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What is Smarter UK?

**Smarter UK Summary**

Smarter UK* is an interactive discussion event for schools, kicked off by a dramatic scenario and delivered by professional science presenters. The discussion explores the social and ethical issues arising from advances in neuropharmacology; encouraging 13-16 year olds to explore their own values about the real possibility of ‘Smarter’ pills becoming commercially available. Pupils will also get the opportunity to meet with a real neuroscientist and question them about contemporary neuroscience research.

1. **The drama:**
   The session begins with a short dramatic scenario (performed by two science presenters/facilitators). The drama portrays two advertising executives, tasked with the job of advertising a new wonder drug – a pill that makes you smarter! The issues arising from the drama set the scene for the subsequent discussion.

2. **Memory game:**
   The class is quizzed on their memory of the play to illustrate how well (or how poorly) they remember. They are then introduced to the resident neuroscience researcher who will briefly explain how memory and cognition works.

3. **Vote with your Feet:**
   The discussion begins! Three areas of the room are designated ‘Yes’; ‘No’ and ‘Unsure’. The two science presenters/facilitators pose a series of questions designed to get pupils to consider the ethical and social implications of taking cognitive enhancement medication. In answer to each question, pupils move to the zone appropriate to their views (e.g. if asked ‘Would you take Smarter pills?’ those students who think they would, will move to ‘yes’). Once they have chosen ‘yes’, ‘no’ or ‘unsure’ the facilitators help the students to explore why they feel that way and to probe deeper into the implications of their decisions. Pupils are also given the opportunity to move if they change their minds as a result of the discussion. The neuroscientist will be on hand to answer technical questions and will also round off the ‘Vote with your Feet’ session with a question of their own – calling on the class to give their views on the neuroscientist’s own research.

4. **Ask the neuroscientist**
   The class will be invited to participate in a question and answer session about contemporary neuroscience research and how the brain works. The neuroscience researcher will answer the pupil’s questions, facilitated by the science presenters/facilitators who may also ask a few questions of their own! N.B. There are two versions of Smarter UK: one that is suitable for a single lesson and another that is suitable for double lessons.

The above activity will conclude the single lesson. However, double lessons will continue with a further activity:

5. **Advertising campaign**
   Pupils will work in groups to put together an advertising campaign for ‘Smarter drugs’ on behalf of a pharmaceutical company; or an anti-enhancement campaign on behalf of a group that are against ‘Smarter drugs’. In their groups they will discuss the benefits and downsides to cognitive enhancement and decide upon a slogan that sums up what they believe to be the number one reason someone should or shouldn’t take brain enhancing medication. Groups will work together to produce their choice of a presentation, poster, jingle or dramatic sketch. The professional science presenters will circulate to assist groups with their discussions. The neuroscience researcher will also be available for consultation, so that groups can check the viability of their ideas. The session will conclude with each group presenting their campaigns to the rest of the class.

*Smarter UK is the brainchild of Graphic Science Ltd and has been developed with funding from the Wellcome Trust. It is delivered by a network of professional science presenters from Glasgow Science Centre; science made simple; Explorer Dome; The Naked Scientists and Science Oxford. It is also delivered in conjunction with the City Neuroscience network, across five UK regions: Bristol, Cambridge, Cardiff, Oxford and Edinburgh.*
Introduction

About the Smarter UK resources for schools

This resource pack was developed by Graphic Science Ltd, with support from the Wellcome Trust. The resources include information about neuroscience and pharmacological cognitive enhancement, along with activities and worksheets to run in class.

Who are the Smarter UK resources for?

You can run these activities with any class but they have been designed with KS3-KS4 and Scottish S3-S4 students in mind. They are primarily focused on supporting the teaching of science but they might have some use in other subject areas such as Citizenship, Drama, English and PSHE. There are curriculum links provided for each activity.

How did you get these resources?

“The Smarter drama and discussion activities were run in my school and I would now like to follow up on the sessions with those classes that were involved.”

There are various activities available for you to run in subsequent lessons. If you received the single lesson form of the session, ‘Advertising Campaign’ might be a natural place to start during the next lesson, as it can be used as a direct follow up to the discussion. There are also a number of quick extension activities which you can use if you have an extra 10 minutes to fill at the end of a lesson. If you want your students to learn more about the science behind Smarter UK, download the PowerPoint files from the Smarter UK webpages: www.graphicscience.co.uk/SmarterUK

“The Smarter drama and discussion activities were run with some classes in my school but I would now like to run similar activities with other classes.”

“I have never seen the Smarter drama and discussion session but would like to use these activities with classes in my school.”

Before you run some of the available activities with other classes, such as ‘Advertising Campaign’, it might be an idea to run a discussion session, such as the ‘Vote with your Feet’ activity with the class – to get the students thinking about the issues arising from cognitive enhancement. This pack includes instructions on how to run the ‘Vote with your Feet’ activity, along with tips on facilitating debate in the classroom. However, there are also a number of activities and extension activities available that can be run without debating these issues in class. If you want your students to learn more about the science behind Smarter UK, download the PowerPoint files from the Smarter UK webpages: www.graphicscience.co.uk/SmarterUK
Background

This section provides you with essential background information about neuroscience and pharmacological cognitive enhancement. We have also provided some background to the science involved in five separate curriculum-linked PowerPoint presentations, which you can run in class.

These are:

**Presentation 1 – How your brain and nervous system work**

*Looking at the structure of the brain and how the nervous system work; including the make-up of a neuron and what happens at a synapse, along with information about how our brains adapt and change as we grow.*

**Presentation 2 – How we know how the brain works**

*Looking at scientific study; including historical case studies and the contemporary use of technology, (such as Magnetic Resonance Imaging).*

**Presentation 3 – Drugs and the human body**

*Looking at the different effects of drugs, from stimulants through to depressants, and how they act upon the central nervous system.*

**Presentation 4 – How memory works**

*Looking at how memory works, from sensory input, to sensory memory, working memory, and long term memory, through to forgetting.*

**Presentation 5 – How neurotoxins work**

*Looking at a range of different neurotoxins, from Cobratoxin to Curare, and their impacts on the nervous system.*

These presentations can be downloaded free of charge from: [www.graphicscience.co.uk/SmarterUK](http://www.graphicscience.co.uk/SmarterUK)
What is cognitive enhancement?

There are plenty of everyday ways to enhance your cognitive abilities – education, sleep, exercise and caffeine all help to improve learning and problem solving and moderate behaviour.

Now, drugs that improve cognitive abilities are becoming increasingly available. These drugs were developed for the treatment of conditions including dementia, narcolepsy and ADHD but a number of them seem to improve cognitive function in healthy individuals, some with negligible side effects.

The potential of these drugs therefore provokes a myriad of ethical and moral questions for the public and regulators alike. For example: is it acceptable for healthy people to use them? What are the implications of this for society? And if their use is prohibited, how do you enforce this?

Background to neuropharmacology

The brain is a phenomenally complex organ containing hundreds of millions of neurones linked through a network of hundreds of billions of connections. Techniques such as functional Magnetic Resonance Imaging (fMRI) are gradually helping to unravel some of this complexity, but even with this growing body of knowledge, the workings of the brain remain to a great extent uncharacterised.

At the cellular level, all brain activity from sensations of pleasure to formation of memory is regulated and modulated at the synapse. Use or neglect of specific pathways and groups of neurones leads to biochemical changes that either increase or decrease the sensitivity of those pathways to stimulation. This phenomenon, known as synaptic plasticity, is the basis of memory.

Transmission of signals across the synapse is mediated by neurotransmitters which can act to excite, inhibit or modulate the propagation of the signal. Each neurotransmitter has a variety of receptor types, and although the neurotransmitters themselves tend to be classified as excitatory, inhibitory or modulatory, their action is more closely defined by the nature their receptors. Different receptor types dominate in different groups of neurones and the localised effects of psychoactive drugs are only possible because of the different specificities of all these receptor types.

Psychoactive drugs act on the nervous system to modulate the process of signal transmission. Almost all known psychoactive drugs produce their effect through their action at the synapse. The only major exceptions to this are local anaesthetics which act by disrupting transmission along the axon.

At the synapse, drugs can act at any stage in the process of neurotransmission and release from synthesis of the neurotransmitter through to its break-down and re-uptake.

Cognitive enhancement

Pathways that rely on the neurotransmitter acetylcholine are important in learning and working memory and for this reason are being targeted in the treatment of Alzheimer’s disease. A number of drugs that prevent breakdown of acetylcholine by blocking the enzyme acetylcholine-esterase are now used in treatment. These drugs address the symptoms of memory loss; they do not address the underlying causes of the disease. Some of them also have potential as cognitive enhancers in healthy
individuals. Trials of the acetylcholine-esterase inhibitor donepezil on pilots in flight simulators found that the drug helped pilots to remember complex flight tasks but there is little sign so far that these drugs are being used as enhancers by people without cognitive impairment.

The drugs most commonly used off-licence as cognitive enhancers by healthy people are Ritalin, licenced for the treatment of ADHD and modafinil which is licenced for the treatment of narcolepsy.

Modafinil has received particular interest because it seems to produce general enhancement of executive function by improving concentration, creativity and problem-solving, most notably in people who are sleep deprived. The drug is thought to be widely used by the military and is increasingly being taken by some of the country’s highest achieving undergraduate students as an aid to study. Its precise mode of action is unclear.

Surveys of the readership of Nature (2008) and New Scientist (2011) magazines have reported significant usage of cognitive enhancers (20% and 38% of respondents respectively said they had tried them at least once).

Memory and executive function

Executive function is a term used to describe combined mental faculties that include working memory and recall, attention and concentration, control of emotion and impulsivity, planning and monitoring of actions, complex problem solving, and verbal reasoning. Executive function is located in the prefrontal cortex and neuroimaging and lesion studies show that specific areas of the prefrontal cortex are linked with different aspects of function.

The prefrontal cortex is one of the latest brain areas to reach maturity and its development continues into early adulthood.

Executive function develops over childhood from the beginnings of working memory in infancy to understanding abstract ideas and anticipating long-term consequences of actions in adolescence. This correlates with changes in the prefrontal cortex and a lessening of the amount of grey matter that are evidence of a reduction of synapse numbers known as synaptic pruning. Synaptic pruning during adolescence is a delicate and essential part of brain maturation, and whether it is affected by psychoactive drug use is not known.

As our understanding of the brain improves, more psychological and psychiatric conditions are being linked with deficits in certain aspects of executive function. In Alzheimer’s disease the dementia often progresses from memory loss to more generalised problems with executive function; people with ADHD have poor executive function; schizophrenia, bipolar disorder, obsessive compulsive disorder and depression all have associated declines in executive function. People with executive function disorders often learn and remember well, but have difficulty using the information effectively.

See the appendix for further information about the drugs currently used for cognitive enhancement, a list of common neurotransmitters, common ways to improve cognitive function and the regulation and governance of medicines and healthcare products.
Facilitating discussions can be daunting and, unless the process is carefully managed, it can sometimes descend into chaos. But, done well, debate can be a highly effective way of engaging students with a wealth of topics.

Here are some hints to help you:

1. Remember that your students may be practised in debating ethical and social issues in the classroom, through other lessons. Take advice from colleagues in other departments, such as English, Drama, PSHE, Citizenship and Humanities.

2. Before the lesson begins, think about some of the issues that might arise during the discussions, but be prepared to be confronted with ideas you have not considered. You might wish to prepare some background information e.g. data, newspaper articles or potential scenarios to help drive the discussion.

3. Set the ground rules before you begin: students should listen and show tolerance and respect for other people’s opinions.

4. Clearly explain the process and the purpose of the session before you begin.

5. Explain to the students that, unlike the debates that take place in a debating society, there are no winners when discussing issues in class. The purpose of the discussion is to explore
their own values, opinions and understanding of a topic, and to highlight the consequences of making certain decisions.

