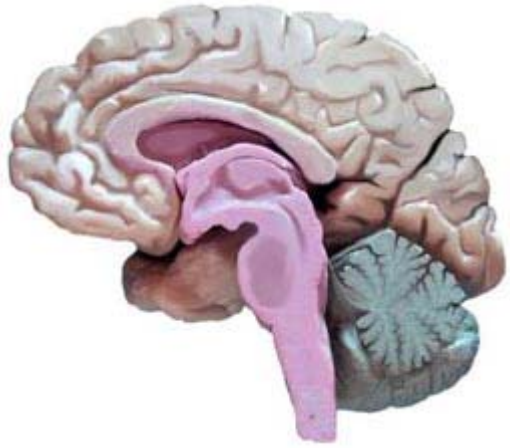
Food for Thought:
The Critical Foundation for Brain Care

By John Joseph

A growing base of research supports the intuitions and claims that poor nutrition affects the functioning of the brain. What is the most efficient way to raise pupil's achievement, asks the New York Times (August 1, 2001). Is it ending social promotion, increasing accountability or adding more testing? It could be none of these, states Richard Rothstein, New York Times journalist, *Improving nutrition might bring a bigger test-score gain.* Research in this field is hotly contested with claims and counter claims. Products are being marketed that make astonishing claims. My recommendation is to become an educated consumer of the research. Look for valid clinical tests, triangulation of results and links to human trials. This article is written for your information only. It is not intended as advice. The author is not a nutritionalist and even if he was, there is widespread opinion within the field. Read on……and enjoy.



The human brain is energy inefficient. Weighing in at about 2% of the body's total adult weight it typically consumes up to 20% of its energy, with effortful learning tasks extending this demand to nearer 30% (Carper, 2000). During the ages 2 – 12 this ratio of energy usage to weight is greater than for the adult brain. In fact, the brain of a child consumes up to 225% of the glucose of an adult's brain (Diamond and Hopson, 1998). Fed with a constant supply of oxygen, water, glucose, protein and trace elements the brain of a child will treble in size until it reaches the adult weight of about 1300 – 1500grams. Growth takes place during our sleeping hours fed by a flow of blood that reaches between 32 and 35 litres per hour – that's about 800+ litres per day!

Proper nutrition helps protect the brain against toxins, improves mental alertness and assists in the formation of memory. The brain's most crucial need is for oxygen. Beyond that, amino acids provide the raw materials for the brain to synthesise its chemical modulators. In order for these raw materials (small nutritional molecules) to make it into the pristine environment of the brain, the body's blood supply must break through the Blood-Brain Barrier (a tight seal of cells that lines the blood vessels in the brain). The Barrier acts as a blocking system against various toxins but can also prevent

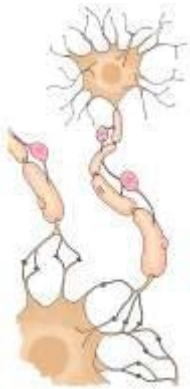
the administration of many beneficial agents such as medicines from reaching the brain through the bloodstream.

To maintain mental alertness and cognitive performance the brain requires a steady supply of oxygenated blood, a steady supply of blood sugar – glucose, and between 8 – 12 glasses of water per day, depending on body size, weather and level of physical activity. Oxygen is supplied through the carotid artery, which receives priority order in freshly oxygenated blood from the heart-lung area. Up to 20% of the body's oxygen intake is utilised by the brain. Deprive the brain of oxygen and consciousness may be lost within less than a minute. Poor airflow, stuffy and overheated classrooms may lead to cognitive underperformance. Researchers Wlodlowski (1985) and Dustman (in Jensen 1995) showed that aerobic exercise improves thinking and learning. Increased blood flow to the brain helps to increase the oxygen available and therefore the brain's capacity to think.

Water is central to optimal brain functioning. Consisting of about 78% water (8% fat and 10% protein) the brain is highly suspect to dehydration, more so than any other organ within the body. Poor hydration leads to an increase in salt concentration in the blood possibly stimulating the release of corticoids into the bloodstream. Corticoids are associated with elevated stress levels. Researchers Levine and Coe (1989) suggest this hormone response to stress is "markedly reduced or absent" (Jensen 1998) when water is available to the learner. Classic signs of dehydration amongst school children include a decline in attentiveness, lethargy and increasing frequency of headaches. Teachers in South Australian schools have found that in classrooms where students are encouraged to drink water learning improves, as does attentiveness.

The case has been set for reduced seat time, active classrooms and water bottles on each student's desk. A word of warning – cordials, soft drinks, fruit juices, tea and coffee do not have the same benefit to the brain as water. These products often contain diuretic agents - they remove larger than usual amounts of water from the bloodstream so that more is expelled from the body as urine.

