READING PASSAGE 1

*You should spend about 20 minutes on **Questions 1–12**, which are based on Reading Passage 1 below.*

A A condition that causes children to dislike being hugged and sometimes reject all physical affection is closer to being understood following research into the part of the brain responsible for our senses. Scientists at Northwestern University, Illinois, and the University of Edinburgh explored fragile X syndrome, a condition associated with hypersensitivity to sounds, touch, smells and visual stimuli that can result in social withdrawal or anxiety. Hypersensitivity is a condition in which the person affected responds in an excessive way to contact with the world around them. Some sufferers are even hypersensitive to material on their skin.

B The scientists found that critical phases in the brain's development may be wrongly timed in people with the condition. This may result in delayed communication between certain neurons in the brain. By recording electrical signals in the brains of mice, bred to exactly copy the effects of the condition, the researchers found that connections in the brain's sensory cortex were late to develop fully. The study, published in the journal *Neuron*, found that normal neural connections in the sensory cortex occur much earlier than previously thought: in the first week of pregnancy in mice, which is equivalent to the middle of the second trimester (or fifth month) of pregnancy in humans. In fragile X syndrome, the mistiming also has a domino effect, causing further problems with the correct wiring of the brain. The hope is that by understanding how and when the functions of the brain are affected in fragile X syndrome, a therapy may become possible.

C 'There is a "critical period" during development, when the brain is very plastic and is changing rapidly,' said Anis Contractor, from the Feinberg School of Medicine at Northwestern University. 'All the elements of this rapid development have to be coordinated so that the brain becomes wired correctly and therefore functions properly.' People with the syndrome have cognitive problems as well as sensory problems that make them physically weaker. 'They have tactile defensiveness,' Dr Contractor said. 'They don't look in people's eyes, they won't hug their parents, and they are hypersensitive to touch and sound. All of this causes anxiety for family and friends as well as for the fragile X patients themselves.' Peter Kind, who led the study at the University of Edinburgh, said: 'We know there are key windows during which the brain develops, both in the womb and afterwards. The general principle is that if these time windows have shifted, then that could explain the cognitive problems.'

D Professor Kind said that this could be demonstrated by the fact that a child with a cataract (a medical condition in which the lens of the eye becomes less and less transparent) that was not corrected would become permanently blind in the affected eye, whereas an adult would be able to regain their sight after an operation. 'We've learnt that these changes happen much earlier than previously thought, which gives valuable insight into when we should begin therapeutic intervention for people with these conditions,' he said. 'It also has implications for the treatment of autism since the changes in the brains of people with fragile X syndrome and autistic people are thought to significantly overlap.' Autism, as many people know, is a disability that affects how a person communicates with and relates to other people, and how they make sense of the world.

E Fragile X syndrome is as common as cystic fibrosis, a genetic disorder that commonly affects the lungs and causes breathing difficulties, and that affects about 1 in 4,000 males and 1 in 8,000 females worldwide. The Fragile X Society believes that there are many people who have the fragile X syndrome but have never been diagnosed. It shows up in early infancy and progressively worsens throughout childhood, causing intellectual disability as well as social, language and behavioural problems.

F Fragile X syndrome is caused by a gene mutation on the X chromosome – one of the two chromosomes that determine the gender or sex of a person. The mutation interferes in the production of a protein called fragile X mental retardation protein. Fragile X is so-named because the X chromosome appears broken or kinked. Tim Potter, of the Fragile X Society, said: 'We welcome any research that helps us understand fragile X and which may open the way to reversing the effects or preventing them ever happening.'

*You should spend about 20 minutes on **Questions 13–26**, which are based on Reading Passage 2 below.*

Mutualism

Mutualism is an association between individuals belonging to two different species that benefit each other. There are numerous examples of this: the way flowers rely on insects to pollinate them or even how we humans rely on bacteria within our digestive system to break down our food.

One of the most visible forms of mutualism can be found in the pampas grasslands of Argentina, where organisms belonging to two different species work together not only to benefit each other but also to change the ecosystem around them. Grasscutter ants have been instrumental in shaping the landscape of the pampas grasslands – in fact, the landscape has been created almost entirely by the ants. Although they are only 1.5 cm long, they are one of the few creatures capable of shaping their own environment and one of the few living creatures apart from humans that cultivate their own food. The ants harvest the grasslands to supply their colony with grass. Each year over 0.5 tonnes of grass are harvested by a single colony. However, grass consists largely of cellulose, which the ants cannot digest, so the ants have developed a mutualistic relationship with an organism that can digest it. Deep inside the ant nests is a fungus that is able to grow on the compost produced by the grass. The fungus is unique to the habitat inside the ants' nest and it produces edible gardens for the ants. The relationship is so successful that a single colony can consist of up to eight million ants.

One of the reasons for the ants' success is the sophistication of their social organisation: they are all members of a single society but there is a division of labour within it. There are three main castes: the queen, the soldiers (or majors) and the worker ants. The worker ants are further divided into categories: the minims (the smallest ants), the minors and the mediae, each with different duties. The soldier ants defend the colony against physical threats. They also clear the paths for the other workers. The mediae are the foraging ants that look for grass to cut up and take back to the nest. Once the grass has been harvested, the forager ants carry it to the nest by following a chemical trail. But often they are not alone: minims ride on them or on the grass in order to protect them from a particular species of fly that parasitises the foragers. As soon as the grass leaves arrive at the nest, the forager ants pass them to smaller gardener ants, which cut up the leaves into smaller and smaller pieces until they are small enough to feed to the fungus. They then pass the tiny pieces on to the smallest ants, which feed the grass to the fungus and tend the fungal gardens.