6. Remember that your role as teacher is to facilitate the discussion. Try not to direct it. Let the students lead you – but be ready to step in with probing questions in order to bring the discussion back on point.

7. Be wary of presenting your own opinions. As the teacher, you need to retain an element of objectivity so that students feel confident to express their views.

8. Be aware that some students may have personal experiences or background knowledge (such as family history of a disease) that makes them more sensitive to certain issues.

9. Don’t allow students to personalise their comments. Criticisms should be aimed at arguments, not people.

10. Don’t allow the loudest voices to dominate the discussion. Allow space for everyone to express their views. (But don’t force it – some may feel too intimidated to speak but can still benefit from listening to, and considering, the issues).

11. Encourage participants to examine their own opinions, by looking at opposing views and exploring their own reasons for drawing their conclusions.

12. Ask questions to draw out deeper discussions e.g.

   - Why do you think that?
   - What is the reason for that?
   - How do you know?
   - Can you think of an argument against your view?
   - Is there another argument to support that?
   - What affect would that have on other people?
   - If [introduce a scenario] were to happen, how would that make you feel?
   - What would be the consequences of that?
activities
Running the ‘Vote with your Feet’ discussion activity

Activity objectives:

Vote with your Feet is an interactive discussion format where students get to indicate and articulate their views on a selected topic by moving between physical opinion posts placed around a classroom.

The Vote with your Feet activity encourages the students to enter into discussion about the issues and implications of the chosen topic.

The ‘Yes’, ‘No’ and ‘Not Sure’ posters should be placed in different areas of the room. The facilitator will pose a series of questions to which the students respond by moving to the relevant area of the room e.g. if they agree, they should move to ‘Yes’. Once they are at their stations, the facilitator will challenge them by asking more questions to probe the reasons they made that particular decision. If they are so inclined, the students may choose to move to another area of the room as the discussion progresses.

After each discussion, students will be asked to return to a starting point before being posed with the next choice.

If you would like to run Vote with your Feet using the topics from Smarter UK, please see the questions below. However, Vote with your Feet can be applied to a variety of topics.

How long will the activity take?

20 minutes

What you need:

- Prepared questions from Smarter UK (or your choice of discussion topic)
- A classroom with enough space for students to move around
- A3 posters stating ‘Yes’, ‘No’ and ‘Not Sure’

Key Curriculum Links

KS3 Science

Unit 1.2 – Implications and applications of science

Unit 4 – Curriculum opportunities

4a – research, experiment, discuss and develop arguments

KS4 Science

Unit 4 – Implications and applications of science

Scotland

SCN 4-20a – I have researched new developments in science and can explain how their current or future applications might impact on modern life.
What to do:

1. Provide the students with stimulus material for the discussion (Smarter UK uses a short drama performance to do this. Other options might be written material, a presentation or a drama presented by students or teachers)

2. Refresh the students on the issues connected with the discussion topic

3. Prepare the room by placing the ‘Yes’, ‘No’ and ‘Not Sure’ posters at different points of the room.

4. Brief the students on what they need to do

5. Get the students to stand up and move to a designated ‘starting point’.

6. Pose the first choice/question from your list and ask the students to move to the poster they agree with.

7. When they are at their chosen stations, ask students in each group why they made that decision.

8. In order to instigate further discussion, pose further questions to get them thinking about their decisions and the implications associated with them. (You may find it helpful to prepare some additional questions that un-pick some of the issues in the main question).
9. If any of the students have changed their mind, encourage them to move if they wish.

10. When you feel that the issue has been properly discussed get the students to return to the starting position before moving onto the next question.

11. Pose the next choice and get the students to move around again. Repeat the process for each question.

The five main questions for Smarter UK are:

1. If there were pills that could make you smarter, would you take them?
2. If there were pills that could make people smarter, should everyone be taking them?
3. Should school age students be allowed to take these pills?
4. Is taking medication to enhance your brain power any different from drinking coffee or red bull, taking vitamins or going for a run?
Discussion points for ‘Vote with your Feet’

These discussion points can be used by teachers to instigate discussion about issues surrounding cognitive enhancement, to support ‘Vote with your Feet’.

If there were pills that could make you smarter, would you take them?

- Would you take smarter pills before an exam?
- Is it cheating? Who is achieving, you or the drug?
- If some people took smarter pills just before an exam (i.e. all the yes’s) and others did not (i.e. all the no’s) is it fair?
- How would you feel if all your friends were taking Smarter pills and you weren’t?
- How would you feel if you had to take a drug test before sitting an exam?
- Will it level the playing field? Or if everyone takes smarter pills, will everyone just get smarter still, retaining the divide?
- Would you take them every day or just on specific occasions?

If there were pills that could make people smarter, should everyone be taking them?

- Would the world be a better place if everyone was a bit cleverer?
- What impact could Smarter pills have on the world, in terms of inventions and greater efficiency?
- Should people who need to stay alert for their jobs (such as soldiers and airline pilots) be given them?
- When considering this, does it matter how clever people are in the first place?
- What would happen if the pills weren’t available anymore?
- Should they be given to old people to help them keep up with younger people?
- Would it be ok to pressurise everyone to take these pills? What about if everyone had to take them?

Should school age students be allowed to take these pills?

- Would you give smarter pills to your children?
- How would you feel if you found out your parents were giving them to you?
- If it is good for us all, should it be put in the water for everyone (like fluoride)?
- Is it unfair? If smarter pills cost £100 for a bottle, would children with more wealthy parents have unfair advantages?
- But advantages already exist for those who can afford them. Are smarter pills any different to private tuition, summer schools, extra resources and educational trips paid for by parents?
- What about the fact that young people’s brains are still developing?
- When would you stop? Would you take Smarter pills for GCSEs? A-levels? Your degree?
• What if you got a job based on your grades and needed to continue taking them to be able to do your job? Would you take them forever?
• If smarter pills are available in schools, should schools subsidise them for poorer families?

Is taking medication to enhance your brain power any different from drinking coffee or red bull, taking vitamins or going for a run?

• How many of you drink red bull? Or coffee? Caffeine has an impact on the chemical balance of your brain, so is it any different to taking brain enhancement medication?
• Are smarter pills like taking vitamins?
• What about the unknown side effects? Even Red Bull has side effects such as headaches, heart palpitations and inability to sleep.
• There has not been time to research the long term effects of taking brain enhancement medication. Would you risk it?
• A good night's sleep helps us to re-boost the chemicals in our body, thus improving our thinking power. Is taking medication any different?
• What about tablets like Pro Plus? Or antidepressants? Are they any different?
• Might people become addicted to Smarter pills?
• People drink coffee every day. Would you take smarter pills daily?
Advertising campaign

Activity objectives:

Pupils will work in groups to put together an advertising campaign for ‘Smarter drugs’ on behalf of a pharmaceutical company; or an anti-enhancement campaign on behalf of a group that are against ‘Smarter drugs’. In their groups they will discuss the benefits and downsides to cognitive enhancement and decide upon a campaign that sums up what they believe to be the number one reason someone should or shouldn’t take brain enhancing medication. Groups will work together to produce their choice of a presentation, poster, jingle or dramatic sketch. The lesson will enable students to explore the social, ethical and moral implications of cognitive enhancement.

How long will the activity take?

Flexible: 30 mins – 1 hour

This activity would take approximately 30 minutes if run once but it could take a full 1 hour lesson, if you instruct the students to create both for and against campaigns.

What you need:

- A3 sheets or flipcharts (enough for 6-8 groups)
- Markers/flipchart pens (enough for each group)
- Instruction cards (enough for each group)
- Access to computers (if you want them to have the option of creating PowerPoint presentations).

What to do:

1. If you have not yet discussed the issues associated with cognitive enhancement with your class, you might wish to run the ‘Vote with your Feet’ session (page 10) or choose another method to start with a discussion about cognitive enhancement in order to introduce the students to some of the issues arising. If the Smarter UK session has already been run in your school, you could begin by having a brief recap over the discussions that took place.
2. Split the students into groups of 3-4 people.
3. Ask some of the groups to imagine that they are advertising executives. Ask them to discuss the benefits of brain enhancement and decide the most important benefit/message to encourage people to take brain enhancing drugs. They should then
come up with an advertising campaign, including a slogan which sums up the number one reason people should take cognitive enhancers.

4. Ask other groups to imagine that they are members of an anti-brain enhancement group who are starting a campaign to ban brain enhancement medication and to discourage people from buying such products. Groups should discuss the negative implications of taking cognitive enhancing drugs and come up with a campaign, including a slogan summing up the number one reason that people should avoid them.

5. Circulate to help groups with their discussions.

6. Give the students some time to talk about the issues before encouraging them to start preparing a presentation. This could be in the form of a poster, a PowerPoint presentation, a jingle, or a dramatic scenario.

7. If there is time, ask them to begin the process again. This time, those that came up with a ‘for’ campaign, should create an ‘against’ campaign and vice versa.

8. Instruct each group to present their campaigns to the rest of the class.

Advertising campaign: instruction cards

You may wish to photocopy, cut out and distribute the below instruction card, to remind each group what they are supposed to do.

---

Advertising Campaign

Imagine you are advertising executives from Hill Walden Hill. A drugs company has asked you to come up with a catchy advertising slogan to advertise their new product: A pill that enhances your brain power.

In groups, discuss the benefits to brain enhancement and come up with an advertising slogan which sums up what you think is the number one reason that people should take them.

Anti-brain enhancement campaign

Imagine that you are part of an anti-brain enhancement group who are starting a campaign to ban brain enhancement and discourage people from buying such products.

In groups, discuss the downsides to brain enhancement and come up with a campaign which sums up what you think is the number one reason to avoid brain enhancement medication.
Smarter consequences

Activity objectives:
The activity is designed to encourage students to explore the issues arising from the use of cognitive enhancement medication and to think about the consequences of their decisions. The activity is based on the parlour game ‘consequences’, whereby students work in pairs to create a conversation between two characters, based on a prompt scenario. Unlike the parlour game, which traditionally has an element of surprise, students will be able to see the comments made by other characters, in order to encourage more considered responses.

How long will the activity take?
Flexible. (Approx. 20-30 mins, depending on the number of scenarios each pair is given).

If the class has not yet been introduced to the issues arising from cognitive enhancement, you should allow an additional 20 minutes at the beginning of this session to discuss the issues or run the ‘Vote with Your Feet’ activity (page 10).

What you need:

- Smarter Consequences Sheets (enough for each pair)
- Scenarios (enough for three per pair)

What to do:

1. If the class has not yet explored the issues arising from the Smarter UK drama, you may wish to begin by running the ‘Vote with your Feet’ activity, or leading the class in a discussion about cognitive enhancement and associated social and ethical issues. (See the ‘Vote with your Feet’ resources for a list of discussion points).
2. Print and cut out the scenarios and photocopy the consequences sheets.
3. Split the class into pairs and provide each pair with a scenario and a consequences sheet.
4. Instruct the class to read their scenario in pairs.
5. Tell each pair to decide which student should take the role of Character 1 and which should take the role of Character 2.
6. Instruct them to take a Smarter Consequences sheet and to take it in turns to fill in the blanks, relating to their scenario. (Each student will give their character a name, and then take it in turns to write down the conversation that might take place. They should then finish
by writing down what they think the consequence of this conversation would be e.g. What is their decision? And what would happen as a result?) (Allow approx. 10 mins).

7. If you have time, give the pairs additional scenarios and consequences sheets to repeat the process.
8. When they have finished writing their scenarios, instruct pairs to join together to create groups of 4 or 6. Encourage them to share their scenarios and to discuss the issues in their groups. They should then decide on the best story to share with the rest of the class.
9. After 10 minutes, encourage each group to nominate two people to read their favourite consequence to the rest of the class. Lead the class in a discussion of the consequences arising from the scenario.