The human brain is composed of billions of nerve cells called neurons and support cells called glial. Along with oxygen, the energising sugar, glucose, is the main fuel of the brain. As a result of the metabolism process (chemical process that utilises oxygen to release energy) throughout the body and including the brain, substances called oxygen free radicals are released into the bloodstream. The free radicals have a toxic effect on a fatty substance in the brain called myelin. Myelin is strongly implicated in memory formation, it provides a fatty white shield around parts of neurons that repeat rote movements or habits. Free radicals in the brain can cause "lipid peroxidation" (where brain fat literally becomes rancid). To counter the effects the brain needs anti-oxidants – these neutralise free radicals. Research shows that people given anti-oxidants early in life stay healthier, suffer less chronic illness and live longer (Carper 2000). Foods that provide good anti-oxidants include prunes, raisins, blueberries, blackberries, garlic, kale, strawberries, spinach (raw is best), broccoli, avocado and raspberries. Also include red wine, dark chocolate (Yeah!) and tomato products, especially tomato sauce and tomato pastes. Eat Omega-3 fatty oils and drink tea to quickly and easily feed your brain antioxidants.



Recent studies are revealing more about the importance of eating food that enhances cognition and protects the brain. Whilst the research is stating the benefits of proper nutrition it also highlights the deficiency in memory and behavioural problems associated with poor nutrition. To complicate the matter, not all nutritional deficiencies result from poor food choice(s). Malabsorpsion, an inability of the body to absorb nutrients or to utilise them once they have been absorbed may require dietary changes or even medical intervention. Overeating may lead to obesity whilst eating even small amounts more of the best foods provides no *guarantee* of improved learning performance. Research into diet and nutrition is occurring at a fantastic rate.

Let's explore the influence that nutrition has on the developing brain. Food provides energy (kilojoules) and nutrients (primarily protein, carbohydrate and fat). Vitamins and minerals are also found in food but in smaller amounts. During digestion, larger molecules of food are broken down into smaller molecules that can then be readily absorbed into the blood stream. Carbohydrate and fat are metabolised by body cells to produce energy. Each of these metabolic processes is aided by a specific enzyme, which in turn often requires a specific vitamin or mineral. The ingredients found in food are

critical for the brain to manufacture its own chemicals – a task it does not trust to any other part of the body. One of the key amino acids found in protein is tyrosine. The brain uses tyrosine to manufacture dopamine and noradrenaline – these two excitatory neurotransmitters are central to alertness, positive moods, attention span and awareness. To boost alertness, eat foods containing a natural source of tyrosine. These can be divided into categories: Animal Protein, Nuts, Legumes and Seeds (see table 1). Protein rich foods would include fish, eggs, poultry, lamb, beef, veal, pork, kangaroo, cheese, yoghurt, almonds, cashews, brazil nuts, walnuts, pecan, macadamia, pistachio, dried peas and dried beans, soya, peanuts, lentils, lima, chick and kidney beans. There is a limit to the amount of protein the brain can handle. An oversupply has no beneficial effect on the brain.

Another key amino acid found in food is tryptophan. Whilst tyrosine (found in protein) enhances thinking, tryptophan slows it down. Tryptophan is one of the key amino acids found in high-carbohydrate foods. The brain uses tryptophan to manufacture serotonin – a neurotransmitter that is central to calmness, sleep induction, regulation of mood and message transmission within the brain. Serotonin is one of the "Master" chemicals in the brain. Some researchers are suggesting that imbalance in the serotonin chemical in the brain could lead to abnormal brain cell message transmission, which might even contribute to the development of eating disorders (Society for Neuroscience 2001). To induce calmness or relaxation, eat foods containing a natural source of tryptophan. These can be divided into categories: Starchy Carbohydrates, Starchy Grains and Sugary Carbohydrates (see table 2). Carbohydrate rich foods include potatoes, pumpkins, sweet potato, sweet corn, unripe bananas, wholemeal bread, pasta, cakes, pastries, wheat flour products, rye, rice, oats, barley, millet, honey, maple syrup, sugar, molasses and dried fruits. Carbohydrate foods are crucial for the brain, but some are better than others while some can create havoc with glucose and insulin levels in the brain.

