Optimizing Nutrition for Girls Affected with Rett Syndrome

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Section One: Nutrition Makes a Difference

Five simple rules to aim for:

1. Always try to buy organic food: every living creature has an individual tolerance level for toxins. The liver is the main detoxifying organ in the body and some people can handle more toxins than others. Girls are already more susceptible to toxins because their livers clear a high volume of hormones (estrogen and testosterone). It is best to put the least amount of stress on our bodies so always aim to buy organic. Organic fruits and vegetables are free of pesticides and organic meats are free of additional hormones and drugs therefore they require less detoxification by the body.

2. Use good quality water: the type of water you decide to give your child is a difficult decision. Bottled water has varying degrees of quality and reverse osmosis depletes necessary minerals from the water. Unfortunately tap water has chemicals and residual pharmaceuticals but may be the only choice available.

3. Use age appropriate liquid vitamins: our girls clearly have digestion issues. They suffer from osteopenia and this may be partially due to an inappropriate fat metabolism therefore inappropriate absorption of fat soluble vitamins required for bone development. Liquid vitamins do not taste very good but are optimally absorbed and ensure that all the vitamins are properly represented. Always give vitamins with food containing fat (meat, milk products, etc.) so the enzymes required for digesting the food are also digesting the vitamins. Health food stores will be able to help you in your choice of vitamin products.

4. Use high quality fish oil: once again give with food containing fat.

5. Completely avoid MSG (see appendix) and aspartame (Nutrasweet) additives.

Liquid vitamins and high quality fish oil can be found at health food stores.

***Apart from vitamins and fish oils I would like to caution you against using other supplements before thoroughly discussing with your doctor or neurologist. It is unclear how girls affected with Rett Syndrome will process any drug or chemical and supplements are drugs. Food is the safest way to deliver the nutrients the body requires.

Rett Syndrome and Improving Nerve Function

The basal ganglia are paired nerve cell clusters deep within the cerebrum and upper brain stem (see Section Two for details regarding the brain and nervous system). They plan, initiate, and control complex patterns and sequences of learned movements, particularly slow, steady movements, such as walking. Their structures are interconnected by many nerve fibre pathways. Nerve cells from all areas of the cerebral cortex send nerve fibres to the basal ganglia. The basal ganglia transmit messages back to the cortex by way of the thalamus to regulate motor functions of the cortex. The normal functioning of all these connections is vital for the smooth control of voluntary movements.

Planning a movement is actually very complicated. It evolves in association areas of the cerebral cortex (supplementary motor area, motor area & areas of the parietal cortex). As seen in Section Two, structures under the cortex, such as the basal ganglia, the cerebellum, and the brain stem, control different aspects of voluntary movement, such as its planning, initiation, updating and coordination.

Information travels by direct nerve fibre connections to nerve cells of the brain's motor cortex. Motor nerve cells then instruct the skeletal muscles to contract. Information also travels from motor nerve cells in the premotor cortex and areas of the parietal cortex to instruct the skeletal muscles.

Nerve cells that originate in the cortex, and in some areas beneath the cortex, transmit signals via long nerve fibres that are located in the spinal cord. These nerve fibres form tracts that control the spinal cord's lower motor nerve cells.

The brain transmits instructions to lower motor nerve cells through the spinal cord. The descending motor pathways activate these spinal motor nerve cells. The spinal motor nerve cell fibres exit the spinal cord and travel in the peripheral nerves. The instructions reach their final destination: the skeletal muscle fibres. These fibres respond by contracting or relaxing to bring about a voluntary movement. Each spinal motor nerve cell acts on certain muscle fibres.

Existing therapies such as occupational and physical are paramount for girls diagnosed with Rett Syndrome. Constant therapy instills 'motor memories'. Motor memories occur when you start to learn rapid, skilled movements. Girls affected with Rett Syndrome hopefully could acquire 'motor memories' with any repeated movement. Your cortex forms 'motor memories' through repeated performance of the movement involved. Rett girls must work at each movement while learning the skill but once motor memories are ingrained they will hopefully perform them automatically. When fully mastered the movements look normal. Speech pathology and behavioural therapy in a large part operate in the same manner.

Neurotransmission:

A nerve cell has 2 functions:

- creating a nerve impulse or signal along its axon
- Transmission of this signal from one neuron to another or to an effector cell to elicit a response.

Neurotransmitters are chemicals released by a nerve ending (synapse); these chemicals bind with an adjacent structure and if received in adequate amounts, elicit a specific physiological response. Many chemicals act as neurotransmitters, I will detail just a few.

The neurotransmitter dopamine has several significant functions. Loss of dopamine containing nerve cells in one area of the brain characterizes the movement disorder known as Parkinson's disease. The amino acid tyrosine is converted to dopamine and continues to be converted to norepinephrine. Norepinephrine is a modulatory neurotransmitter that selectively enhances or reduces the effects of other neurotransmitters. Norepinephrine helps us cope with emergency situations when released outside the brain in response to stimulation by acetylcholine, another neurotransmitter.

GABA is the major inhibitory neurotransmitter in the brain. GABA is derived from glutamic acid. Loss of inhibitory GABA nerve terminals in the cortex may cause increased excitability of nerve cells in people with epilepsy, resulting in seizures. Serotonin is a form of tryptophan found in platelets and in cells of the brain and intestine. It acts as a neurotransmitter and is important in controlling our mood and sleep patterns.

The amino acids glutamate and aspartate are the major excitatory neurotransmitters in the CNS. Glutamate also helps to form long term memories. There appears to be high levels of glutamate in some girls afflicted with Rett Syndrome so I will explain the glutamate pathway in greater detail. Glutamate functions in the cortex, cerebellum and spinal cord. Gluatamate receptors (typically another neuron) are classified as NMDA and non-NMDA receptors.

NMDA receptors affect the levels of sodium, potassium and calcium within a neuron. Non-NMDA receptors do not affect the level of calcium. Over stimulation of these excitatory receptors by glutamate causes toxic effects.

Synthesis of nitric oxide occurs in response to glutamate. Overstimulation of NMDA causes an increase in calcium levels which stimulate nitric oxide production. Excessive nitric oxide is toxic to neurons; therefore **it is imperative that your girl receives absolutely no MSG or aspartame food additives**. Be careful as MSG can be hidden in other ingredients – see the Appendix at the back of this document for hidden sources of MSG.