Alternatively, you might wish to run the session as a role play activity. Use the scenarios as prompts and encourage students to use the model illustrated on the Smarter Consequences sheet, to create a short sketch of a conversation between two people and then act out the consequence. These consequences can then be performed back to class.
# Smarter consequences sheet

**Character 1 is called:**

**Character 2 is called:**

<table>
<thead>
<tr>
<th>Says:</th>
<th>Says:</th>
<th>Says:</th>
<th>Says:</th>
</tr>
</thead>
</table>

**The consequence is:**

**And:**
### Smarter consequences scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Two parents are discussing whether to put their child on pills that make you smarter.</strong> Character 1 has heard that the neighbour’s child is taking them and is concerned that their child will fall behind. Character 2 is worried about the consequences of putting their child on medication.</td>
<td><strong>Two mothers are waiting at the school gates for their children to come out of school.</strong> Character 1 says that her daughter is taking those ‘new pills that you make you smarter’ and has seen an improvement in her concentration already. She asks Character 2 if she will give them to her child.</td>
</tr>
<tr>
<td><strong>Character 1 is 14. She is the only one in her group of friends that is not taking smarter medication.</strong> She tries to persuade her parent (character 2) to let her take them too.</td>
<td><strong>A journalist (character 1) is interviewing the Health Minister (character 2) about her latest proposal to make it compulsory for everyone in the country to take pills that make you smarter.</strong></td>
</tr>
<tr>
<td><strong>A head teacher and deputy head teacher are discussing the fact that a neighbouring school has begun conducting drug tests (for brain enhancement medication) before exams. They are trying to decide whether to introduce drug tests to their own school.</strong></td>
<td><strong>Two University students are writing up important essays. They have both left it very late and are working through the night. Character 1 takes out a pill pot, containing smart pills and offers one to Character 2. Character 2 is not sure whether to take them.</strong></td>
</tr>
<tr>
<td><strong>Character 1 has been offered a new job. His new boss (character 2) tells him that all of the team take smart pills when they are working on a big project. Character 2 asks character 1 if he would be willing to take smart pills too. Character 1 does not want to take medication but is worried he might not be able to keep up with the rest of the team, (or might not get the job) if he says no.</strong></td>
<td><strong>Two school students are discussing smart pills, (pills that make you smarter) which have just been introduced to the market with a very expensive price tag. Character 1 comes from a wealthy family, and has always been given the best of everything. Character 2 knows her parents won’t be able to afford the pills and thinks this is unfair.</strong></td>
</tr>
<tr>
<td><strong>Two journalists at a press conference are discussing the breaking news that the celebrated scientist Professor Hans Wünderbar, who recently discovered the cure for cancer, has been taking smart pills. Character 1 thinks he should have his Nobel Prize revoked, but Character 2 thinks it was a good thing that he took them.</strong></td>
<td><strong>Two students go to pick up their exam results. Character 1 was surprised to find out that Character 2 got an A, while he only got a B, when he usually gets better grades than his friend. Character 2 tells him that he has been taking smart pills. Character 1 thinks that taking smart pills is cheating.</strong></td>
</tr>
</tbody>
</table>
Cognitive enhancement in the news

Activity objectives:

Through this activity, students will gain an appreciation of the ways in which cognitive enhancement has been represented in the UK media.

Working in small groups they will compare the content of two different newspaper articles about cognitive enhancement. They will perform a structured analysis of the two articles to look at the way information and opinions are presented.

This pack contains four newspaper articles and a worksheet for this activity.

How long will the activity take?

15-20 minutes

If the class has not yet been introduced to the issues arising from cognitive enhancement, you should allow an additional 20 minutes at the beginning of this session to discuss the issues. You could run the ‘Vote with your Feet’ activity (page 10) in order to do this.

What you need:

- Printouts of the three-page Cognitive enhancers in the news worksheet
- Printouts of the newspaper articles—enough for one article per pair.

What to do:

1. If the class has not yet explored the issues arising from the Smarter UK drama, you may wish to begin by running the ‘Vote with your Feet’ activity, or leading the class in a discussion about cognitive enhancement and associated social and ethical issues. (See the ‘Vote with your Feet’ resources (page 10), for a list of discussion points.
2. Split the class into pairs and provide each pair with a newspaper article and a worksheet.
3. With the class working in pairs, instruct each pair to read through their newspaper article and consider its content by working through the questions on the worksheet.
4. Once all the pairs have had enough time to consider the content of their article and work through the activity, ask each pair to join up with another pair that has been working on a different article.
5. Working in fours, ask the students to compare their articles using the questions on the worksheet for guidance and write a short summary of what they have found.
Cognitive enhancement in the news – worksheet

**Part 1:** Working in pairs or small groups, read through the newspaper article you have been given and consider the following:

1) What is the article about? Write a short summary of what it says (one or two sentences).

2) What issues does it raise? List them below:
3) Who is quoted in the article? What are they saying? Are they expressing facts or giving their point of view? Use the table below to make notes on this.

<table>
<thead>
<tr>
<th>Name and job</th>
<th>What they say</th>
<th>Fact(F) or opinion (O)</th>
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4) Does the journalist who wrote the article have a view? If so, what is it?


5) How well do you think it addresses the subject and the issues?
   What information have you used to form this view?


6) What is your reaction reading to this article?


Part 2: Now join with another group who have been looking at a different article.

1) Use your summary of the article; briefly explain what your article was about to the other group.

2) Compare the issues raised in each article.
   - Do they look at the same issues or different ones?
   - If they are quite similar, are there issues in one article that are not in the other?

3) Are there any points where the articles contradict each other?

4) Do you feel differently about cognitive enhancing drugs depending on what article you read?

5) Write a brief summary of what you have discussed, include the following points:
   - When each article was written and where it was published.
   - A brief summary of what each article was about.
   - Your comments on the similarities and differences between the two articles
   - Whether you thought the articles were balanced and accurate
   - Your reaction to the articles – how did they make you feel about drugs for cognitive enhancement?

Summary of discussion:
Academics say 'smart' drugs could be prescribed

Academics say school students should be able to take 'smart' drugs to help them revise

By Denis Campbell

Use of drugs such as Ritalin among young people is becoming so common that family doctors should be able to prescribe them as study aids to school pupils aged under 18.

That is the provocative but cogently argued view of Dr Ilina Singh, an academic at the London School of Economics. "Psychotropic neuroenhancement by young people under 18 is growing, and is certain to increase further with the availability of effective drugs and increasing tolerance for neuroenhancement practices," she writes in the American Journal of Bioethics-Neuroscience. This, and the difficult ethical issues raised by teenagers being given drugs to boost their learning, has prompted her and co-author Kelly J Kelleher to suggest what they call "a rationale for clinical management of psychotropic drug neuroenhancers for young people".

They explain: "If neuroenhancement in young people is to become a common social practice, which is likely ... if they meet the rigorous parameters that will ensure minimum risk and maximum benefit, all young people ought to have access to existing resources to improve themselves and their performance".

They suggest a situation whereby GPs would be able to prescribe these substances to schoolchildren wanting to boost their memory or capacity to stay awake – to revise, for example. Safeguards would have to include both the child and parents consenting to the taking of these "smart" drugs, and, crucially, proof that pushy parents had not cajoled their offspring into it.

Singh is the LSE's Wellcome Trust university lecturer in bioethics and society, and her LSE profile says she specialises in "the psychosocial and ethical implications of new biomedical technologies for children and families". Kelleher is a professor of paediatrics and psychiatry at the Nationwide Children's Hospital in Columbus, Ohio. Briefly, they argue that consumption of these drugs by both adults and young people in America, Europe and the UK is growing. Use of stimulants "will also increase, not least because the use of psychotropic neuroenhancing agents will likely become normal in future generations".

More controversially, they say that "from an ethical perspective" these drugs are little different from using caffeine, "brain exercise" regimes, tutors, vitamins and early learning programmes such as Baby Mozart.

"We believe the acceptance of drug delivery techniques will normalise, as more and more people choose to take these drugs. At that point, several advantages of drug-delivered neuroenhancement – ease of use, quick results and the perception of greater efficacy..."
than other interventions – will likely outweigh the intuition that it is wrong to psychotropically enhance young people's cognition and performance."

Singh insists she is not endorsing NHS prescription on demand in the UK, and says her views and research on this only apply to the US, although her paper appears to offer advice to any country where there is an emerging trend. The authors argue that as a safeguard, only stimulants that cannot easily be abused should be prescribed, and that pupils should be able to take them only for a short while. And the fact that young people are probably more vulnerable to side-effects than adults would have to be flagged up.

New memory-enhancing drugs developed to help Alzheimer's patients "have clear applications in the enhancement of young people's academic performance, and it is highly probable that they will eventually be used for this purpose", the authors predict.

http://www.guardian.co.uk/education/2010/may/11/ritalin-drugs-young-people
Johann Hari: They were great at first – but then the creativity dries up

Last year, I had my own brief experiment with smart drugs. I felt burned out after a series of long foreign assignments, and my brain was rustily chug-chugging along at half-speed. That's when I first read about a drug being billed as "Viagra for the brain" – not Ritalin, but Provigil, a brand name for modafinil.

It was originally designed for narcoleptics, but clinical trials stumbled across something odd: if you give it to non-narcoleptics, they become smarter. Their memory and concentration improves considerably, and so does their IQ. There were no known side-effects, except – oh, thank you! – weight loss.

I hunted it down online. A week later, the little white pills arrived in the post. Within a few hours of a 200mg dose, I found myself gliding into a state of long, deep concentration, able to read a book for six or seven hours at a time without looking up. My mood wasn’t any different; I wasn’t high. It was like I had opened a window in my brain and all the stuffy air had seeped out, to be replaced by a calm breeze. On Provigil, I had the most productive month of my life, writing reams of articles. I didn't notice any side-effects – until the third week.

At any given time, only a small amount of your brainpower is dedicated to the tasks immediately in front of you. The rest is working on other stuff – processing memories, your subconscious, your creative thoughts. But Provigil points all your mental guns forward. It deploys far more of your brainpower on to your direct task.

It's great at first – but it has a cost. After a while, you realise that your mental life is oddly depleted. Creative thoughts don't come to you any more. You are running on the imaginative store you built up before Provigil, and whizzing through it efficiently, but you aren't inventing anything new. That part of your brain is undernourished. You feel fast and flat.

When I stopped taking them, my brain went back to its slower, scrappier state – but my creative impulses came back. I was more spontaneous again. So I have cut a deal with myself. I keep a pack in the bathroom cabinet for the days when I am really knackered and have to be able to work fast and fluently – but I don’t ever take more than one or two a month.

But if I ever had to do exams again, I would take Provigil. And here's the ethical dilemma. Is this the equivalent of athletes taking steroids? Does it create an unfair pressure for other people to take these drugs – which are still pretty expensive – to keep up with other students and co-workers? Or would we be unfairly holding the human race back by refusing to smarten up?

We can't escape these dilemmas now. Smart drugs are only going to become more subtle and powerful as money flows in. As Professor Anjan Chatterjee says: "This age of cosmetic neurology is coming, and we need to know it's coming."

My little pack of Provigil is a challenge to us all.

http://www.independent.co.uk/opinion/commentators/johann-hari/johann-hari-they-were-great-at-first--dash-but-then-the-creativity-dries-up-1708987.html
Can a pill make you smarter?

PAT HAGAN

FORGET morning caffeine boosts. In future, we could all be popping brain-boosting ‘smart’ pills to give us the edge in school and at work.

In fact, thousands of people are already using powerful prescription medicines to sharpen their minds.

But experts are warning too little is known about the long-term effects of the new generation of smart pills.

Oxford University students swotting through the night for exams confess to downing Ritalin, the drug used to treat hyperactivity in kids.

They say it boosts concentration and attention span.

Some education experts say they know parents who buy the drug on the internet and feed it to their kids to try to beef up exam results.

