group modification to the structure of morphine that results in the semi-synthetic drug diamorphine

			(heroin).
D.3.4	Discuss the advantages and disadvantages of using morphine and its derivatives as strong analgesics.	3	Include the social as well as physiological effects of both short- and long-term use.

D4 Depressants
3 hours

	Assessment statement	Obj	Teacher's notes
D.4.1	Describe the effects of depressants.	2	At low doses a depressant may exert little or no effect. At moderate doses the compound may induce sedation (soothing, reduction of anxiety). At higher doses it may induce sleep. At extremely high doses it may cause death. Depressants are often described as antidepressants because they relieve depression.
D.4.2	Discuss the social and physiological effects of the use and abuse of ethanol.	3	Include effects on the family, cost to society and the short- and long-term health effects.
D.4.3	Describe and explain the techniques used for the detection of ethanol in the breath, the blood and urine.	3	Include potassium dichromate(VI) in the breathalyser, analysis of blood and urine by chromatography, and absorption of infrared radiation or use of a fuel cell in the intoximeter.
D.4.4	Describe the synergistic effects of ethanol with other drugs.	2	Examples should include increased risk of stomach bleeding with aspirin and increased risk of heavy sedation with any drug that has a sedative effect on the central nervous system.
D.4.5	Identify other commonly used depressants and describe their structures.	2	Only the uses of diazepam (Valium®), nitrazepam (Mogadon® and fluoxetine hydrochloride (Prozac®) will be assessed.

D5 Stimulants
2.5 hours

	Assessment statement	Obj	Teacher's notes
D.5.1	List the physiological effects of stimulants.	1	
D.5.2	Compare amphetamines and epinephrine (adrenaline).	3	Amphetamines and epinephrine (adrenaline) are chemically similar in that

			both derive from the phenylethylamine structure. Amphetamines mimic the effects of epinephrine (adrenaline) and are known as sympathomimetic drugs.
D.5.3	Discuss the short- and long-term effects of nicotine consumption.	3	Short-term effects include increased heart rate and blood pressure and reduction in urine output, as well as stimulating effects. Long-term effects include increased risk of heart disease, coronary thrombosis and peptic ulcers. Include also the addictive properties of nicotine and the further risks associated with smoking tobacco.
D.5.4	Describe the effects of caffeine and compare its structure with that of nicotine.	3	Caffeine is a respiratory stimulant. When consumed in large amounts it can cause anxiety, irritability and sleeplessness. It is a weak diuretic. Both caffeine and nicotine contain a tertiary amine group.

D6 Antibacterials

2 hours

	Assessment statement	Obj	Teacher's notes
D.6.1	Outline the historical development of penicillins.	2	Include the discovery by Fleming and the development by Florey and Chain. **TOK:** What part does serendipity play in scientific discoveries?
D.6.2	Explain how penicillins work and discuss the effects of modifying the side-chain.	3	Penicillins work by interfering with the chemicals that bacteria need to form normal cell walls. Modifying the side-chain results in penicillins that are more resistant to the penicillinase enzyme.
D.6.3	Discuss and explain the importance of patient compliance and the effect of penicillin overprescription.	3	**Aim 8:** Strict adherence to a recommended treatment regime is necessary for the effectiveness of anti-TB drugs (frequently several drugs are used in combination). The use of penicillins in animal feedstock also contributes to the resistance problem.

D7 Antivirals

1.5 hours

	Assessment statement	Obj	Teacher's notes
D.7.1	State how viruses differ from	1	

	bacteria.		
D.7.2	Describe the different ways in which antiviral drugs work.	2	Antiviral drugs may work by altering the cell's genetic material so that the virus cannot use it to multiply. Alternatively, they may prevent the viruses from multiplying by blocking enzyme activity within the host cell.
D.7.3	Discuss the difficulties associated with solving the AIDS problem.	3	**Int:** Specific proteins on the HIV virus bind to a receptor protein on certain white blood cells (T cells). Because of the ability of the HIV viruses to mutate, and because their metabolism is linked closely with that of the cell, effective treatment with antiviral drugs is very difficult, as is vaccine development. The control and treatment of HIV is exacerbated by the high price of anti-retroviral agents and sociocultural issues.

HL D8 Drug action

2.5 hours

	Assessment statement	Obj	Teacher's notes
D.8.1	Describe the importance of geometrical isomerism in drug action.	2	Students should be aware that *cis*- and *trans*-isomerism can occur in inorganic complexes and that the two different isomers can have different pharmacological effects. Examples should include the anti-cancer drug cisplatin.
D.8.2	Discuss the importance of chirality in drug action.	3	The two enantiomers in a racemic mixture of a drug may have very different effects, for example, Thalidomide. One enantiomer of Thalidomide alleviates morning sickness in pregnant women, while the other enantiomer causes deformities in the limbs of the fetus.
D.8.3	Explain the importance of the beta-lactam ring action of penicillin.	3	The high reactivity of the amide group within the four-membered ring structure is a result of strain. The ring opens so that the penicillin becomes covalently bonded to the enzyme that synthesizes bacterial cell walls, thus blocking its action.
D.8.4	Explain the increased potency of diamorphine (heroin) compared to morphine.	3	The polar hydroxyl groups in morphine are replaced by non-polar ester groups, facilitating transport into the non-polar

			environment of the central nervous system.

HL D9 Drug design

2.5 hours

	Assessment statement	Obj	Teacher's notes
D.9.1	Discuss the use of a compound library in drug design.	3	Traditionally, a large collection of related compounds are synthesized individually and evaluated for biological properties. This approach is time-consuming and expensive.
D.9.2	Explain the use of combinatorial and parallel chemistry to synthesize new drugs.	3	Combinatorial chemistry is used to synthesize a large number of different compounds and screen them for biological activity, resulting in a "combinatorial library". Alternatively, parallel synthesis can produce smaller, more focused libraries. Students should be aware of the importance of solid-phase chemistry.
D.9.3	Describe how computers are used in drug design.	2	Three-dimensional models of drugs can be created *in silico* and molecular modelling software can be used for the virtual development and evaluation of new drugs.
D.9.4	Discuss how the polarity of a molecule can be modified to increase its aqueous solubility and how this facilitates its distribution around the body.	3	Students should be aware of the ability of acidic (carboxylic acid) and basic (amine) groups to form ionic salts, for example, soluble aspirin and fluoxetine hydrochloride (Prozac®).
D.9.5	Describe the use of chiral auxiliaries to form the desired enantiomer.	2	A chiral auxiliary is used to convert a non-chiral molecule into just the desired enantiomer, thus avoiding the need to separate enantiomers from a racemic mixture. It works by attaching itself to the non-chiral molecule to create the stereochemical conditions necessary to force the reaction to follow a certain path. Once the new molecule has been formed, the auxiliary can be taken off (recycled) to leave the desired enantiomer. An example is the synthesis of Taxol, an anti-cancer drug.

HL D10 Mind-altering drugs

2 hours

	Assessment statement	Obj	Teacher's notes
D.10.1	Describe the effects of lysergic acid diethylamide (LSD), mescaline, psilocybin and tetrahydrocannabinol (THC).	2	
D.10.2	Discuss the structural similarities and differences between LSD, mescaline and psilocybin.	3	Students should be aware of the similarities of all three drugs and compare them to the indole ring.
D.10.3	Discuss the arguments for and against the legalization of cannabis.	3	**Aim 8:** Arguments for legalization include the ability of cannabis to offer relief from certain diseases. Arguments against legalization include the possible harmful effects and the possibility of cannabis users moving on to harder drugs.