The amino acid glutamine is formed into glutamate. Glutamine is 10-15x more concentrated in the brain than in the blood. It is a source of energy for the brain. Glutamine is converted in the glia cells of the brain into glutamate. There are special enzymes within the glia cells that allow glutamine to be converted to glutamate when it is

needed by the neurons for neurotransmission. When glutamate accumulates in a concentrate higher than is normally safe for the brain some is reconverted to glutamine and stored in the glia cells. It is currently unknown why glutamate collects in the brains of girls with Rett Syndrome so avoid supplementation of glutamine until further findings or after you discuss with your health care provider. Glutamine as it relates to muscle function will be discussed in the further section.

B Vitamins

- All the B Vitamins are extremely important to neuron health. Supplement all girls with a good quality liquid multi-vitamin

The chemistry of the B Vitamins is very detailed so I will only include highlights as they apply to the brain and neurons.

B1 (Thiamin)

Thiamin pyrophosphate (TPP) is the active form and it has a specific role in neurophysiology. It works at the nerve cell membrane to allow displacement so that sodium ions can freely cross the membrane. Thiamin is needed for the metabolism of carbohydrates, fat and protein. It is especially involved in carbohydrate metabolism in the brain.

- Diabetic sensory neuropathy: Mirsky, Stan. Diabetes: Controlling it the easy way. Random House, 1981. Abstract: about 80% of patients were found to improve when supplemented with B1. TPP is involved in the oxidative pathway and may be responsible for the energy required for nerve conduction.
- B1 def. May decrease the availability of serotonin: AJCN Abstract: 20 patients, mostly teenagers, who had a varied array of symptoms classified as anxiety were studied. These symptoms included irritability, intermittent diarrhea, lack of appetite, fatigue and insomnia. It was found that these patients had a high intake of simple carbohydrates. It was postulated that this increased consumption of carbohydrates resulted in an increased stimulation in the brain. Every one of the subjects studied had a decreased level of serum thiamin. Supplementation of 150-600 mg of thiamin completely relieved symptoms in these patients.

There is very little evidence of thiamin toxicity. In monkeys the lethal dose is greater than 350 mg/kg of body weight.

Sources of Thiamin

Brewer's yeast	1T	1.25 mg
Sunflower seeds	1/4cup	0.72 mg
Dried soybeans	1/4cup	0.58 mg
Oatmeal	1cup	0.19 mg
Salmon steak	3oz	0.15 mg

As well as whole milk, baked beans, almonds, peanuts

Cooking affects thiamin content. Cook rapidly in small amounts of water. Save cooking water to add to food.

Alcohol, aging, black tea and chlorinated water all destroy thiamin

B2 (Riboflavin)

A deficiency of riboflavin usually occurs in concert with other B vitamin deficiencies. However, clinical signs are less dramatic than other deficiencies.
Riboflavin

a) causes the activation of B6
b) is involved in the conversion of folate to its coenzymes
c) aids in beta oxidation of fat metabolism
d) is involved as a coenzyme component of the dehydrogenases in the first step in glucose metabolism
e) is needed for the production of corticosteroids; erythropoiesis; gluconeo-genesis; and thyroid enzyme regulation

In animals riboflavin deficiencies cause baldness, anemia, neuropathy, corneal vascularization (precataracts) and congenital malformations.
No toxicity to riboflavin has been found.

Sources of Riboflavin

Kidney, beef	3oz	4.1mg
Liver, beef	3oz	3.6mg
Liver, chicken	3oz	1.5mg
Heart, calf	3oz	1.2mg
Yogurt	1cup	0.5mg

Vegetables: broccoli, spinach
Whole milk has relatively large amounts of B2 but riboflavin is light sensitive and that is why most milk is now kept in opaque containers.

B3 (Niacin)

Niacin serves as a coenzyme for a group of enzymes known as dehydrogenases. These dehydrogenase enzymes are responsible for innumerable biochemical reactions in the body including detoxifying alcohol and utilizing carbohydrates, fats and proteins. Niacin is also required for the synthesis of both fatty acids and steroids. Niacin is also vital for the regeneration of reduced glutathione from oxidized glutathione, which is an important step for increasing antioxidants.
Niacin is also a cofactor for delta 6 desaturase required for the conversion of linoleic acid into GLA, this will be discussed under the section Fish Oils.

Naturopathic Doctors use niacin to treat anxiety, Multiple Sclerosis, Bell's palsy, trigeminal neuralgia, tardive dyskinesia (impaired movement from long term over use of L-dopa), insomnia, Raynaud's syndrome, menstrual cramps and Alzheimer's.

Sources of Niacin

Liver, beef	3oz	14mg
Tuna	3oz	11.3mg
Chicken	3oz	10.6mg

Kidney, beef	3oz	9.1mg
Swordfish	3oz	8.7mg
Salmon steak	3oz	8.4mg
Halibut	3oz	7.2mg

Vegetables: potatoes, tomatoes, asparagus, mushrooms

Niacin can be synthesized from tryptophan with B1, B2, and B6 as essential cofactors. 60mg of tryptophan yields 1mg of niacin.

Niacin IS toxic, do not over supplement.

B5 (pantothenic acid) – Vitamin B5 is primarily required for the adrenal glands and will not be reviewed here. A deficiency of pantothenic acid is very uncommon because of its wide distribution in foods.

Experimentally induced deficiencies in humans causes insomnia, leg cramps, numbing of the hands and feet, mental depression, decreased antibody formation, easy fatigue, postural hypotension, gastro-intestinal disturbance, and upper respiratory infections.

Interestingly, Dr. Roger Williams conducted a study with 2 groups of mice. They were fed identical diets, but one group received pantothenic acid in their drinking water. The supplemental group lived, on average, 19% longer.

B6 (pyridoxine)

Pyridoxine in its active form is pyridoxine 5 phosphate (P5P) and it is vital for a number of functions.

a) transamination – the transfer of NH2 to other amino acids
b) deamination – removal of amino groups from certain amino acids to be used for an energy source
c) desulfuration – transfer of the sulfhydryl group (HS) from one amino acid, methionine, to another, serine, to form cysteine.
d) Decarboxylation – the removal of COOH groups from certain amino acids to form another compound. Required in the synthesis of the neurotransmitters serotonin, norepinephrine, and histamine from tryptophan, tyrosine, and histamine, P5P can be highly concentrated in the brain even when low levels exist in the blood.
e) Tryptophan to niacin requires P5P
f) Linoleic acid to GLA requires P5P
g) Vital for the formation of sphygolipids involved in the development of the myelin sheath surrounding nerve cells.