Meanwhile, pilots, soldiers and shift workers are turning to a pill called modafinil (Provigil) to stay awake.

The drug was originally developed to treat narcolepsy, a condition where people suddenly fall asleep dozens of times a day.

Tests show that, as well as keeping the brain awake for up to 40 hours at a time, it can actually BOOST short-term memory and the ability to plan properly.

Even jet-lagged scientists attending conferences are reported to use the drug to pep up their presentations.

Psychiatrist Professor Philip Harvey takes modafinil to ward off jet lag. He says: ‘It makes me feel alert, like I had more sleep.’

The medic, from Emory University in Atlanta, Georgia, claims the drug doesn’t create a high like other stimulants but does focus the mind.

The Ministry of Defence is said to have given it to soldiers exhausted by battle. Other drugs that perk up brain cells include amphetamines and ampakines, a new class of medicines that bolster memory.

However, thousands of users are thought to be buying them on the internet without getting clearance from their GPs.

The British Medical Association believes a growing number of healthy people are using brain-boosting drugs that should only be taken on prescription, buying stimulants like Ritalin for as little as 67p a pill.

Apart from potential long-term side-effects, this raises the risk of dangerous interactions with other medicines.

A report last year by Government think-tank Foresight said brain boosters like modafinil could be “as common as coffee” within 20 years.
The Government has asked the Academy of Medical Sciences to investigate the use of so-called ‘intelligence drugs’.

Professor Barbara Sahakian, from Cambridge University, says if studies prove drugs like modafinil are safe, adults could one day buy them over the counter to help them cope with long hours.

That would be safer than buying them from unknown suppliers on the internet.

She says: “I know scientists who buy modafinil on the internet and take it a few hours before a presentation. But some then start to use it when they are busy. One even took it to stay up late for a party.

"It may be that one day you could go into Boots and buy these pills.

“As we get more effective drugs, people will definitely want to use them. But it may be that you have to be over 16 to get them because we have to be careful about the long-term effects on the developing brain.”

In the US, research at the University of Michigan shows just over eight per cent of undergraduates have used prescription stimulants. And the National Institute On Drug Abuse found one in twenty 17 and 18-year olds had used amphetamines.

But how exactly do ‘smart pills’ increase brain power and what are the risks in taking them?

Give Ritalin to healthy people to boost their brain power, says medical expert

By JENNY HOPE

Healthy people should be allowed to take Ritalin to boost their brain power, a medical expert has argued.

Professor John Harris said it was unethical to stop the controversial drug being used for this purpose - as students have been known to at exam time.

He said that Ritalin, which is prescribed for hyperactivity in the young, is safe and offers 'significant advantages' to the healthy.

Professor John Harris believes healthy people should be allowed to take Ritalin to enhance mental performance.

It is known to boost academic performance, focus and concentration.

Professor Harris, bioethics professor at the University of Manchester, writes in an article today on bmj.com that 'it is not rational to be against human enhancement'.

He said: 'Humans are creatures that result from an enhancement process called evolution and moreover are inveterate self-improvers in every conceivable way.

'Many healthy students are thought to use Ritalin and other chemical cognitive enhancers to improve academic performance. The arguments against their being permitted to do so have not been persuasive.'

The drug is routinely used on the Health Service to treat attention deficit hyperactivity disorder. Around 400,000 British children aged five to 19 years with ADHD are believed to be on drugs including Ritalin.

Professor Harris said it had been deemed 'safe enough' to give to young people.

His comments were part of a debate in the journal. He was opposed by Professor Anjan Chatterjee from the University of Pennsylvania, who argued there are too many risks in taking Ritalin unless people are actually ill.

He said the U.S. Food and Drug Administration labelled it with the most alarming of warnings because of its high potential for abuse, dependence, risk of sudden death and serious adverse effects on the heart.

If it became widely available, he questioned whether pupils would take Ritalin in 'epidemic proportions'.

There was the danger that pilots, police officers and on-call doctors would be pressured into taking the drug to perform better in their jobs.

He also mentioned possible cognitive trade-offs involved in taking Ritalin, such as a loss in creativity.

He said: 'Being smarter does not mean wiser. The fact that very smart people generating complicated models to distribute financial risk contributed to the current global economic crisis should at least give us pause.'
Synapse flicker book

Activity objectives:
This flicker book contains a sequence showing the release of neurotransmitters at the synapse. By constructing the flicker book, students will learn this sequence in an interactive form that they can keep for revision.

There are two versions of the activity, a full colour version, where the students simply need to cut out each image and staple them together and a version they need to colour-in themselves before assembly.

How long will the activity take?
Flexible: 10-30mins (depending on whether you choose the colour-in version)

If using the colour-in version of this, and time is limited, you might like to suggest that students do not colour in the actual synapses in each picture.

What you need:
- A4 print-outs of the 2 page synapse flicker book, either colour (page 31) or colour-in (page 33) versions. (Enough for one per student)
- Scissors
- Large stapler capable of joining 30 pages
- Colouring pens/pencils if using the version to colour in themselves

What to do:
Give each student the two-page hand-out containing the images. Instruct them to:

1. For the colour-in version, colour the images using the same colour for each component in each image.
2. Cut along the lines to create a set of 28 rectangular sheets (23 containing a picture and 5 blanks). This needs to be done as neatly as possible to make sure the images line up when the book is constructed. The bottom edge in particular needs to be cut carefully to get the best results from the book.
3. Stack the images in sequence with image 1 at the bottom. Add some blank pages beneath image 1 (this will help the images to run more smoothly).
4. Carefully line all the sheets up paying particular attention to the bottom of the book, and staple the sheets together at the top.
5. Hold the book in one hand and use the other hand to flick through the pages from the back of the book to the front. You should see how neurotransmitters are released at the synapse
Flicker book instructions

1) Cut along the thick black lines to make a sequence of individual pictures.

3) Stack up the pictures neatly in order with picture number 1 at the BACK. Include some blank pages at the back of the stack and make sure the bottoms of all the pieces of paper are lined up very neatly.

4) Staple the pictures together in the centre at the top.

5) Your flicker book is ready. To play the sequence back, hold the stapled end of the book firmly in one hand. Hold the block of pages in the other hand and flick them down one page at a time.
Flicker book instructions

1) Colour in the pictures - you need to use the same colours for each picture. If you are short of time, don't colour in the synapse itself.

2) Cut along the thick black lines to make a sequence of individual pictures.

3) Stack up the pictures neatly in order with picture number 1 at the BACK. Include some blank pages at the back of the stack and make sure the bottoms of all the pieces of paper are lined up very neatly.

4) Staple the pictures together in the centre at the top.

5) Your flicker book is ready. To play the sequence back, hold the stapled end of the book firmly in one hand. Hold the block of pages in the other hand and flick them down one page at a time.
Make and label your own neurone

Activity objectives:

Students can familiarise themselves with the structure of a motor neurone, using this cut out and assemble model.

How long will the activity take?

10mins

What you need:

- A4 print outs of the activity (page 37) – preferably in colour, enough for one per student
- Scissors
- Stick glue

What to do:

1. If you have not yet covered the nervous system in your teaching, you could introduce the class to the topic, using the PowerPoint presentation ‘How your brain and nervous system works’ which you can be download at www.graphicscience.co.uk/SmarterUK. If you have covered this topic in a previous session, you might wish to run this presentation as a revision activity.
2. Print and distribute the motor neurone worksheet on page 37.
3. Instruct students to cut out all of the parts of the neurone and assemble (Note – the myelin sheath should wrap around the axon, so that the flap can be left open to reveal the axon inside).
4. Instruct students to cut out and stick on the labels.

Key Curriculum Links

GCSE
OCR – B1d: The nervous system
OCR 21st Century Science – B6: Brain and mind
AQA – 11.1: How to human bodies respond to changes inside them and their environment
Edexcel – Topic 2: Responses to a changing environment
Scotland
SCE Standard Grade – Topic 5: The body in action
Cut out the parts to make and label your own neurone.

Motor neurone

- Nucleus
- Myelin sheath
- Axon
- Cytoplasm
- Nerve ending
- Dendrite

Direction of impulse:
quick extension activities
Memory activities

Activity objectives:

The following activities introduce the class to the limits of working memory, introducing them to different kinds of sensory memory and looking at memory binding. Using the worksheets and the ‘Memory Games’ PowerPoint file provided [www.graphicscience.co.uk/SmarterUK], your students will get the opportunity to test how good their memory is, understand its limits and see how different people have different strengths. The activities include:

- Remembering Patterns
- Auditory Memory v Visual Memory
- Memory Binding
- Improving your Working Memory

How long will the activity take?

Flexible: depends how many of the activities are run.

Remembering patterns

What you need:

- ‘Memory Games’ PowerPoint file (available from www.graphicscience.co.uk/SmarterUK)
- Remembering Patterns Worksheets (page 42)– enough for one per person
- Pencils

What to do:

1. Photocopy and distribute the Remembering Patterns worksheets to each student.
2. Instruct them not to shade the grids on their worksheets until they are told to do so.
3. Run through slides 3-8 in the ‘Memory games’ PowerPoint file, first introducing the class to the concept of working memory.
4. The slides will show a series of grids, with patterned squares. After each pattern fades, the slide will prompt the class to copy the pattern on the grids on their worksheets, using pencils. At this point, pause for approximately 30 seconds, to allow students to shade their grids, before progressing to the next slide.
5. The students should find the activity progressively harder as the patterns become more complex. When students have completed all five grids, go back through the slides to see how many students got right.

Key Curriculum Links

OCR 21st Century Science – Brain and Mind
B6.5 Mapping brain function: models for understanding memory.
Sensory memory

What you need:

- ‘Memory Games’ PowerPoint file (www.graphicscience.co.uk/SmarterUK)
- Pens and paper
- A hard copy printout of the words listed on Slide 13 of the ‘Memory Games’ file.

What to do:

1. Run through slides 9-13 in the ‘Memory games’ PowerPoint file, first introducing the class to the concept of sensory memory and how some people are stronger with their auditory memory and some are stronger with their visual memory.
2. The slides will show a series of grids, with patterned squares. After each pattern fades, the slide will prompt the class to copy the pattern on the grids on their worksheets, using pencils. At this point, pause for approximately 30 seconds, to allow students to shade their grids, before progressing to the next slide.
3. The students should find the activity progressively harder as the patterns become more complex. When students have completed all five grids, go back through the slides to see how many students got right.
4. Slide 10 will flick through a series of objects. Instruct students not to write them down, but to try to remember them.
5. At the end of slide 10, pause and allow students 30 seconds to write down as many objects as they can remember.
6. Move to slide 11 to check how many they got right.
7. Next, test their auditory memory by reading out a series of objects (as listed on slide 13). Tell students not to write them down until you have finished but to try to remember them.
8. Give students 30 seconds to write down as many as they can remember.
9. Move to slide 13 to check how many they got right.
10. Get students to work out whether their auditory or visual memory are stronger, by counting how many they got right in each memory test.

Memory Binding

What you need:

- ‘Memory Games’ PowerPoint file (www.graphicscience.co.uk/SmarterUK)
- Memory Binding Instruction Worksheets (page 43), enough for one per table
- Memory Binding Worksheets (page 44), enough for one per student
- Colouring pencils

What to do:

1. Run through slides 14-26 in the ‘Memory games’ PowerPoint file provided, first introducing the class to the concept of memory binding and how the more variables we have to remember, the more difficult it becomes.
2. The slides will show the students a series of coloured shapes, at different positions on the screen. After each shape is positioned, students will be instructed to draw the correct shape, in the correct position, using the correct colour. Tell students not to draw them until they are instructed to do so.