A very important function of the smallest ants is to keep the fungus healthy. They do this by carefully inspecting each piece of grass leaf and making sure that it is free from other fungi or pests. In fact, the mutualistic relationship is supplemented by bacteria that live on the ants and give out chemicals that kill microbes harmful to the fungus. The relationship between the fungus and the ants is so developed that the grasscutter ants are sensitive to the fungus's reaction to different plants; if a particular plant is poisonous to the fungus, the ants no longer collect it. Waste disposal is another serious concern. Waste is collected by waste-disposer ants, which tend to be the older ants, thus ensuring that the younger ones can tend to other work. The waste-disposer ants remove waste (including dead ants) from the nest and take it underground into the deepest tunnels, where they aid its decomposition by moving it around.

Because the fungus at the heart of the colony nest is a living and breathing organism, it produces carbon dioxide – a very toxic gas. The ant nest is a masterpiece of construction, carefully made to keep air circulating in order to prevent suffocation through the build-up of carbon dioxide. The nest has two methods of air circulation. Firstly, the hot air produced by the fungal gardens at the centre of the nest flows up through a central tunnel and draws in cooler, cleaner air from the outside passages. The second method involves a series of towers at the top of the nest. When the wind blows over the towers, it draws out old air and fresh air rushes into the nest from nest holes that extend outwards from the main nest. A nest can measure up to 30 metres across, and other mounds extend away from the central nest for up to 80 metres. As the nest also dominates the underground world, often extending seven metres down, the rapid flow of air through the nest is essential to the health of the inhabitants and their garden.

READING PASSAGE 3

*You should spend about 20 minutes on **Questions 27–40**, which are based on Reading Passage 3 below.*

Is it really true that human adults are less able to learn as they grow older? Traditionally, the brain was thought to be 'completed' at the latest by the start of adulthood. During adulthood the brain was viewed as relatively stable until at last the aging brain started to decline. We have around 86 billion neurons at birth, and that's it. Or is it? Until two decades ago, it was thought that new neurons – the cells that carry messages between the brain and other parts of the body – did not grow in adults. Moreover, it was believed that functions in the brain were fixed or localised in distinct areas, one common assumption being that language functions resided solely in the left hemisphere of the brain. The functions were fixed in childhood and did not change.

But this is not strictly true. Research has shown that adult brains are not fixed, and nor are they degenerating or dying as we grow older. In fact, the opposite seems to be the case: neurons are dying and being regenerated all the time and new experiences create new connections between neurons. Furthermore, when the brain suffers damage, it has the ability to shift brain functions to other parts of the brain.

The first evidence that refuted the idea that the brain was a stable organ was produced over 30 years ago. Fernando Nottebohm's study of male songbirds at The Rockerfeller University showed that new neurons would grow when a bird learnt a new song. And more recently, evidence from studies done at Wayne State University has shown that physical exercise or lack of it is a factor in remodelling the brain. Two regions of the brain are capable of producing new neurons: the hippocampus and the olfactory cortex. In particular, the hippocampus is extremely important in turning short-term memories into long-term memories. It appears that new neurons regularly grow and move into the hippocampus. Conversely, the loss of brain tissue, most often associated with brain damage or illness can also have a positive function. We know that most of the neurons that die off in children and adults are the ones that are not effective or are not needed. In short, the brain needs to operate at maximum efficiency and neurons which become unused are discarded. So, far from being a stable organ, the brain is constantly changing, losing what is not needed and developing what is needed.

A landmark study by neuroscientist Dr Eleanor Maguire and her colleagues at University College, London confirmed findings from other studies which reveal that when humans spend time repeating a particular skill, the area of the brain associated with that skill becomes better developed. For four years, Dr Maguire and her team followed a group of 79 London taxi drivers who shared certain characteristics including age, gender and education. They used magnetic resonance imaging (MRI) to map changes to their posterior hippocampi. The hippocampus plays a major role in short-term memory and spatial navigation, both of which are very important to the work of taxi drivers, and London taxi drivers in particular. To become a taxi driver in London, you need to learn 'the Knowledge' – a detailed understanding of the streets in central London as well as tourist spots and other places of interest. Gaining 'the Knowledge' takes on average three to four years, at the end of which taxi drivers have to take a test that only fifty per cent of candidates pass.

At the start of the study, the taxi drivers had similar sized hippocampi but after four years of intensive spatial and memory training, Dr Maguire found that the taxi drivers who successfully passed their tests had more developed hippocampi than those who failed. This was confirmed by a series of memory tests and MRI images which showed that certain parts of their brains had developed over time. Furthermore, other experimental studies over the last few decades have shown that the adult brain can change its structure and function massively. In a 1982 study carried out by Jon Kaas at Vanderbilt University, changes in brain patterns were noted in people whose limbs had been amputated or who suffered nerve damage. Since then, it has become clear that the living brain is constantly changing depending on external experiences. As Boston University neurobiologist Howard Eichenbaum (commenting on Dr Maguire's research) stated: '... you can produce profound changes in the brain with training. That's a big deal.'