Sources of Pyridoxine

100% bran cereal	1 cup	12.1 mg
40% bran cereal	1 cup	0.80mg
pork loin chop	3 oz	0.78mg
watermelon	1 slice	0.69mg

Banana	1 med	0.66mg
Avocado	1 med	0.56mg

Fish: mackerel, halibut, haddock, ocean perch, tuna

Adults given deoxypyridoxine (prevents P5P from absorbing) developed depression, nausea, vomiting, mucous membrane lesions, dermatitis and peripheral neuritis, ataxia, hypoeracusis, hyperirritability, altered mobility and alertness, abnormal head movements and convulsions.

Due to the processing of food we are consuming less than 90% of RDA. Competitors; (prevent pyridoxine from being absorbed) with pyridoxine in the environment increases need for supplementation. Common competitors are hydraxzine compounds (found in some drugs), used to ripen fruit and as a herbicide
Yellow dye #5
Birth control pills
PCB's
Tobacco
Alcohol
Caramel colouring: this is produced from heating up of certain sugars and has been found to prevent B6 from entering the brain.
Malabsorption causes extreme deficiencies.

Theurapeutic supplements have been used with success for Carpal tunnel syndrome, Infant seizures, Rheumatism, tardive dyskinesia, diabetic neuropathy, dementia, hyperkinetic behaviour, schizophrenia and MSG sensitivity which our girls seem to be prone too.

B6 is toxic and in very large doses it can cause axonal degeneration of the sensory nerves, and does interact with a number of drugs. Do not supplement outside of a liquid vitamin unless under the care of a doctor. If your daughter is taking L-dopa then B6 will convert the L-dopa into dopamine outside the blood brain barrier which will cause the L-dopa to be ineffective as dopamine can not pass the blood brain barrier.

If taking Sinemet (L-dopa and Carbidop) B6 may actually increase the drug's effect. Carbidopa stops conversion of L-dopa outside the blood brain barrier. B6 would then cross the blood brain barrier along with L-dopa. Once inside the brain B6 would then convert the L-dopa into dopamine where it could then effectively be used by the brain.

B12 (Cobalamin)

Cobalamin is involved as a cofactor in the transfer of methyl groups. Cobalamin is only absorbed in the presence of intrinsic factor which is released from cells in the stomach and along with hydrochloric acid and proteases B12 enters the blood. B12 is needed to remove the methyl group from methyl tetrahydrofolate so that THF can be used for the synthesis of DNA.

The methyl B12 is used to transfer the methyl group onto homocysteine to form methionine. Methionine is important in methyl transfers and is necessary for the synthesis of myelin sheaths. In the absence of B12, DNA is not produced and the cells grow without dividing.

B12 is also involved in carbohydrate metabolism. It has been noted that lactic acid and pyruvate increased from 50% to 100% during B12 deficiencies. Neurological problems often occur when there is a B12 deficiency because the nervous system relies on carbohydrates as its main source of fuel.

Sources of B12

Liver, beef	3oz	93.5 µg
Clams	3oz	60 µg
Salmon	3oz	3 µg
Lamb	3oz	2.6 µg
Lobster	3oz	2.6 µg
Beef	3oz	2 µg
Tuna	3oz	1.8 µg
Cheese	3oz	1-2 µg
Milk	8oz	0.9 µg

B12 is not affected by normal cooking methods

Folic acid (folate)

Folacin, the active form was first isolated from green leafy vegetables in 1941 and is considered an essential nutrient.

Folic acid:

a) facilitates the synthesis of purines: guanine and adenine and pyrimidine thymine
b) is essential for the formation and maturation of red and white blood cells
c) folacin is the single carbon carrier in the formation of heme
d) folate is essential in the conversion of histidine to glutamic acid
e) and phenylalanine to tyrosine

Before conception supplementation with folate decreases the incidence of spinal bifida, cleft palate and fragile X.

- Botez, Cadotte, Beaulieu and Pichette. *Neurological Disorders Responsive to Folate Therapy.* Can Med Assoc J. 115:217-23, 1976. Abstract – three women with acquired folate deficiency had mild signs and symptoms of restless legs, depression, muscular and mental fatigue, depressed ankle jerks, diminution of vibratory sensation in the legs and chronic constipation. All three recovered with folate supplementation.

Sources of Folate

Liver, chicken	3oz	654 µg
Brewer's yeast	1 T	313 µg

Black-eyed peas	½ cup	280 µg
Lentil beans	½ cup cooked	180 µg
Turnip	1 cup	171 µg
Orange juice	1 cup	136 µg

Other fruits: nectarines, cantaloupe, pineapples, avocados
Vegetables: spinach, asparagus, sweet potatoes, beet greens, broccoli, romaine lettuce, Brussels sprouts
Milk and eggs

Vegetables stored at room temperature suffer considerable loss of folic acid.
Anticonvulsant drugs may also cause folate deficiency.
Folate deficiencies result in poor growth, megaloblastic anemia and other blood disorders, glossitis, and GI tract disturbances.

Folate may interfere with anticonvulsants do not over supplement before discussing with your doctor.

Vitamin E

Vitamin E is an anti-oxidant, which means it protects you from oxidative damage. Oxygen is such a powerful reactant that it can disrupt cellular function. In particular, Vitamin E protects fatty acids against oxidative damage caused by various pollutants, peroxides and free radicals formed during metabolic processes. If vitamin E is deficient PUFA's (polyunsaturated fatty acids which contain at least two double bonds, and include omega 3's. They tend to be unstable and susceptible to oxidative damage.) may become oxidized in the body.

Children with Down Syndrome have an increased oxidative problem and there is some evidence children with Rett Syndrome may as well. Vitamin E serum levels were analyzed in 28 patients with Rett Syndrome. Lower Vitamin E levels were found in nine cases (32%). Rett girls may have a problem with oxidative free radical metabolism.