3. Allow 30 seconds for students to draw their shapes on their worksheets before moving on to the next slide.

4. As more shapes are introduced, the students should find it progressively harder to remember all of the variables.

5. When students have completed their worksheets, go back over the previous slides to see how many they got right.

Improving your working memory

What you need:

- ‘Memory Games’ PowerPoint file (www.graphicscience.co.uk/SmarterUK)
- Pens and paper

What to do:

1. Run through slides 28-31 in the ‘Memory games’ PowerPoint file, introducing the class to a variety of techniques which we can use to improve our short-term retention.

2. Using the objects listed on slides 11 or 13, encourage students to pick a mnemonic method, such as the journey method or the story method, and allow them 5-10 minutes to memorise the list of objects, using their mnemonics, before removing the list from the screen.

3. Next, tell students to write down as many of the objects as they can remember, using their mnemonic.

4. Return to the slide to see how many they were able to get right.

5. Get students to discuss their mnemonics in groups of 3-4, sharing how well they did and to describe the mnemonic they used.
MEMORY ACTIVITIES

Working memory – remembering patterns

- Your teacher will work through the PowerPoint session about working memory and remembering patterns.
- You will be shown a series of patterns, made up of shaded squares on a grid.
- Wait to be instructed, before shading the patterns you have seen on each of the grids below, using a pencil.
- You will find that as the pattern becomes more complicated, you reach the limits to your working memory and you will find it more difficult to remember.

Grid 1

Grid 2

Grid 3

Grid 4

Grid 5
MEMORY ACTIVITIES

Memory binding

You will need:

1. A pen/pencil
2. Colouring pens/pencils (one each of red, yellow and green)
3. A memory binding worksheet

What to do:

1. Your teacher will run through the memory binding game with the whole class.
2. You will be shown a series of 6 slides. They will show a coloured shape being placed in position. The shapes will be one of three shapes: a heart, a triangle or a lightning bolt. They will be coloured one of three colours red, yellow and green. There are four possible positions.
3. You will not see the shapes for long - your teacher will skip to the next slide quickly.
4. Do not write down the colours, shapes or positions or pick up the correct colour – try to depend on your memory alone.
5. When your teacher instructs you, draw the correct shape(s) and colour them the correct colour(s) in the correct position(s) on each of the six diagrams on your worksheet. Do not skip ahead – wait until you are instructed to do so.
6. After you have completed all six diagrams, your teacher will go through each of the slides again to see how many you got right.
Memory binding

1

2

3

4

5

6

WORKSHEET
Executive function tests

Activity objectives:

The following activities introduce the class to the executive functions of the brain, to help them understand how they think and perform; how impairments to the frontal lobe might impact upon performance abilities; and to imagine how their thought processes might be enhanced through taking cognitive enhancement medication. The activities include: reading an information sheet; a quick One Minute Executive Function Test; a Card Matching Game and the Stroop Effect Game.

How long will the activity take?

Flexible: 5 mins - 30 mins

There is an information sheet for the students to read, followed by a series of three executive function tests. If you choose to run all of the activities, it would take approximately 30 minutes. However, you could choose to run just one or two of the activities, which take 5-10 minutes each individually.

What you need:

- Information sheets (1 per pair) [page 46]
- If you are running the Card Matching Game:
  - Worksheets (1 per pair) [page 47-48]
  - Sets of stimulus cards and shape cards for each group (printed in colour and cut out) (1 of each set per pair) [page 49]
- If you are running the Stroop Effect Game:
  - Colour printed worksheets (1 per pair) [page 48]
  - Scissors

What to do:

7. Decide which of the following activities you wish to run (you might choose to run them all, or you might like to choose just one or two of the activities).
8. Print and prepare the above resources, which you will find over the following pages.
9. Instruct the class to read the information sheet on executive function. (Alternatively you may wish to brief them on this information yourself).
10. Briefly explain what you want the class to do. Instructions are on the worksheets.
11. Lead the class in a brief discussion about what happened and what they have learned about executive function.

Key Curriculum Links

OCR 21st Century Science – Brain and Mind
B6.4 How do humans develop more complex behaviour? Formation of neuron pathways and learning through repetition
B6.5 What do we know about the way in which the brain co-ordinates our sense? Mapping brain function; models for understanding memory
Executive function

What is executive function?

Executive Function is a set of higher mental processes that help to guide actions, such as monitoring and changing behaviour and planning for future behaviour when faced with a novel situation. They help us to learn from past experiences, to anticipate outcomes and adapt to change. We use executive function in planning, organising, strategising, paying attention and managing our time. It is an umbrella term for cognitive processes including:

- Verbal reasoning
- Inhibition
- Working memory
- Attention
- Mental flexibility
- Multi-tasking
- Initiation
- Monitoring of actions

The theoretical framework for research into executive functions is based on the work of British Psychologist Donald Broadbent, in the 1950s.

What part of the brain deals with executive function?

Executive function is primarily located in the prefrontal regions of the frontal lobe. The frontal cortex develops more slowly than other parts of the brain so many executive functions do not fully develop until adolescence. People with frontal lobe injuries often have difficulties with higher level processing power.

Executive function deficits

Problems with executive functions are associated with disorders such as Schizophrenia, Tourette’s Syndrome, Attention Deficit Hyperactivity Disorder, Asperger’s Syndrome, Autism and Obsessive Compulsive Disorder. People who abuse drugs and alcohol over a long period of time have also shown impairments to their executive functions. There are a number of simple tests used to determine a person’s level of executive functioning.
EXECUTIVE FUNCTION ACTIVITIES

Quick – one minute executive function test

This activity looks at the organisational aspects of our minds. People with executive function impairment would have difficulty thinking of many animals.

1. Write down as many animals, that begin with the letter ‘S’, as you can think of in 1 minute.
2. Share your results with your friends.
3. Did you find it difficult? Did they think of animals you did not think of?

Card matching game

The following activity is based on the Wisconsin Card Sorting Test™ written by David A. Grant and Esta A. Berg. It is used to test a person’s ability to display flexibility and adapt to change.

What you need:

- A partner to work with
- A set of 4 stimulus cards
- A pack of 12 shape cards

What to do:

1. Working in pairs, choose one person to be the tester and one to be the person being tested.
2. The tester should take the four stimulus cards and the person being tested should take the pack of 12 shape cards.
3. If you are the tester, lay down your four stimulus cards. Decide in your head how you would like your partner to match them. You can choose for them to be sorted by shape, colour or quantity.
4. If you are the person being tested, try to sort your cards into four piles, on top of the four stimulus cards. You might sort them so that all colour cards are piled together, OR so that all of the same shapes are sorted into piles together, OR so that all cards with the same quantity of shapes are sorted together.
5. The tester should not give any clues, other than to tell their partner if they are matching the cards wrong.
6. If you are the tester, during the course of the test, change the rules. If they have been sorting the cards into piles correctly (e.g. by shape) but you now want them to sort by colour, tell them that they are going wrong. You can change the rules a number of times during the test.
7. If you are the person being tested, try to adapt to the changes and work out from what you have been told is wrong, which is the correct way to sort the cards.
8. After 5 minutes swap roles and play again.
The Stroop Effect game

The Stroop effect is a strange phenomenon, which was discovered by an American Psychologist, John Ridley Stroop, in the 1930s. He found that when a colour is written as a word, but coloured differently, we find it difficult to say the colour, choosing instead to speak the word. It is thought that words have a strong influence over our ability to say the colour because it causes interference in the brain. There are two theories about how this interference affects our executive functions:

1. **Speed of Processing Theory**: We read the words faster than colours are said
2. **Selective Attention Theory**: Naming colours requires more attention than reading words

**What you need:**
- A partner to work with
- A set of 16 coloured word cards

**What to do:**
1. Cut out the below word cards and shuffle them.
2. Working in pairs, choose one person to be the cardholder and one person to be the tester.
3. The tester should take the set of coloured word cards and put them down for the tester to see (flip through them quickly).
4. The tester should name the COLOUR of the word, rather than the WORD itself.
5. Try to do it quickly and keep going, even if you get muddled – don’t think about it too much.
6. The cardholder should keep score.
7. At the end the cardholder should tell the tester their score.
8. After 5 minutes, swap roles and play again.

**Coloured word cards**

<table>
<thead>
<tr>
<th>Red</th>
<th>Blue</th>
<th>Yellow</th>
<th>Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Blue</td>
<td>Yellow</td>
<td>Green</td>
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<tr>
<td>Red</td>
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<td>Green</td>
</tr>
<tr>
<td>Red</td>
<td>Blue</td>
<td>Yellow</td>
<td>Green</td>
</tr>
</tbody>
</table>
Card matching game

Print [in colour] the two sets of cards (4 stimulus cards and 12 shape cards) onto card or paper. Print enough so that the class can work in pairs, each having a full set of both.

1. Cut them out and allocate a set of stimulus cards and a set of shape cards to each pair.
Colour and label motor neurone

Activity objectives:

This activity involves a diagram of a motor neurone to colour and label.

This class can be used to support lessons about the nervous system or as a revision activity for thinking about the nervous system.

How long will the activity take?

10mins

What you need:

- A4 printouts of the worksheet
- Colouring pens or pencils

What to do:

1. If you have not yet covered the nervous system in your teaching, you could introduce the class to the topic, using the PowerPoint presentation ‘How your brain and nervous system works’ which can be download at www.graphicscience.co.uk/SmarterUK. If you have covered this topic in a previous session, you might wish to run this presentation as a revision activity.
2. Photocopy and distribute the motor neurone worksheet (page 51)
3. Instruct students to colour in and label the different parts of the motor neurone.

Key Curriculum Links

GCSE
OCR – B1d: The nervous system
OCR 21st Century Science – B6: Brain and mind
AQA – 11.1: How to human bodies respond to changes inside them and their environment
Edexcel – Topic 2: Responses to a changing environment
Scotland
SCE Standard Grade – Topic 5: The body in action
Motor Neurone
Nervous system crossword and wordsearch

**Activity objectives:**

The crossword and wordsearch in this section are both based on the nervous system and act as a recap for students who have recently learned about the way the nervous system works. It includes clues about the peripheral nervous system, central nervous system, neurotransmitters and the different elements of a nerve cell.

**How long will the activity take?**

**Flexible: 15-30 mins**

Completing and checking the answers for each of the crossword and wordsearch should take approximately 15 minutes. The time taken to complete this activity depends on whether you would like to use one, or both, of the activities.

**What you need:**

- Copies of the crossword and/or wordsearch – enough for one per person.
- Answer sheets – for yourself, or to be circulated if you want students to mark their own work.

**What to do:**

1. If you have not yet covered the nervous system in your teaching, you could introduce the class to the topic, using the PowerPoint presentation ‘How your brain and nervous system works’ which can be downloaded at www.graphicscience.co.uk/SmarterUK. If you have covered this topic in a previous session, you might wish to run this presentation as a revision activity.
2. Decide whether you would like to run the nervous system crossword, wordsearch or both.
3. Photocopy and distribute the crossword (page 53) or wordsearch (page 55)
4. After 10-15 minutes the students should have completed their crossword or wordsearch.
5. Run through the answers, or distribute copies of the answers for students to check their own work.
6. If you are running both activities, distribute the second sheet.
7. After 10-15 minutes the students should have completed their crossword or wordsearch.
8. Run through the answers, or distribute copies of the answers for students to check their own work.