Essentially, carbohydrates differ in their capacity to raise glucose levels – some packing a short and powerful glucose punch while others provide a steady, gradual effect. The current scientific view is that each food has its own distinctive signature for the rate it raises blood sugar levels. Technically, those foods that *quickly* raise glucose levels are called "high glycemic index" or high GI foods (the term glycemic refers to blood sugar or glucose). Those foods that *gradually* raise glucose levels are "low glycemic index" or low GI foods. A diet that is persistently high in high GI foods

can threaten the brain long-term while providing sugar surges in the sort to medium term. It is important for individuals to know what carbohydrates will help them maintain optimal blood glucose levels over an extended period of time. For a steady supply choose foods such as, apples, dried apricots, baked-beans, oatmeal, carrots, cherries, some chocolate bars, skim milk, fettucine, oranges (including juice) spaghetti, lentils, peanuts, soybeans and low-fat yoghurt.

The chemistry of fat in the brain can profoundly influence the structure and workings of the brain. According to Carper (2000) *The type of fat you put in your brain from birth to death is one of the most critical decisions you can ever make for the good or detriment of your brain* (Page 49). Be wary of saturated fats, such as those often found in meat, whole milk, butter and cheese; trans fatty acids such as those often found in hot chips, margarines and fast fried foods, and overloads of Omega-6 vegetable oils, such as those often found in corn, safflower and sunflower oils.

The saturated fats tend to cause detrimental effects on memory and learning, and the effects appear to be cumulative. Periodic binges are not as bad as sustained dietary intakes. One of the current areas of research interest is the relationship between high levels of consumption of saturated fats and its affects on the hormone insulin. Researcher Greenwood (in Carper, 2000) says *that the major underlying reason saturated fat harms the brain is that it predisposes and accompanies diabetes, and is the root of memory problems* (page 54).

Inferior brain function has also been linked to an increase in consumption of Omega-6 oils, associated with a decrease in Omega-3 consumption. It is not so much the increase in Omega-6s that bothers nutritionalists but the ratio between the 6s and the 3s. Evidence suggests a ratio of about 4:1 – Omega-6 to Omega-3 is ideal. To understand how this ratio currently sits, Carper (200) suggests that most Americans now eat Omega-6 at a 15:1 - 20:1 ratio to Omega-3. The High levels of Omega-6 oils may lead to spectacular degeneration and ultimately, the destruction of neurons (Carper, 2000). Omega-3 fats help to curtail the damaging effects of Omega-6 oils and at the same time inject vitality into the brain. Omega-3 oils can help defeat free radicals, reduce immune responses that cause brain inflammation, positively change the firing patterns of neurons, and, support the neurotransmitters in the brain make contact with receptor sites on neighbouring dendrites. Further, evidence suggests that the Omega-3 found in fish oils helps

regulate serotonin, a neurotransmitter known to regulate positive moods. Depresses, impulsive and violent persons often have low serotonin levels.

The two specific acids found in Omega-3 are DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid). They are found in fatty fish or Omega-3 supplements. Best sources include, mackerel, herring, sardines, tuna, anchovy and salmon. Lower-fat fish such as whiting, cod, snapper and flounder contain little Omega-3. Evidence suggests that DHA may be a powerful antidepressant, may reduce feelings of hostility and aggression, may speed up brain waves leading to faster thinking and may even protect you from developing Alzheimer's disease (Carper, 2000). Compelling isn't it.

Vitamins are essential complex chemicals that the body is unable to manufacture itself and therefore we need to take them in through our diet. Vitamins are essential to brain development, repair and maintenance, and brain metabolism. Minerals and trace elements enhance brain alertness and memory. A large industry has developed around the provision of vitamin and mineral supplements and with it a familiar range of warnings: "…taking supplements unless under medical direction is not advisable…", "…exceeding the body's daily requirement is not beneficial…" and "…large doses may be harmful..." Widely available preparations of vitamins (especially multi-vitamin) are not likely to be harmful unless the recommended dose is greatly exceeded.

Especially important to cognition are vitamins A, B, C, E and folic acid (Jensen 2000). Researchers Riggs and colleagues (1996) found that individuals with the highest levels of B-12, B-6 and folic acid in their blood performed significantly better on memory and spatial copying tests when compared to subjects with lower levels of these vitamins. B-vitamins are found abundantly in shellfish, chicken, fish and whole-wheat products. Folic acid is found in liver, mushrooms, fortified cereals and leafy green vegetables. Researchers Chaing, et al (1998) found that the hippocampus (a section of the brain linked to memory formation and retrieval) has particular cell receptors for vitamin A and is known to activate brain-neuron activity. Dietary levels of vitamin A (or its precursor beta-carotene) can be found in liver, egg yolks, milk, cheese, carrots, spinach, broccoli, red and green peppers, pumpkin, sweet potatoes, apricots, peaches, rock-melons and mangos.