- Indian Pediatr. 2004 Mar; 41(3): 297-8
- J Neurol. Sci. 1998 Apr 1; 156(2): 227-30

Vitamin E works synergistically with other antioxidant nutrients including selenium, Vitamin C, B-carotene and others to remove free radicals and peroxides.
Apoptosis (a form of cell death) accounts for much of the pathology seen in such diseases as Alzheimer's, Parkinson's, Huntingtons' and Lou Gehrig's disease, they are marked by the loss of brain neurons. Elevated apoptosis in these neurological diseases seems to be related to lack of production of the nerve growth factor and to free radical damage. It seems likely that a combination of such factors could cause many cells to destroy themselves.

Vitamin E is vital for protecting nerve and muscle cell function. In children who had a lack of bile necessary to absorb fats and vitamin E, it was found that vitamin E was needed to protect against damage to Schwann cells, dorsal root ganglia and muscle cells.

Sources of Vitamin E

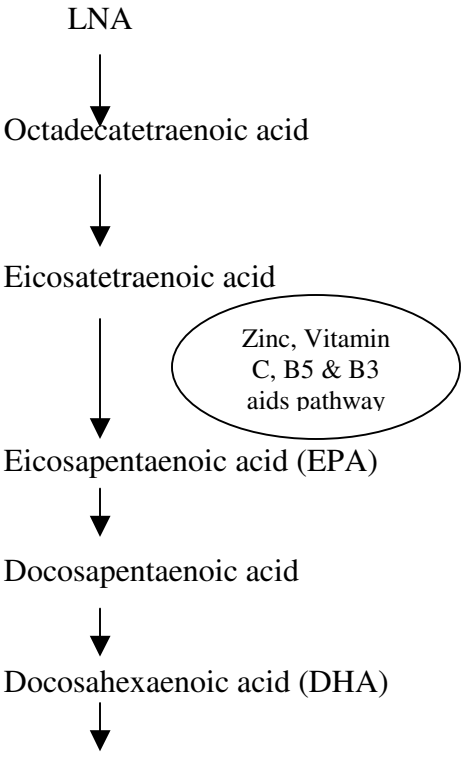
Wheat germ oil	1T	37.2 IU
Yogurt	1 cup	variable
Sunflower seeds	¼ cup	26.8 IU
Mayonnaise, Hellmans	1 T	16.5 IU
Almonds	¼ cup	12.7 IU
Sunflower oil	1T	12.7 IU
Sweet potato	1 med	9 IU

Vitamin E interacts with Iron, and vitamin K and can be toxic in large doses. As the amount of polyunsaturated fatty acids goes up in the diet, vitamin E requirements increase proportionally.

Fish Oils (omega 3)

Essential fatty acids (EFAs) are omega 6 fatty acids (nuts, seeds, grain, evening primrose oil, borage oil and black currant oil) and omega 3 fatty acids (fish). Alpha linolenic acid (LNA) is classified as an omega 3 fatty acid. Currently, the ratio of omega 6 to omega 3 fatty acids is about 18 to 1. It has been calculated that thousands of years ago, hunters and gatherers consumed a primarily vegetarian diet, the ratio between omega 6 to omega 3 was a more balanced 5 to 1.

Biochemistry



PGE3 – this is a prostaglandin responsible for decreasing platelet aggregation, decreasing inflammation, decreasing cell permeability, increasing HDL cholesterol (good cholesterol) and decreasing triglycerides.

In some people there may be a problem converting LNA into EPA and DHA. In such cases, it may be necessary to directly supply these in the diet either through foods or supplements. In infancy, DHA is supplied directly through mother's milk. Infants not receiving DHA (formula fed) have been found to develop their brain function and visual acuity more slowly.

Omega 3 is found in higher amounts in fish but I would recommend a high quality fish oil as it would be constantly screened for heavy metals that are so often found in farmed or wild fish.

Fatty acids are susceptible to oxidation by the nature of their carbon bonds. Generally speaking, the more double bonds a fatty acid has, the more unstable the molecule and the more susceptible it will be to oxidative attack. Certain factors tend to facilitate the production of free radicals or oxidative products. Temperature (**do not heat fish oils**), light, oxygen and the presence of certain cofactors such as iron and copper may speed up the oxidative process. Foods that have a significant amount of unsaturated fatty acids should be kept cold and away from light and air. These items include nuts, seeds, whole grains, oils and fish.

An 18-year study concluded that (docosahexaenoic acid) DHA was the likely breast milk nutrient that provided the improved academic outcome experienced by breast-fed children.[13]
http://www.fi.edu/brain/fats.htm#top

Mother's milk is high in DHA, and children who receive adequate amounts of DHA were shown to have higher IQs, as well as better vision than children who didn't get enough DHA.[14]

Copper

Copper is found in highest concentrations in the brain, liver, heart, bones, teeth and kidneys. Although muscle has a lower concentration, because of the large mass, the muscular system stores 40% of the copper.
Copper acts as a cofactor for dopamine beta monooxygenase which converts dopamine to norepinephrine. Specifically for girls copper is involved in the breakdown of estrogen. It is essential for the formation of the myelin surrounding the nerves.
Copper is used for connective tissue repair.
A copper deficiency is not uncommon. Symptoms of deficiency include brain damage, anemia, kinky hair, depigmentation of skin, hypotonia and hypothermia.

Sources of Copper		
Beef liver	3oz	2.4mg
Rye	1/2cup	0.9mg
Cashews	1/4cup	0.8mg
Molasses, black	2T	0.6mg
Banana	1med	0.35mg

Copper **is** toxic so do not supplement outside of a vitamin without discussing with your doctor.

Selenium

Selenium is one of the best antioxidants but it has a very narrow margin of safety. Selenium quantities vary in foods depending upon the levels in the soil. Many areas are extremely deficient. Generally grains are a fairly good source. Garlic and mushrooms are sometimes high in selenium. Asparagus is a good source as well.

Some diseases are associated with increased selenium excretion, these diseases include Duchennes muscular dystrophy and other forms of myotonic dystrophy.

Sources of Selenium

Brazil nuts	1/4cup	380µg
Snapper	3oz	148µg
Halibut	3oz	113µg
Salmon	3oz	70µg
Oats	3oz	50µg
Orange juice	1cup	50µg
Molasses, black	2T	25µg

DLPA (D,L-Phenylalanine)

DLPA is normally found free in the blood stream. But in the brain it is found to be part of other important brain proteins, peptides and neurotransmitters. Phenylalanine is the precursor for tyrosine. One defect in DLPA metabolism is Phenylketonuria (PKU) which was first identified in 1934 and occurs in 1 in 5000 births and results in mental retardation.