Key Curriculum Links

**GCSE**

- OCR – B1d: The nervous system
- OCR 21st Century Science – B6: Brain and mind
- AQA – 11.1: How to human bodies respond to changes inside them and their environment
- Edexcel – Topic 2: Responses to a changing environment

**Scotland**

- SCE Standard Grade – Topic 5: The body in action
CROSSWORD

The nervous system

Across:
1. The ______ nervous system connects everything to the brain and spinal cord.
2. The ______ neurone connects neurones to other neurones.
3. The cells of the nervous system are called ______.
4. What is the name of the membrane bound structure found in the body of the cell? ______.
5. The small space between two nerve cells is called the ______ cleft.
6. The ______ neurone sends signals to your muscles to make them move.
7. The ______ nervous system consists of the brain and spinal cord.
8. Transmitters are stored and packaged into a ______ before being released into the synaptic cleft.
9. Neurotransmitters are stored and packaged into a ______ before being released into the synaptic cleft.
10. The ______ nervous system consists of the brain and spinal cord.
11. Neurotransmitters are stored and packaged into a ______ before being released into the synaptic cleft.
12. A neurone is a type of nerve ______.
13. The ______ sheath is an insulating layer, surrounding peripheral nerve cells.
14. The part of the brain that deals with planning, language, recognising images and memory is called the ______ cortex.
15. The Central nervous system is made up of the spinal cord and the ______.
16. The ______ neurone communicates with the sense organs.
17. A nerve impulse is an electrical ______.

Down:
1. The ______ nervous system connects everything to the brain and spinal cord.
2. The ______ neurone connects neurones to other neurones.
3. The chemicals in the brain that facilitate communication across the nervous system are called ______.
4. The synapses at the neuromuscular junction use a neurotransmitter called ______.
5. The synapses at the neuromuscular junction use a neurotransmitter called ______.
6. An ______ is a long, slender projection of a nerve cell that conducts electrical impulses away from the cell body.
7. The sensory nerve terminal that responds to stimuli at the synapse is called a ______._
8. An ______ is a long, slender projection of a nerve cell that conducts electrical impulses away from the cell body.
9. The sensory nerve terminal that responds to stimuli at the synapse is called a ______._
Answers to the Nervous System Crossword

Across:
1. The **peripheral** nervous system connects everything to the brain and spinal cord.
3. The cells of the nervous system are called **neurones**.
4. What is the name of the membrane bound structure found in the body of the cell? [**Nucleus**]
6. The small space between two nerve cells is called the **synaptic** cleft.
8. The **motor** neurone sends signals to your muscles to make them move.
10. The **central** nervous system consists of the brain and spinal cord.
11. Neurotransmitters are stored and packaged into a **vesicle** before being released into the synaptic cleft.
12. A neurone is a type of nerve **cell**.
13. The **myelin** sheath is an insulating layer, surrounding peripheral nerve cells.
14. The part of the brain that deals with planning, language, recognising images and memory is called the **cerebral** cortex.
15. The **sensory** neurone communicates with the sense organs.
17. A nerve impulse is an electrical **signal**.

Down:
2. The **relay** neurone connects neurones to other neurones.
3. The chemicals in the brain that facilitate communication across the nervous system are called **neurotransmitters**.
5. The synapses at the neuromuscular junction use a neurotransmitter called **acetylcholine**.
7. An **axon** is a long, slender projection of a nerve cell that conducts electrical impulses away from the cell body.
9. The sensory nerve terminal that responds to stimuli at the synapse is called a **receptor**.
14. The **sensory** neurone communicates with the sense organs.
Answers

to the Nervous System Wordsearch

CELL  SIGNAL  AXON
BRAIN  IMPULSE  SYNAPSE
NEURON  RECEPTOR  NUCLEUS
VESICLES  RELAY NEURONE  DENDRITES
SPINAL CORD  MOTOR NEURONE  MYELIN SHEATH
CENTRAL NERVOUS SYSTEM  SENSORY NEURONE  SYNAPTIC CLEFT
PERIPHERAL NERVOUS SYSTEM  NEUROTRANSMITTER

www.graphicscience.co.uk/SmarterUK
appendices
Appendix 1 – Signs for ‘Vote with your Feet’

These images should be made into three posters, laminated and displayed around the room to support the ‘Vote with your Feet’ discussion activity.
Appendix 2 – Summaries of recent news reports

BBC News, 3 April 2011

Do 'smart drugs' really make us brainier?

“One pill. Anything is possible.” That’s the claim of the fictional pill in the film Limitless. But how close is this to the truth?

“Smart drugs” do already exist – growing numbers of UK students are using the drug Modafinil to help beat exam fatigue and it has been used by soldiers to help them stay awake during combat.

17% of students at some US universities are using Ritalin and 1 in 5 respondents to a survey by the journal Nature said they had taken medication to improve focus, concentration or memory. Even if the drugs improve memory by just 10% (as some studies have suggested) it could be the difference between passing and failing an exam.

However “If you’re not a genius before, you won’t be afterwards. They don’t make you brainier,” says Professor Harris.

The Guardian, 11 March 2010

Academics say 'smart' drugs could be prescribed

Dr Ilina Singh, from the London School of Economics argues that, in the US, it has become so common for young people to use drugs such as Ritalin that doctors should be allowed to prescribe them as study aids.
If they can “ensure minimum risk and maximum benefit, all young people ought to have access to existing resources to improve themselves and their performance” she suggests.

New memory-enhancing drugs developed to help Alzheimer’s patients "have clear applications in the enhancement of young people's academic performance, and it is highly probable that they will eventually be used for this purpose", she predicts.

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**The Telegraph, 6 July 2010**

**Students and academics increasingly using 'smart drugs' to boost performance**

A recent survey showed that 1 in 10 Cambridge students are using cognitive enhancing drugs and in a survey by the journal Nature, whose readership tends to be academics and researchers, one in five respondents said that they had used smart drugs.

But fears are growing for the students’ safety – they are buying them from suppliers as far afield as India and could be exposing themselves to unknown health risks by buying counterfeit drugs.

Barbara Sahakian, professor of neuroscience at the University of Cambridge says the Government needs to review its policy on smart drugs.

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**BBC News, 20 January 2010**

**Can ADHD drug make you smarter?**

Scientists are investigating how the ADHD drug Ritalin can also work as a cognitive enhancer, meaning it can make people without ADHD cleverer.

Student researcher Ed Wetherell has been taking the ADHD drug Ritalin in a voluntary trial to see how it affects his studying. While some students have been abusing the drug, the NHS has warned against taking it without doctors’ advice.
Drug tests for exam students 'inevitable'

Will the time come when students have to take doping tests before they sit exams?

Australian psychologist Vince Cakic notes that the spread of academic doping poses challenges for society but thinks that banning the drugs would be almost impossible and would lead to similar problems to those seen in sport where, despite testing, 95% of elite athletes are said to have used performance enhancing drugs.

And is saying they should be banned because they give people an unfair advantage like suggesting that private tuition should be banned because it favours those who can afford it?

Johann Hari: They were great at first – but then the creativity dries up

Journalist Johann Hari tried modafinil after a spell of particularly hard work that left him feeling burnt out. To begin with, he found the effect impressive.

“I wasn’t high. It was like I had opened a window in my brain and all the stuffy air had seeped out, to be replaced by a calm breeze.” he said.

But after a while he realised he wasn’t having any creative thoughts anymore, all his new work was based on ideas he’d had before he started using the drug. So he stopped and his brain went back to being slower and scrappier. But he was more spontaneous again.
Appendix 3 – Existing drugs for cognitive enhancement

Drugs to treat ADHD

ADHD is commonly treated using the stimulants methylphenidate (Ritalin, Equasym, Concerta, Medikinet) and dexamphetamine (Dexedrine), both of which are related to amphetamine. These drugs work by increasing the levels of the neurotransmitters dopamine and noradrenaline. When the drugs are used at prescribed doses, the increase in dopamine seems to improve levels of concentration. However, taken at high dose, the drugs can give users a high. This, combined with dopamine’s involvement in pleasure and reward pathways, means the drugs also have potential for abuse and addiction.

Drugs to treat Narcolepsy

Narcolepsy is a rare neurological disorder of the control of sleep. Symptoms include excessive daytime sleepiness and strong urges to sleep at inappropriate times - when driving for example. It isn’t clear what causes narcolepsy, but it seems to be related to the levels of a protein called orexin that controls sleep patterns and appetite. The daytime sleepiness can be reduced using many of the stimulants used to treat ADHD. Of other drugs used to treat the condition, modafinil is particularly significant in cognitive enhancement. The drug increases noradrenaline and dopamine levels in a similar way to amphetamines, but unlike amphetamines, which affect the whole brain, its action seems to be more localised to regions involved in wakefulness. However, it isn’t clear exactly how modafinil works. The drug was controversially trialled by the MoD to see if it could help keep soldiers alert with little sleep. The drug improves concentration, memory and wakefulness with relatively few side-effects and is increasingly being used illicitly by university students to help them study better on dramatically reduced amounts of sleep. The drug is banned in sport.

Drugs to treat Alzheimer’s disease

In Alzheimer’s disease there is visible degeneration in the brain. Accompanying this is a drop in levels of a number of neurotransmitters including acetylcholine which is particularly important in learning and working memory. Three of the licenced drugs to treat Alzheimer’s disease increase levels of the acetylcholine by blocking the enzyme acetylcholine esterase which is responsible for breaking down acetylcholine. Trials of the acetylcholine esterase inhibitor donepezil on pilots in flight simulators found that the drug helped pilots to remember complex flight tasks.
Appendix 4 – Regulation and governance of medicines

Drug licensing is overseen by the Medicines and Healthcare products Regulatory Agency (MHRA).

MHRA is the government agency responsible for safety and quality standards of medicines. The Agency licences manufacturers and approves medicines based on their safety, quality and efficacy. The MHRA is responsible both for licencing new medicines and monitoring the safety of existing medicines. This includes regulating the availability of each medicine, for example whether it can be bought over the counter, what medical conditions it can be used for, what form it can be taken in, who can take it, and its dosage.

In doing this, key questions it asks are:

- Do the advantages outweigh the disadvantages of taking the medicine?
- Does the medicine do the most good for the least harm for most people who will be taking it?
- Are the side effects acceptable?

The MHRA is also responsible for licensing of clinical trials. The Agency does not make any decisions based on the medication’s cost (NICE – the National Institute for Health and Clinical Excellence, which is an NHS organisation, is responsible for cost-benefit assessments of all medical interventions).

The Agency has a role in policy development in relation to medicines regulation and new treatments such as gene therapy and tissue engineering.

Much medicines regulation is now being harmonised across the EU.

Foods and nutritional supplements

The Food Standard Agency is responsible for regulation of food and nutritional supplements in the UK. Under food labelling regulations, no foods can carry any claims regarding treatment, prevention or cure of a particular disease. Supplements that claims medical benefits fall under the Medicines Act so are regulated by MHRA.

Regulation of controlled drugs

Narcotic and psychotropic drugs are regulated under the Misuse of Drugs Act 1971 and the accompanying Misuse of Drugs Regulations 2001. The Act falls within the workings of the Home Office and is under the control of the Home Secretary. Drugs are regulated under the Act through an assessment of their respective harms and in accordance with recommendations of the Advisory Council on the Misuse of Drugs. The Act covers the non-medical use of these drugs. Their medical use is regulated under the Medicines Act 1968. Legislation relating to alcohol does not fall under the Misuse of Drugs Act.
Possession of a prescription only drug without a prescription is only an offence if the drug is also controlled under the Misuse of Drugs Act 1971.

**How to regulate drugs for cognitive enhancement**

At present there is no regulatory mechanism for drugs such as enhancing medication that could be used by the healthy population.

The governance issues raised by the prospect of human enhancement reach far beyond the basic question of drug safety. Developments in science and technology confront society with complex policy problems. How should fundamental philosophical and ethical questions surrounding enhancement be addressed? And how should any associated problems of social justice and fairness be dealt with? Should the anti-doping policy for sports be replicated for cognitive enhancement?

Policy-makers are keeping a watchful eye on developments assisted by reports and reviews from expert bodies.
Appendix 5 – Known side effects of licensed drugs

There is no such thing as a drug without side-effects. These could be mild, moderate or severe and will vary from person to person.