Researcher Prasad (1991) reports that there is a large body of evidence showing that iron deficiency states are associated with reduced cognitive function, maladaptive behaviour and motor development. The body may have difficulty in absorbing iron into the bloodstream, especially during stress and physical growth spurts, in addition to the loss during menstruation. Vitamin C, taken with iron, seems to greatly enhance the body's capacity to uptake iron into the bloodstream. Sources of iron include dark green vegetables, liver, red meat, poultry, fish, eggs, grains and rice. Sources of vitamin C include orange juice, broccoli, citrus fruits, tomatoes, potatoes and melons.

Vitamin E is found in vegetable oils, liver, eggs, green vegetables, fruit and whole-grain cereals. It is a good anti-oxidant source to fight free radicals.

For a young, developing brain the most important meal of the day is arguably breakfast. The metabolic rate in the brain increases soon after the alertness chemicals move us out of sleep patterns and into daytime cycles. An increase in blood flow to the brain will ensure that nutrients are carried to the brain for conversion into chemicals. Protein in the morning will likely ensure alertness for classes, while carbohydrate will likely induce relaxation. Eating protein just before carbohydrate may ensure that tyrosine becomes the dominant chemical in the brain after early morning food intake. Most foods have a mixture of amino acids so it is the *dominant one*, not the *only one* we are addressing here. If the order of food taken in the morning is important, eat the protein first.

Interesting research studies by Conners, Harpers and Peters, Goldman et al and Bolton (all in Jensen 1995) show the growing brain to be especially vulnerable to sugar. Attention spans, focus, behaviour and activity levels are all influenced to varying degrees by sugar. Further, it seems that when sugar is taken with carbohydrates the effects on the child were much worse than when taken with protein. In fact, the studies suggest that sugar is beneficial to the brain when taken with protein. From these research studies it would appear that protein provides as protective role to the brain when sugar is absorbed with it, while the sugar – carbohydrate mix may lead to unwanted outcomes.

Given the wide variance in students' eating habits, from no breakfast, high carbohydrate/sugar mixtures, high/low GI foods, and the more brain-alertness protein/carbohydrate mixes, it would seem that classroom teachers may be dealing with typical learning problems and behaviour difficulties where the root of these may lay primarily in poor nutrition or under-nutrition. Schools have traditionally responded to such scenarios by running education programs, offering breakfast programs and breaking the day into chunks where regular meal breaks are provided. The timing of meal breaks as well as what is eaten is increasingly the subject of action research in schools. A study by Jenkins et al published in the *New England Journal of Medicine* showed that brains run better on a "Nibbling Diet." Nibblers were shown to have better cognitive functioning, fewer discipline problems, lower cortisol levels, better glucose tolerance and maintained better insulin levels. Some South Australian primary schools have reported significant drops in behaviour problems and increased learning performance since making nibbling food available at various times throughout the day. What is eaten during these times remains the subject of further research. However, suggestions include celery and carrot sticks, yoghurt-based dips, yoghurt or fresh fruit, peanuts (subject to due consideration of a child's age), rice cakes, popcorn (unsweetened variety), cheese or cheese sticks, tomato slices and mushrooms. Many kids will bulk at the sheer thought of digesting some of these so a program that educates, and provides good role models, might lead to healthier diets. Is your school canteen a positive nutritional role model?

The "Nibbling Diet" has its opponents, especially as it relates to tooth decay. Sugary carbohydrate food varieties such as dried fruit, small biscuits, muesli bars, cakes, potato crisps, sticky breakfast bars and sweets can cause dental decay if they stay in contact with the teeth. The bacteria ferments any sugars from residues of carbohydrate foods. While fermenting the sugars, acids are produced which can eat into tooth enamel. Saliva helps to counteract the effects of the acid produced by bacteria, however it needs time to complete its functions before the next meal is introduced. The worst attacks by acids comes from constant nibbling of sugary carbohydrates and it strongly recommended that such foods are avoided – or at least taken in one or two bursts throughout the day (from the perspective of your teeth, it is better to have 1 or 2 acid attacks a day than 10 or 12, even better is none at all!).

Too much time in between eating can cause loss of concentration and decrease alertness. Benton, in Carper (2000) draws on research that suggests we eat about 6 smaller meals per day as opposed to 3 larger ones. "Our bodies were designed to eat little and often." Numerous research studies (Jensen 1996) indicate improved cognitive performance when subjects ate on a nibbling diet. Poor nutrition can lead to a range of body disorders, some with life long consequences. Yet too much nibbling can cause dental decal and the wrong type of nibbling can cause glucose surges. The research presents educators and the wider community with difficult decisions. We need to be

vigilant so that we do trade one set of problems for another. Perhaps the responsibility for seeking direction with regard to school children's eating habits should come from an informed community - awareness of the issues leads to better choices. Read the research and make adjustments as you feel appropriate. Rather than an "all or nothing" approach, what would a balanced nutrition program look like within classrooms, and who would need to be a part of the decision-making processes?