A deficiency of DLPA may lead to depression and diminished growth

Sources of DLPA

Cottage cheese	1 cup	1700mg
Chicken	3oz	1100mg
Cheddar cheese	3oz	1116mg
Turkey	3oz	950mg
Tuna	3oz	776mg
Oatmeal	1 cup	500mg
Milk	1cup	400mg
Yogurt	1cup	400mg
Avocado	1/2med	75mg

Tryptophan

Tryptophan is actively transported into the brain and competes with other amino acids for active transport systems. Tyrosine, phenylalanine, valine, leucine and isoleucine all compete with tryptophan for transport into the brain. Tryptophan gets metabolized into niacin, melatonin and serotonin. If enough tryptophan is present in the diet, niacin is not required. Tryptophan is the least abundant amino acid in foods.

Sources of Tryptophan

Cottage cheese	1cup	400mg
Liver, beef	3oz	334mg
Peanuts	3oz	291mg
Turkey	3oz	283mg
Lamb	3oz	283mg
Oatmeal	1cup	200mg
Avocado	½ med	200mg
Whole milk	1cup	110mg
Chocolate	1cup	110mg

It is the tryptophan in the thanksgiving dinner of turkey, chocolate and red wine that causes everyone to be sleepy.
Tryptophan has low toxicity.

Tyrosine

Tyrosine is involved with the synthesis of neurotransmitters in the brain. It is a precursor to dopamine, norepinephrine and epinephrine. Brain concentrations of these neurotransmitters are dependent upon intake of tyrosine. Tyrosine requires biopterin (a folate derivative), NADPH and NADH (forms of niacin), copper and vitamin C. L-dopa is an amino acid which is synthesized from tyrosine.
Tyrosine is also involved with the synthesis of enkephalins, substances which have pain relieving effects in the body and melanin, body pigment.

Sources of Tyrosine

Cottage cheese	1 cup	1700mg
Cheese	3oz	900mg
Wild game	3oz	600mg
Pork	3oz	500mg
Whole milk	1cup	400mg
Granola	1cup	400mg
Chocolate	1cup	400mg
Yogurt	1cup	400mg
Oatmeal	1cup	350mg
Turkey	3oz	260mg
Egg	1med	250mg
Avocado	1/2med	50mg

Tyrosine has very low toxicity but tyrosinemia (extremely high levels of tyrosine accumulation) does exist.

Methionine

Methionine is an essential amino acid, meaning the body can not synthesize this without ingesting food. Methionine is converted to S-adenosylmethionine (SAM) which is

considered the activated form of methionine. SAM is an extremely potent methyl donor. It is intimately involved in the synthesis of brain chemicals and also in detoxification reactions.

As a methyl donor SAM is involved in

a) breakdown of estrogens
b) carnitine synthesis
c) choline synthesis
d) creatinine synthesis
e) epinephrine synthesis
f) melatonin synthesis
g) nucleic acid synthesis
h) degradation of histamine

SAM also increase levels of glutathione and has antioxidant functions and maintains cartilage health.
SAM may also stimulate the production of L-dopa in the brain.
Deficiencies in B12, folate and methionine can cause a deficiency of SAM

Best Sources of Methionine:

Tuna	3oz	733mg
Cheddar cheese	3oz	555mg
Salmon	3oz	505mg
Wild game	3oz	444mg
Shrimp	3oz	400mg
Ricotta cheese	1/2cup	350mg
Pork	3oz	333mg
Luncheon meat	3oz	241mg
Granola	1cup	200mg
Egg	1med	200mg
Whole milk	1cup	200mg

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Rett Syndrome and Osteopenia

It is being found that a large percentage of girls with Rett Syndrome are affected by osteopenia and osteoporosis. Osteopenia is a condition of abnormally mineralized bone, for bone to develop normally it requires some weight bearing forces and osteopenia may partially be a result of immobility in girls affected with Rett. Osteoporosis is a disorder characterized by abnormal loss of bone density. It occurs in postmenopausal women because estrogen is low in the body after menopause and estrogen aids proper bone mineralization. It also occurs in sedentary or immobilized individuals.

The following is a list of nutrients that can aid in proper bone formation.

Magnesium

Due to the GI problems associated with Rett Syndrome it is unclear how much of any nutrient is being absorbed unless every nutrient is tested. For all the nutrients involved in bone maintenance I am only aware that Calcium has been shown to be adequately absorbed. Magnesium intake has gone down dramatically in the last 100 years. In areas where drinking water tends to be hard, having higher levels of magnesium, the incidence of coronary heart disease is lower.

Magnesium regulates the absorption of calcium and is involved in the structural integrity of bones and teeth.

Sources of Magnesium

Soybean flour	1cup	310mg
Buckwheat flour	1cup	246mg
Raisin bran	3oz	144mg
Tofu	½ cup	118mg
Cheerios	3oz	117mg
Banana	1med	58mg

Magnesium deficiency can cause nerve conduction problems

Magnesium can be used therapeutically for constipation, consult your doctor as magnesium causes diarrhea in high quantities and can affect the level of calcium absorption.

Medications that induce magnesium deficiency
Antibiotics
Cortisone
Asthma drugs
Alcohol
Laxatives-when used to create loose stools

Calcium

Calcium is the most abundant mineral in the body. Calcium makes up 1.5% to 2% of total body weight and 99% of this is in the bones and teeth.

Vitamin D is intimately involved with calcium metabolism. Hydrochloric acid is important for calcium absorption. Neurotransmitters at synaptic junctions are regulated by calcium.

Sources of Calcium
Dairy products
Oatmeal
Broccoli
***For children and women with dairy sensitivities other alternatives include

Tofu, firm	6oz	190mg
Rice Drink	1cup	200mg
Molasses	1T	137mg

Almond milk, soy milk – check label for specific amounts of calcium. Cows' milk is also a source of protein and fat. If you are using an alternative to cows' milk make sure your child is receiving another source of protein and fat that is equal to cows' milk.