Modern drugs are licenced for treatment of specific conditions where the risk of taking the medication has been carefully weighed up against the benefits to the patient. It can take many years for the side-effects of a drug to come to light, and occasionally, apparently successful medications are withdrawn after years of use when their side effects are found to be unacceptable. For example, the diabetes medication Rosiglitazone was withdrawn in November 2010 after more than a decade of use when a Europe-wide review found it was associated with an increased risk of heart problems. The regulators concluded the benefits of taking the drugs no-longer outweighed the risks.

Children and young people (classified as under 18) have developmental, physiological and psychological differences from adults that can make them more vulnerable to drugs’ side-effects. These may also differ from those experienced by adults. Drug companies rarely invest in clinical trials in children and it is estimated that more than half of drugs given to under 18s have never been studied in this age-group. The medical profession is duly cautious about prescribing new medication to under-18s without good clinical grounds.

Prescription medicines should only be taken with appropriate medical supervision. Purchasing drugs online carries significant health risks since the dose of the active ingredient and absence of contaminants cannot be guaranteed.

Below are some examples of prescription or over-the-counter medication and their known side effects:

**Aspirin**

Aspirin is a member of a group of drugs called salicylates, used for pain relief, which can be purchased over-the-counter. It is often used for its anti-platelet effect, to thin the blood and prevent clotting and for its anti-inflammatory properties in conditions such as arthritis. Aspirin should not be given to children under the age of 18 with viral syndromes, as this increases the risk of Reye’s syndrome (a rare, but potentially fatal disease which leads to a fatty liver, kidney damage, swelling of the brain (encephalopathy) and low blood sugar (hypoglycaemia)). Survivors of Reye’s syndrome can be left with severe brain damage. Because aspirin inhibits the aggregation of platelets (an important aspect blood clotting functions) it can cause gastrointestinal bleeding, along with gastric irritation and ulcers. Aspirin can also lead to irreversible damage to the ears (ototoxicity) and tinnitus (ringing in the ears). Pregnant women are advised to avoid taking aspirin unless specifically instructed to do so by their doctor; it has been associated with miscarriage in early pregnancy and heart and lung defects in later pregnancy.
**Epilim**

Epilim, which contains the anti-convulsant sodium valproate, is widely used to treat many types of epilepsy. It has been found to be effective in reducing seizures in people with epilepsy but it has a long list of side effects. Its common effects include: tiredness, tremors, weight gain, abdominal problems, double vision, insomnia and hair loss. It can also cause problems with menstruation (in some cases halting it altogether) and can lead to depression, abnormal dreams and agitation. Some of the more serious side effects include the risk of inflammation or damage to the liver and, when taking high doses, a shortage of blood platelets and an increased risk of bleeding around the brain. Epilim should not be taken by women who wish to become pregnant due to its high potential to cause birth defects such as spina bifida, developmental problems and facial changes known as ‘foetal valproate syndrome’.

**Hydrocortisone Cream**

Hydrocortisone cream contains a type of medicine called a topical corticosteroid – used for reducing inflammation. It can be used to treat a variety of inflammatory skin complaints, including reactions to plants, insect bites, jewellery, cosmetics and toiletries. It is also used to treat eczema and is sometimes used to treat acne. It works by acting inside cells to decrease the release of inflammatory substances. Side effects can include: drying or cracking of the skin, itching, burning and skin discolouration. It can even cause acne. Some people suffer from severe allergic reactions to hydrocortisone cream such as contact dermatitis, swelling of the face, lips and tongue, hives, rashes and difficulty breathing.

**Paracetamol**

Paracetamol is widely used medicine taken as a pain reliever (analgesic) and to reduce fever (antipyretic). An overdose of paracetamol can cause potentially fatal liver damage and is one of the most common causes of poisoning worldwide. Paracetamol toxicity is the number one cause of acute liver failure in the western world. The threshold for overdose is lowered through alcohol consumption, taking prescription medications or from being under-nourished. Prolonged daily use of paracetamol may cause liver or kidney damage.

**Prozac**

Prozac (a commercial name for fluoxetine) is one of a number of SSRIs (Selective Serotonin Reuptake Inhibitors) used to treat forms of depressions such as major depressive disorder and pre-menstrual dysphoric disorder (PMDD); panic disorders; obsessive compulsive disorder (OCD) and bulimia nervosa. Its common side effects include: anxiety, headaches, nausea, insomnia, increased sweating and decreased sexual appetite. Less common side effects include agitation, impulsiveness, tremors and hyperactivity. It can even cause more serious problems such as seizures, hallucinations and problems with balance and coordination. Paradoxically, considering its role in treating depressive disorders, Prozac and other anti-depressants have been known to increase suicidal ideation (suicidal thoughts). Taking Prozac during the 3rd trimester of pregnancy may increase the baby’s risk of developing a serious and potentially fatal lung disorder: persistent pulmonary hypotension.
Appendix 6 – Examples of neurotransmitters

More than 40 different neurotransmitters have been identified, below are descriptions of some of the better known examples.

Acetylcholine
In the peripheral nervous system, acetylcholine activates muscle contractions. In the brain, it is involved in learning, working memory, arousal and reward. Damage to acetylcholine pathways is associated with Alzheimer’s disease.

Adenosine
Adenosine has many different biological functions. In the brain it is believed to play a role in promoting sleep and suppressing arousal.

Adrenaline (also known as epinephrine)
Adrenaline is an important hormone best known for its role in the fight or flight response to stress where it increases heart rate and makes air passages dilate. However, it also has a minor role as a neurotransmitter in the central nervous system.

Dopamine
Dopamine affects brain processes that control movement, emotional response and the ability to experience pain and pleasure. It is thought to play a major role in addiction. Dysfunction of dopamine pathways are also implicated in schizophrenia and Parkinson’s disease.

Glutamate
Glutamate is the most abundant excitatory neurotransmitter in the brain - it is estimated that over half of the brain’s neurons release glutamate. Glutamate is important in learning and memory.

Endorphin
Endorphins are neurotransmitters that act as natural pain killers and create a feeling of well-being. They are natural opiates and act in a similar way to morphine (and heroin). Endorphins are produced during exercise, excitement, pain and orgasm. They are said to be responsible for the “runner’s high” though there is growing evidence that a substance called anandamide may be more important.

Noradrenaline (also known as norepinephrine)
Brain pathways that rely on noradrenaline are thought to be associated with attention and arousal. Outside the brain, noradrenaline plays an important role in the fight or flight response and is associated with changes in heart rate, blood pressure and digestion.

Serotonin
Serotonin is most closely associated with mood, and drugs that increase levels of serotonin are used to treat depression. Serotonin is also involved in a number of other functions including regulation of sleep, appetite and temperature.
Appendix 7 – Curriculum links

KS3 Science

**Unit**

1.2 Applications and implications of science
   a) exploring how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave
   b) examining the ethical and moral implications of using and applying science

2.3 Communication
   a) use appropriate methods to communicate scientific information and contribute to presentation and discussions about scientific issues

3.3 Organisms, behaviour and health
   a) life processes are supported by the organisation of cells into tissues, organs and systems
   c) conception, growth, behaviour and health can be affected by diet, drugs and disease
   e) behaviour is influenced by internal and external factors and can be investigated and measured

4 Curriculum opportunities
   a) research, experiment, discuss and develop arguments
   c) use real-life examples as a basis for finding out about science
   d) study science in local, national and global context and appreciate the connections between these
   h) explore contemporary and historical scientific developments and how they have been communicated

Assessment Criteria – KS3 Science

**Criterion**

AF2 – Understanding the applications and implications of Science
- **Level 8)**
  o Explain the unintended consequences that may arise from scientific and technological developments
  o Make balanced judgements about particular scientific or technological developments by evaluating the economic, ethical/moral, social or cultural implications
- **Level 7)**
  o Suggest economic, ethical/moral, social or cultural arguments for and against scientific or technological developments

AF3 – Communicating and collaborating in science
- **Level 8)**
  o Critically evaluate information and evidence from various sources explaining limitations, misrepresentation or lack of balance
  o Present robust and well-structured explanations, arguments or counter arguments in a variety of ways

KS3 Citizenship

**Unit**

2.1 Critical thinking and enquiry
2.2 Advocacy and representation

- a) express and explain their own opinions to others through discussions, formal debates and voting
- b) communicate an argument, taking account of different viewpoints and drawing on what they have learnt through research, action and debate
- c) justify their argument, giving reasons to try to persuade others to think again, change or support them
- d) represent the views of others, with which they may or may not agree

4 Curriculum Opportunities

- a) debate, in groups and whole-class discussions, topical and controversial issues including those of concern to young people
- j) make links between citizenship and work in other subjects and areas of the curriculum

Key Stage 4

Science

How Science Works

During key stage 4, pupils learn about the way science and scientists work within society. They consider the relationships between data, evidence, theories and explanations, and develop their practical, problem-solving and enquiry skills, working individually and in groups. They evaluate enquiry methods and conclusions both qualitatively and quantitatively, and communicate their ideas with clarity and precision.

Applications and implications of science

Pupils should be taught:
- a) about the use of contemporary scientific and technological developments and their benefits, drawbacks and risks
- b) to consider how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions
- c) how uncertainties in scientific knowledge and scientific ideas change over time and about the role of the scientific community in validating these changes.

Citizenship

Critical thinking and enquiry: Using real case studies to explore issues and problems can help to develop skills of critical thinking, enquiry, debate and advocacy. Students should interrogate evidence, develop judgements based on that evidence, and explore, question and reflect on their own ideas as well as those of others.

Topical and controversial issues and problems: Political, social and ethical issues and problems can be sensitive and can lead to disagreement. They should not be avoided, but need to be handled so that students develop skills in discussing and debating citizenship issues and considering points of view that are not necessarily their own. Setting ground rules and using distancing techniques can help to manage the discussion of such issues.

Content

- g) how information is used in public debate and policy formation, including information from the media and from pressure and interest groups

Curriculum opportunities

- j) make links between citizenship and work in other subjects and areas of the curriculum.
Links to GCSE Biology Syllabuses

OCR

Unit

3.3 Fundamental Scientific Processes

| B1b, B1c, B2f, B3g, B4g, B5h, B6d | Identify different views that might be held regarding a given scientific or technological development. |
| B1h, B2e, B2g, B3f, B3g, B3h, B4g, B5g, B5h, B6d, B6h | Identify how a scientific or technological development could affect different groups of people or the environment. |
| B1a, B1b, B1c, B2g, B1h, B3g, B3h, B5g | Describe risks from new scientific or technological advances. |

Assessable learning outcomes

Standard demand

- Explain how the application of science and technology depends on economic, social and cultural factors.
- Describe the ways in which the values of society have influenced the development of science and technology.

Higher Tier

- Identify some arguments for and against a scientific or technological development, in terms of its impact on different groups of people or the environment.
- Evaluate the application of science and technology, recognising the need to consider what society considers right or wrong, and the idea that the best decision will have the best outcome for the majority of the people involved.
- Suggest ways of limiting risks and recognise the benefits of activities that have a known risk.
- Analyse personal and social choices in terms of a balance of risk and benefit.

Module B1d – The nervous system

Assessable learning outcomes

Foundation tier only: low demand

- Describe how animals detect changes in their environment (stimuli) using receptors which generate nerve impulses.
- Name and locate the main parts of the nervous system, to include:
  - the central nervous system (CNS) (brain and spinal cord)
  - the peripheral nervous system
- Describe the nerve impulse as an electrical signal that is carried by nerve cells called neurones.
- Describe reflex actions as fast, automatic and protective responses.
- Recognise that voluntary responses are under the conscious control of the brain.

Both tiers: standard demand

- Name and locate the parts of a motor neurone: cell body, axon and sheath.
- Recall that the nerve impulse passes along the axon of a neurone.

Higher tier only: high demand

- Explain how neurones are adapted to their function by their length, insulating sheath and branched endings (dendrites).
- Recall that the gap between neurones is called a synapse.
- Describe how an impulse triggers the release of a transmitter substance in a synapse and how it diffuses across to bind with receptor molecules in the membrane of the next neurone causing the impulse to continue.

