

## Additional higher level topics

**Essential idea:** Chiral auxiliaries allow the production of individual enantiomers of chiral molecules.

### D.7 Taxol—a chiral auxiliary case study

#### Nature of science:

Advances in technology—many of these natural substances can now be produced in laboratories in high enough quantities to satisfy the demand. (3.7)

Risks and problems—the demand for certain drugs has exceeded the supply of natural substances needed to synthesize these drugs. (4.8)

#### Understandings:

- Taxol is a drug that is commonly used to treat several different forms of cancer.
- Taxol naturally occurs in yew trees but is now commonly synthetically produced.
- A chiral auxiliary is an optically active substance that is temporarily incorporated into an organic synthesis so that it can be carried out asymmetrically with the selective formation of a single enantiomer.

#### Applications and skills:

- Explanation of how taxol (paclitaxel) is obtained and used as a chemotherapeutic agent.
- Description of the use of chiral auxiliaries to form the desired enantiomer.
- Explanation of the use of a polarimeter to identify enantiomers.

#### Guidance:

- The structure of taxol is provided in the data booklet in section 37.

#### International-mindedness:

- There is an unequal availability and distribution of certain drugs and medicines around the globe.

#### Utilization:

Syllabus and cross-curricular links:

Topic 20.2—synthetic routes  
Topic 20.3—stereoisomerism

#### Aims:

- **Aim 8:** Consider the ethical implications of using synthetic drugs instead of natural sources.

**Essential idea:** Nuclear radiation, whilst dangerous owing to its ability to damage cells and cause mutations, can also be used to both diagnose and cure diseases.

D.8 Nuclear medicine	
<b>Nature of science:</b>	
Risks and benefits—it is important to try and balance the risk of exposure to radiation with the benefit of the technique being considered. (4.8)	
<p><b>Understandings:</b></p> <ul style="list-style-type: none"> <li>Alpha, beta, gamma, proton, neutron and positron emissions are all used for medical treatment.</li> <li>Magnetic resonance imaging (MRI) is an application of NMR technology.</li> <li>Radiotherapy can be internal and/or external.</li> <li>Targeted Alpha Therapy (TAT) and Boron Neutron Capture Therapy (BNCT) are two methods which are used in cancer treatment.</li> </ul> <p><b>Applications and skills:</b></p> <ul style="list-style-type: none"> <li>Discussion of common side effects from radiotherapy.</li> <li>Explanation of why technetium-99m is the most common radioisotope used in nuclear medicine based on its half-life, emission type and chemistry.</li> <li>Explanation of why lutetium-177 and yttrium-90 are common isotopes used for radiotherapy based on the type of radiation emitted.</li> <li>Balancing nuclear equations involving alpha and beta particles.</li> <li>Calculation of the percentage and amount of radioactive material decayed and remaining after a certain period of time using the nuclear half-life equation.</li> <li>Explanation of TAT and how it might be used to treat diseases that have spread throughout the body.</li> </ul> <p><b>Guidance:</b></p> <ul style="list-style-type: none"> <li>Common side effects discussed should include hair loss, nausea, fatigue and sterility. Discussion should include the damage to DNA and growing or regenerating tissue.</li> <li>Isotopes used in nuclear medicine including; Tc-99m, Lu-177, Y-90, I-131 and Pb-212.</li> </ul>	<p><b>International-mindedness:</b></p> <ul style="list-style-type: none"> <li>The use of nuclear technology in medical treatments is not consistent across the globe. Culture, cost, availability and beliefs are some factors that can influence its use.</li> </ul> <p><b>Theory of knowledge:</b></p> <ul style="list-style-type: none"> <li>There is often no reference to the term “nuclear” in MRI. Are names simply labels or do they influence our other ways of knowing? How does public perception influence scientific progress and implementation?</li> </ul> <p><b>Utilization:</b></p> <p>Syllabus and cross-curricular links:            Topics 11.3 and 21.1—NMR            Options C.3 and C.7—nuclear reactions and half-life            Physics option C.4—medical imaging.</p>

**Essential idea:** A variety of analytical techniques is used for detection, identification, isolation and analysis of medicines and drugs.

D.9 Drug detection and analysis	
<b>Nature of science:</b>	
Advances in instrumentation—advances in technology (IR, MS and NMR) have assisted in drug detection, isolation and purification. (3.7)	
<p><b>Understandings:</b></p> <ul style="list-style-type: none"> <li>Organic structures can be analysed and identified through the use of infrared spectroscopy, mass spectroscopy and proton NMR.</li> <li>The presence of alcohol in a sample of breath can be detected through the use of either a redox reaction or a fuel cell type of breathalyser.</li> </ul> <p><b>Applications and skills:</b></p> <ul style="list-style-type: none"> <li>Interpretation of a variety of analytical spectra to determine an organic structure including infrared spectroscopy, mass spectroscopy and proton NMR.</li> <li>Description of the process of extraction and purification of an organic product. Consider the use of fractional distillation, Raoult's law, the properties on which extractions are based and explaining the relationship between organic structure and solubility.</li> <li>Description of the process of steroid detection in sport utilizing chromatography and mass spectroscopy.</li> <li>Explanation of how alcohol can be detected with the use of a breathalyser.</li> </ul> <p><b>Guidance:</b></p> <ul style="list-style-type: none"> <li>Students should be able to identify common organic functional groups in a given compound by recognition of common drug structures and from IR (section 26 of the data booklet), <math>^1\text{H}</math> NMR (section 27 of the data booklet) and mass spectral fragment (section 28 of the data booklet) data.</li> <li>A common steroid structure is provided in section 34 in the data booklet.</li> </ul>	<p><b>International-mindedness:</b></p> <ul style="list-style-type: none"> <li>The misuse of drugs in sport is an international problem.</li> </ul> <p><b>Theory of knowledge:</b></p> <ul style="list-style-type: none"> <li>Developments in technology have increased the chances of people being caught using illegal substances. How do changes in technology influence our ethical choices?</li> </ul> <p><b>Utilization:</b></p> <p>Syllabus and cross-curricular links: Topic 10.2—functional groups</p> <p><b>Aims:</b></p> <ul style="list-style-type: none"> <li><b>Aim 4:</b> A variety of spectroscopy techniques can be used to identify newly developed molecules.</li> <li><b>Aim 7:</b> Computer databases with spectroscopy data could be used to confirm the identity of newly synthesized molecules.</li> <li><b>Aim 8:</b> Developments in technology have increased the chances of people being caught using illegal substances. How do changes in technology influence our ethical choices?</li> </ul>