Manganese
Manganese is poorly absorbed but is not commonly deficient. It is needed for connective tissue and bone function, including skin integrity, tendon and ligament strength, skeletal development and hearing development. Manganese works with vitamin K to allow calcium ions to properly form in the bone. It is vital for pancreatic and brain function. It is also an antioxidant.
If levels of Manganese are low, magnesium can substitute for its functions. Symptoms of deficiency, however, include sterility, skeletal abnormalities, glucose intolerance and ataxia.

Sources of Manganese

Whole wheat flour	1/2cup	2.6mg
Brown rice	1/4cup	1.9mg
Barley	1cup	1.8mg
Banana	1med	1.1mg
Oats	1cup	0.6mg

Manganese is toxic if inhaled. There are few toxic symptoms when ingested.

Vitamin D
Vitamin D is synthesized in the skin when exposed to UV light. It is a fat soluble vitamin, which means it has to be ingested with fat to be properly absorbed. It increases the absorption of calcium from the intestine.

Fortified dairy and non dairy drinks are the best source of Vitamin D, as well as fortified cereals.
It is estimated that 20 minutes with face and arms exposed to UV light will stimulate about 200IU per day. Vitamin D can be synthesized and stored for the winter.

In high levels Vitamin D is toxic

Vitamin A

Vitamin A is another fat soluble vitamin and it is necessary for growth and development of skeletal and soft tissues through its effect upon protein synthesis. It has an essential role in the differentiation of bone cells. Beta-carotene is a vitamin A precursor, vitamin A can be very toxic in moderate to high doses, beta-carotene, however, has a much lower toxicity level.

Sources of Vitamin A (Beta Carotene)

Carrot juice	1cup	120,000IU
Cod liver oil	1T	14,000IU
Sweet potato	1med	12,000IU
Mango	1med	8,000IU

Vitamin A (retinol) **IS** toxic in moderate to high doses

Vitamin K

Vitamin K is another of the fat soluble vitamins. Vitamin K is best known for its effect on blood coagulation. It was discovered by a Danish scientist and the Danish word for coagulation is Koagulation, hence, Vitamin K.
It is important, however, in the synthesis of a protein called osteocalcin. Osteocalcin contains specific amino acid residues such as gamma carboxy glutamic acid which attract calcium ions resulting in the calcification of bone.

Sources of Vitamin K

Turnip	1/2 cup	471 µg
Broccoli	1med stalk	360 µg
Lettuce	1cup	71 µg
Oats	150g	30 µg

Dilantin interferes with vitamin K functions and can lead to problems associated with bone development.
Vitamin E may interfere with the absorption and utilization of vitamin K.

Zinc

I have included zinc primarily for its action as an antioxidant. But zinc is involved in the synthesis of cholesterol, protein and fats, as well as regulates the release of vitamin A from the liver.

Sources of Zinc

Oysters, eastern	1/2cup	113mg
Roast beef	3oz	5.3mg
Dark turkey meat	3oz	3.8mg
Cheddar cheese	3oz	3.3mg
Ground beef	3oz	3.0mg
Oats	1cup	2.8mg

References:

Marz, Russell. Medical Nutrition From Marz. 2nd edition. Omni-Press, 1999

Rett Syndrome and Improving Muscle Function

Girls affected with Rett Syndrome may have weaker muscles when compared to other individuals of the same age. The following is a list of nutrients that help maintain and build muscle strength. As you recall glutamine gets converted to glutamate which can be neurotoxic, do not be hasty when supplementing, always discuss with your doctor.

Glutamine

Glutamine acts to preserve muscle mass by regulating protein synthesis in muscles as well as glycogen synthesis in the liver. The main site of glutamine synthesis is the skeletal muscle, accounting for over 60% of the free intracellular amino acids. When the body is under severe stress, glutamine concentrations will actually decrease as glutamine production is increased and released from the skeletal muscle for use by the cells of the immune system and intestine. This in turn, leads to a depletion of glutamine in the muscle. Since the level of glutamine in the muscle is correlated to muscle protein synthesis, supplementing glutamine can counteract the depletion process. *[Firshein, R. (1998) The Nutraceutical Revolution. Riverhead Books, New York: pp113-130]*

- When Wistar rats were induced with Zymosan A-induced systemic inflammation, the maximum force generated by the extensor digitorum longus muscles of those treated with L-Glutamine was significantly higher. *[Maglara et al. (2003) Prevention of muscle function impairment by glutamine supplementation during systemic inflammation. Clinical Nutrition 22(S1): S32]*

Foods rich in glutamine include plant and animal protein sources; meat, milk, beans, and soy. Cooking however, can diminish the glutamine concentration, especially in vegetables. *[various nutritional websites]*

Creatine Monohydrate

Creatine monohydrate is known for its ability to build muscle and increase exercise capacity. It is absorbed into muscle cells from the liver, kidney, and pancreas where it is then used to store energy. *[Firshein, R. (1998) The Nutraceutical Revolution. Riverhead Books, New York: pp276-282]*

- Studies have shown that creatine monohydrate supplementation increases strength in both healthy subjects and those with disease.
    - When creatine monohydrate was administered to 81 patients with neuromuscular disease, handgrip, dorsiflexion, and knee extensor strength were all increased *[Tarnopolsky, M. and Martin, J. (1999) Creatine monohydrate increases strength in patients with neuromuscular disease. Neurology, 52(4): 854-7]*.
    - A significant increase in handgrip strength was also seen in a double-bind cross-over study involving boys with Duchenne muscular dystrophy (an X-linked progressive myopathy due to mutations within the dystrophin gene). *[Tarnopolsky et al. (2004) Creatine monohydrate enhances strength and body composition in Duchenne muscular dystrophy. Neurology, 62: 1771-77]*

- Research involving creatine monohydrate supplementation with mdx mice (models for Duchenne muscular dystrophy) also reveals its potential for improving muscle function. Necrosis of the extensor digitorum longus muscles of these mice for example, has been shown to be significantly less in those supplemented. *[Magali et al. (2004) Effect of creatine supplementation on skeletal muscle of mdx mice. Muscle Nerve 29: 687-92]*
- One study involving 34 adults with myotonic muscular dystrophy type 1 however showed that creatine monohydrate supplementation did not have an effect on muscle strength, mass, or function. *[Tarnopolsky et al. (2004) Creatine monohydrate supplementation does not increase muscle strength, lean body mass, or muscle phosphocreatine in patients with myotonic dystrophy type 1. Muscle Nerve 29: 51-58]*

Creatine is especially rich in red meat and fish. *[Firshein, R. (1998) The Nutraceutical Revolution. Riverhead Books, New York: pp113-130]*. Supplements are also available in powdered form and can be used to enrich other foods or meals.