Item B1e: Drugs and You
Assessable learning outcomes

Foundation tier only: low demand
- Recognise that drugs can be beneficial or harmful.
- Explain why some drugs are only available on prescription.
- Explain the terms: addiction, withdrawal symptoms, tolerance and rehabilitation.
- Describe the general effects of each drug category:
  - depressants: slow down brain’s activity
  - pain killers: block nerve impulses
  - stimulants: increase brain’s activity
  - performance enhancers: muscle development
  - hallucinogens: distort what is seen and heard

Both tiers: standard demand
- Recall examples of drugs:
  - depressants, limited to alcohol, solvents and temazepam
  - pain killers, limited to aspirin and paracetamol
  - stimulants, limited to nicotine, ecstasy and caffeine
  - performance enhancers, limited to anabolic steroids
  - hallucinogens, limited to LSD

Higher Tier only: high demand
- Explain the action of depressants and stimulants on the synapses of the nervous system:
  - depressants bind with receptor molecules in the membrane of the next neurone blocking the transmission of the impulses
  - stimulants cause more neurotransmitter to cross the synapse

OCR 21st Century Science

MODULE B3: LIFE ON EARTH
B3.3 How did humans evolve? How are our nervous systems organised?
1. recall that sensor (receptor) cells detect stimuli and effector cells produce responses to stimuli;
2. recall that nervous systems are made up of nerve cells (neurons) linking receptor cells (e.g. in eyes, ears and skin) to effector cells (in muscles/glands);
3. understand that nervous systems use electrical impulses for fast, short-lived responses;
4. recall that in humans and other vertebrates the nervous system is coordinated by a central nervous system (spinal cord and brain);
5. understand that nervous systems use electrical impulses for fast, short-lived responses;
6. recall two examples, in humans, of each of nervous and hormonal communication;
7. understand that nervous and hormonal communication systems are involved in maintaining a constant internal environment (homeostasis);
8. recall that the evolution of a larger brain gave some early humans a better chance of survival;

MODULE B6: BRAIN AND MIND – OVERVIEW
Topics
B6.1 How do organisms respond to changes in their environment? Co-ordination of responses to stimuli via the central nervous system.
**AQA**

### Unit

**11.1 How do human bodies respond to changes inside them and their environment?**

- The nervous system enables humans to react to their surroundings and coordinate their behaviour.
- Receptors detect stimuli which include light, sound, changes in position, chemicals, touch, pressure, pain and temperature. (The structure and functions of sense organs such as the eye and the ear are not required.)
- Information from receptors passes along cells (neurones) in nerves to the brain. The brain coordinates the response.
- Reflex actions are automatic and rapid. They often involve sensory, relay and motor neurones.
- The role of receptors, sensory neurones, motor neurones, relay neurones, synapses and effectors in simple reflex actions.

**11.3 How do we use/abuse medical and recreational drugs?**

Drugs affect our body chemistry. Medical drugs are developed to relieve illness or disease. Drugs may also be used recreationally as people like the effect on the body - e.g. alcohol and tobacco. People cannot make sensible decisions about drugs unless they know their full effects.

Candidates should use their skills, knowledge and understanding of how science works:

- to evaluate the different types of drugs and why some people use illegal drugs for recreation

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- Drugs can be beneficial but may harm the body.
- Many drugs derived from natural substances have been known to indigenous peoples for many years.
- Scientists are developing new drugs. These need to be thoroughly tested
- Some people use drugs recreationally. Some of these recreational drugs are more harmful than others. Some of these drugs are legal, some illegal.
- The overall impact of legal drugs on health is much greater than the impact of illegal drugs, because far more people use them.
- Drugs change the chemical processes in people’s bodies so that they may become dependent or addicted to them and suffer withdrawal symptoms without them. Heroin and cocaine are very addictive.
### Edexcel

<table>
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<tr>
<th><strong>Unit</strong></th>
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<tbody>
<tr>
<td><strong>Topic 2: Responses to a changing environment</strong></td>
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<tr>
<td>- 2.19) Recall that the central nervous system consists of the brain and spinal cord and is linked to sense organs by nerves</td>
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<tr>
<td>- 2.20) Explain the structure and function of dendrons and axons in the nervous system</td>
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<tr>
<td>- 2.21) Describe how stimulation of receptors in the sense organs sends electrical impulses along neurones</td>
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<td>- 2.23) Describe the structure and function of sensory, relay and motor neurones and synapses including:</td>
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<td>- c) the reflex arc</td>
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| **Topic 3: Problems of, and solutions to a changing environment** |
| - 3.1) Define a drug as a chemical substance, such as a narcotic or hallucinogen, that affects the central nervous system, causing changes in psychological behaviour and possible addiction |
| - 3.2) Describe the general effects of: |
| | o painkillers that block nerve impulses, including morphine |
| | o hallucinogens that distort sense perception, including LSD |
| | o stimulants that increase the speed of reactions and neurotransmission at the synapse, including caffeine |
| | o depressants that slow down the activity of the brain, including alcohol |
Scotland

Scottish S3-S4

Science

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<thead>
<tr>
<th>Unit</th>
<th>Biological Systems - Body systems and Cells</th>
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<tr>
<td>SCN 2-12a</td>
<td>I have explored the structure and function of organs and organ systems and can relate this to the basic biological processes to sustain life</td>
</tr>
<tr>
<td>SCN 3-12b</td>
<td>I have explored the role of technology in monitoring health and improving the quality of life</td>
</tr>
<tr>
<td>SCN 4-12a</td>
<td>I can explain how biological actions which take place in response to external and internal changes work to maintain stable body conditions</td>
</tr>
<tr>
<td>SCN 4-13c</td>
<td>I can debate the moral and ethical issues associated with some controversial biological procedures</td>
</tr>
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| Topical Science | SCN 3-20a | I have collaborated with others to find and present information on how scientists from Scotland and beyond have contributed to innovative research and development |
| | SCN 3-20b | Through research and discussion, I have contributed to evaluations of media items with regard to scientific content and ethical implications |
| | SCN 4-20a | I have researched new developments in science and can explain how their current or future applications might impact on modern life. |

| Health and Wellbeing - Substance misuse | HWB 3-38a/ HWB 4-38a | I understand the positive effects that some substances can have on the mind and body but I am also aware of the negative and serious physical, mental, emotional, social and legal consequences of the misuse of substances |
| | HWB 3-40a/ HWB 4-40a | I am developing a range of skills which can support decision making about substance use. I can demonstrate strategies for making informed choices to maintain and improve my health and wellbeing and can apply these in situations that may be stressful or challenging, or involve peer pressure |
Scottish Certificate in Education, Standard Grade Biology

Unit

Topic 5: The body in action
Subtopic c: Coordination

- **18)** Examine the gross structure of the nervous system of a mammal.
  - State that the nervous system is composed of the brain, spinal cord and nerves.
- **19)** Obtain and present information on the flow of information in the nervous system.
  - State that the nerves carry information from the senses to the central nervous system and from the central nervous system to the muscles. Describe how a reflex action works, using a simple model of a reflex arc.
  - State that the central nervous system sorts out information from the senses and sends messages to those muscles which make the appropriate response.
- **20)** Obtain and present information on the three main parts of the brain.
  Identify the cerebrum, cerebellum and the medulla and state their functions in simple terms.
Appendix 8 - Glossary of terms

**Alzheimer’s disease**
The most common cause of dementia. Symptoms include loss of memory, mood changes, and problems with communication and reasoning.

**Acetylcholine esterase**
Enzyme responsible for breakdown of acetylcholine.

**Acetylcholine esterase inhibitor**
Class of drugs that block the action of acetylcholine esterase, preventing its breakdown and increasing the concentration of acetylcholine in the synaptic cleft.

**Action potential**
Electrical impulse in a neurone.

**Alcohol**
CNS depressant with a range of other side-effects. It works by enhancing the effects of the inhibitory neurotransmitter GABA.

**Autonomic Nervous System**
System responsible for controlling heart rate, digestion, respiration rate, salivation, perspiration, diameter of the pupils, urination and sexual arousal. It is divided into two subsystems: the parasympathetic nervous system and sympathetic nervous system.

**Axon**
The long filament of the neurone that transmits signals via electrical impulses.

**Central Nervous System (CNS)**
The part of the nervous system consisting of the brain and spinal cord.

**Cognition**
The mental processes of knowing, including aspects such as awareness, perception, reasoning and judgement.

**Cortex**
The cerebral cortex or cortex is the outermost layer of the brain. It plays a key role in memory, attention, perception, thought, language, and consciousness. The human cerebral cortex is 2-4 mm thick. Different regions of the cortex are responsible for different aspects of cognition.

**Dendrite**
The part of a neurone that receives chemical signals.

**Depressant**
Substance that reduces the function or activity of a specific part of the body or brain.

**Drug**
Broadly speaking, any chemical that alters the normal function of the body.
Executive function
A set of higher mental processes that help to guide actions, such as monitoring and changing behaviour and planning for future behaviour when faced with a novel situation. They help us to learn from past experiences to anticipate outcomes and adapt to change. We use executive function in planning, organising, strategising, paying attention and managing our time.

Hippocampus
Brain structure with a central role in consolidating information from working memory into long term memory. So called because the 16th century anatomist who first identified it thought it looked like a seahorse - hippocampus is the Latin name for a seahorse.

Motor neurone
Motor neurones relay signals from the central nervous system to muscles and glands. Motor neurones form part of the peripheral nervous system.

Nerve
A bundle of axons in the peripheral nervous system.

Neuropharmacology
A branch of medical science dealing with the action of drugs on the nervous system.

Neurone
The specialised cell of the nervous system responsible for conducting signals via electrical and chemical impulses. The major functional parts of a neurone are the axon and the dendrites.

Neurotransmitter
Chemicals, such as acetylcholine and noradrenaline, which transmit nerve impulses across a synapse.

Parasympathetic nervous system
The system responsible for maintaining the body at rest. It can be viewed as having the opposite function to the sympathetic nervous system.

Parkinson's disease
Degenerative disease resulting from death of a specific group of dopamine containing cells. Early symptoms of the disease include shaking, rigidity, slowness of movement and difficulty with walking.

Peripheral Nervous System (PNS)
The peripheral nervous system consists of all of the nerves outside the brain and spinal cord - i.e. that responsible for connecting the CNS to the limbs and organs. It includes sensory and motor neurones.

Reflex
A very rapid, involuntary response to a stimulus. Reflex reactions are not mediated by the brain.
Reward system
The collection of brain structures that influences behaviour by inducing pleasurable effects. Almost all drugs that cause addiction increase dopamine release in the major pathways of the reward system.

Selective serotonin reuptake inhibitor (SSRI)
A class of antidepressant drugs. They are thought to work by increasing levels of serotonin in the synaptic cleft by blocking the transporters that move the serotonin back into the axon.

Sensory neurone
Sensory neurones relay signals from sense organs to the central nervous system. Sensory neurones form part of the peripheral nervous system.

Stimulant
Substance that activates mental function, physical function or both.

Sympathetic Nervous System
The sympathetic nervous system mobilises response to stress commonly referred to as “fight or flight” including increase in heart rate and widening of respiratory passages.

Synapse
A junction between two nerves. Signals are transmitted across the synapse when neurotransmitters released from one side of a synapse bind to receptors on the other side of the synapse. One neurone can form thousands of synapses. In the central nervous system, most psychoactive drugs act at the synapse. In the peripheral nervous system, synapses link to muscles and glands.

Synaptic cleft
The tiny gap (measured in nanometres) between one side of a synapse and the other.

Synaptic plasticity
The ability of synapses to change in responsiveness as a result of use or disuse. Synaptic plasticity is one of the important foundations of learning and memory.

Vesicle
A pouch within the axon terminal that stores and releases neurotransmitters.