Summary: 10 Key Tips for Healthy Brain Function

1. Eat Omega-3 Fish Oil: present in fatty fish such as salmon, tuna, sardines. Supplements with DHA and EPA are best.

Fights attacks by free radicals, reduces inflammation caused by immune system responses, assists function of neurotransmitters (eg regulates serotonin), modifies structure of brain cells (eg keeps cell-membranes soft and flexible). Some evidence to suggest that Omega-3 fish oil may improve learning performance of students with ADD, ADHD and dyslexia.

2. Watch vegetable oils – these contain Omega-6 oils, which can produce inflammation and cell damage in the brain.

The best vegetable oils to use are olive oil (this aids memory formation) and canola oil. Vinegar is also good brain food and can be combined with these in salad dressings.

3. Cut back on sugar, especially sucrose and fructose. Blood sugar is vital to good brain function, but high sugar levels may lead to sugar spikes and greater susceptibility to diabetes, strokes, arterial damage and brain dysfunction. Dried fruits (high in concentrated fructose) do not provide the brain directly with energy because fructose cannot pass the blood – brain barrier.

Eat more complex carbohydrates and fewer simple carbohydrates. Legumes (including non-salted peanuts), nuts, vegetables, popcorn are good for steady blood sugar levels.

4. Take anti-oxidants. Free radicals are chemicals released in the blood stream as a result of our breathing, or burning of glucose during normal metabolism. Free radicals attack cells throughout the body – in the brain, they cause 'lipid peroxidation' (where brain fat literally becomes rancid) and other cell damage. Anti-oxidants neutralise free radicals.

The best anti-oxidant foods include prunes, raisins, blueberries, blackberries, garlic, kale, strawberries, cranberries, raw spinach and raspberries. Tea, red wine, tomato products (especially tomato paste and sauce) and chocolate are good sources of anti-oxidant chemicals also. Five important anti-oxidants to take are Vitamins C and E, Lycopene, Coenzyme Q10 and Lipoic Acid – it may be worth taking these in supplement form.

5. Avoid overdosing on caffeine.

Caffeine can be a useful memory enhancer, but 120mg (2 cups of tea) a day is sufficient for this function. Caffeinated beverages can provide a mental lift that lasts for several hours. Whilst coffee has been cited as a brain stimulant, it has also been noted to decrease blood flow to the brain at the same time. Any more can cause insomnia, anxiety and high blood pressure.

6. Take vitamins – but follow manufacturers directions.

B vitamins are especially important, along with Vitamins C and E, and the minerals selenium and chromium. Lecithin is an important dietary inclusion because it forms part of the myelin sheath that surrounds the axons of high functioning neurones.

7. Try using Ginkgo Biloba and Ginseng.

Gingko provides support for brain cells and ginseng enables cells to better utilise energy.

8. Eat eggs (in moderation).

Egg yolks contain vital choline, a B vitamin that limits the levels of homocysteine in the blood (this causes clogging of blood vessels in the brain and increases the risk of strokes). Homocysteine levels are increased by smoking.

9. Limit alcohol consumption.

Alcohol does have a negative effect on blood pressure and so should be limited as much as possible.

10. Limit salt intake.

Salt (sodium) boosts blood pressure in some people and can make blood vessels more permeable and leaky.

Source: Carper J (2000), *Your Miracle Brain*, Harper Collins

Tables

Sources of Protein

Animal Protein	Legumes	Nuts	Seeds
Cheese	Dried beans	Almonds	Sunflower
Yoghurt	Dried peas	Cashews	Sesame
Eggs	Soya beans	Brazil	Tahini
Fish	Peanuts	Hazel	Linseed
Poultry	Lentils	Walnuts	Pepitas
Lamb	Lima beans	Pecan	
Veal	Chick peas	Macadamia	
Beef	Kidney beans	Pistachio	
Pork			
Kangaroo/Game			

Table 1

Sources of Carbohydrate

Starchy carbohydrates	Starchy grains	Sugary carbohydrates
Potatoes	Wholemeal bread	Honey
Pumpkins	Pasta	Sugar
Sweet potatoes	Wheat flour products	Molasses
Sweet corn	Buckwheat	Dried fruits
Unripe bananas	Cakes and pastries	Maple syrup
	Rye	
	Rice	
	Oats and barley	
	Millet	

Table 2

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