Coenzyme Q_{10}

It is believed that Coenzyme Q_{10} can improve energy as well as muscle performance. Coenzyme Q_{10} is an electron acceptor for complexes I and II of the mitochondrial electron transport system and is said to have the potential to be beneficial in neurodegenerative diseases where there is impaired mitochondrial function *[Shults, C. (2003) Coenzyme Q10 in neurodegenerative diseases. Current Medicinal Chemistry 10(19): 1917-21]*.

Since Rett syndrome is associated with mitochondrial abnormalities, and research has reported decreased enzyme activity in complexes I, II, and III of the electron transport system, perhaps coenzyme Q_{10} could play a role in treatment?

Healthy bodies can manufacture ample amounts of CoQ10 and it is not considered an essential dietary nutrient. No recommended daily intake has been established but synthesis of this antioxidant becomes less efficient with age and low levels of CoQ10 have been associated with cardiovascular disease, cancer, Alzheimer's and Parkinson's. Taking CoQ10 with Vitamin E appears to slow the progress of Parkinson's. *{Matthews RT, et al. Coenzyme Q10 administration increases brain mitochondrial concentrations and exerts neuroprotective effects. Proc Natl Acad Sci U S A 1998 Jul 21; 95 (15):8892-7}*

Good sources of coenzyme Q_{10} include meat and poultry, the richest source being organ meats, beef, soy oil, sardines, mackerel, and peanuts, spinach and broccoli. Cooking is only said to have a small impact on coenzyme Q_{10} activity. While frying destroys approximately 20% of the enzyme, boiling has no effect. *[various nutritional websites]*

L-Carnitine

Although no long-term trials involving L-carnitine as a therapy for Rett syndrome have been documented, several single case reports indicate it may be useful.

Carnitine has been determined to be an essential substance in humans for the metabolism of fats.

- When L-carnitine (75 – 150 mg/kg/day) was administered to a young girl (3 1/2 years) with Rett syndrome, significant improvements in physical activity and muscle hypotonia were noted. These improvements were lost once treatment was terminated, but were regained upon administering the supplement again. *[Kelly, G.S. (1998) L-Carnitine: therapeutic applications of a conditionally-essential amino acid. Alternative Medicine Review 3(5): 345-360]*
- When a 17-year old girl was supplemented with L-carnitine at the rate of 50 mg/kg/day similar improvements were noted within a couple of months. Again, these were diminished following a wash-out period, but regained once supplementation was re-introduced. *[Kelly, G.S. (1998) L-Carnitine: therapeutic applications of a conditionally-essential amino acid. Alternative Medicine Review 3(5): 345-360]*

- L-carnitine supplementation in patients with Rett syndrome has also shown to cause a significant increased serum very long chain fatty acid levels. Research reveals that Rett syndrome is characterized by depressed carnitine and very long chain fatty acid levels. *[Stradomska et al. (1999) Very long-chain fatty acids in rett syndrome. European Journal of Pediatrics 158: 226-29]*

The richest sources of L-carnitine include meat such as ground beef, fish, and dairy products.

Others / Combinations

- When a combination of creatine, ribose, and glutamine was given to 28 resistance-trained men for an 8-week period in a double blind, placebo controlled randomized trial, no difference in muscle strength, muscular endurance, or body composition was observed between the two groups. *[Falk et al. (2003) Effects of effervescent creatine, ribose, and glutamine supplementation on muscular strength, muscular endurance, and body composition. Journal of Strength and Conditioning Research 17(4): 810-6]*
- One scientific review report states that alpha-lipoic acid, beta-OH-methylbutyrate, riboflavin, and nicotinamide have been shown to improve various metabolic parameters in the brain and/or muscle. *[Baker, S. and Tarnopolsky, M. (2003) Targeting cellular energy production in neurological disorders. Expert Opinion on Investigational Drugs 12(10): 1655-79]*

I have written this handbook primarily to provide information. It is in no means inclusive, certain nutrients work better when combined with others and certain toxicities can be decreased when nutrients are combined. Some supplements, however, in high doses would require liver enzymes to be monitored.
Please consult a health care practitioner when changing any feeding routine. Certain states and provinces do not regulate natural health care providers, it is wise to determine where you doctor, naturopath, nutritionist etc. has been educated and how much training they have received.

Food Items and Recipe Suggestions

Foods Rich in CHO (carbohydrates), Calcium, and Fat

If maintaining weight is an issue try giving your daughter yogurt, custard etc. at least one serving before bed. Digesting fat is one of the more complex digestive processes. Fat (including fat soluble vitamins) is water insoluble, so the digestive tract must change large water insoluble particles into a soluble (absorbable form).
The process involves enzymes from the mouth, the stomach, the pancreas and the gallbladder. If fat absorption is a problem, essential fatty acid deficiency and vitamin deficiency may result in addition to the loss of the highest dietary source of calories.

- Puddings, Custard
- Chocolate Milk (can increase CHO and fat by using whole milk and adding chocolate syrup or powder)
- Milkshakes (can increase CHO and fat by adding extra ice cream, etc)
- Canned Milk (condensed, sweetened)
- Yogurt (CHO, calcium, and fat content increased when made with whole milk, fruit, and added milk solids)

Food	Serving	Calories (kcal)	Fat (g)	CHO (g)	Calcium (mg)
Canned Milk (condensed, sweetened)	1 cup	982	27	166	868
Milkshake (commercial)	10.6 fl oz	356	8	63	396
Chocolate Milk (commercial, whole)	1 cup	208	8	26	280
Yogurt (plain, with whole milk & no added milk solids)	8 oz	139	7	11	274

Breakfast

Slow cooked rolled oats (your grandmother was right) with chopped bananas, 1T blackstrap molasses and a dusting of brewer's yeast if your child does not have a yeast sensitivity.
You can also add mangos, oranges etc.

Lunch

My daughter is only 2 so I can cook large amounts of the following and freeze them but you may have to prepare these meals weekly to freeze for 7-10days. Puree to feeding ability.
Sauce:
1 Box organic squash soup
In one pot boil, 2 large sweet potatoes, 3-5 parsnips or turnips (or another root vegetable), celery root if available, ½ bag of carrots.

When tender, mash or puree and combine with soup
Boil ground beef and add to sauce
Fry mushrooms and add to sauce
You can also add pasta

For children I prepare all dark green vegetables with 4 peeled and boiled apples. I boil either broccoli, asparagus, Brussels sprouts in one pot with 4 apples. Mash or puree to feeding ability.

Dinner
I combine 1 box organic vegetable soup mix (typically contains tomatoes, carrots, potatoes etc)
Boil, ½ bag carrots, sweet potatoes, parsnips, celery root
Boil chicken breasts
Combine

Any vegetables may be substituted and any meat may be substituted, lamb is an exceptionally good quality meat. Don't forget to buy organic.

Snacks
Avocado, Banana, Custard etc.

What happens to wheat flour when it is refined:
- 93% of fibre is removed
- 50% of essential fatty acids are lost
- 22 minerals and vitamins are reduced by 20%
- most of the vitamin E is lost
- it is bleached stripping nutrients

The best flour
- comes from stone ground mills
- bought in stores with high turnover and refrigerates its flour
- when at home remove from package and refrigerate in a glass, airtight container
- purchase small amounts at a time and use within 1-2mths

If your child has a wheat allergy or gluten sensitivity then some alternatives are:
Non-wheat grains – amaranth, buckwheat, quinoa, bean flours (soy, chickpeas)
Gluten free – Amaranth, arrowroot, bean, brown rice flour, millet, soy to name a few.

This is a handbook that will be continually updated and more recent references included. Please feel free to email me comments, suggestions or additions. I hope you find this helpful.

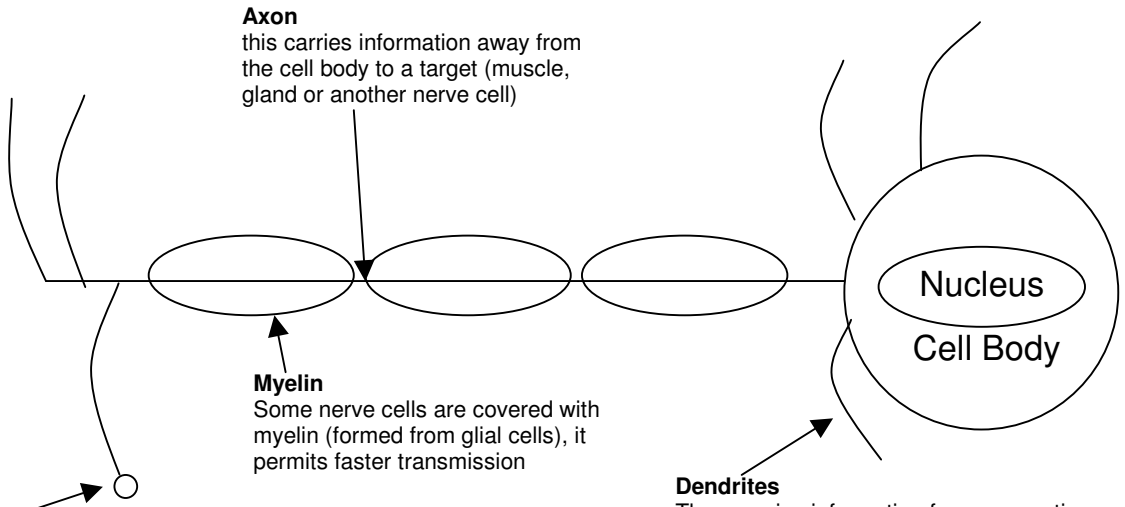
Sincerely,
SJ White

Section Two:
Understanding the Brain and Nervous System

Most of this section is taken from The American Medical Association Home Medical Library series published by Reader's Digest. I would highly recommend the whole collection if you have an interest in medicine. The information is accurate, detailed and presented in easy to read language.

The brain and nervous system is an interconnected network of nerve cells (neurons) that coordinates your actions. It senses the environment and helps you react to external stimuli by thinking, moving and speaking. Your nervous system also regulates your internal, involuntary functions such as breathing and heart rate. Girls affected with Rett Syndrome have a neurological disease caused by a genetic mutation in the gene encoding a protein known as MeCP2. There can be many different mutations in this gene so a variety of symptoms can be seen but all the symptoms Rett girls exhibit stem from inappropriate brain/nervous system development.

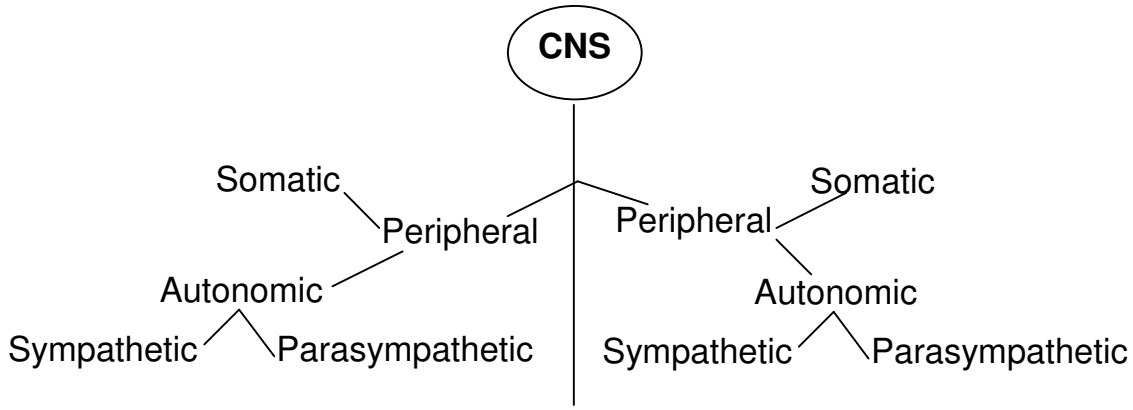
Your brain is like a computer as it does all the processing of information but then it must communicate with the rest of the body. Cells that send signals from the brain are called nerve cells or neurons. Each has a cell body and at least one long extension (axon) that carries the signal to its target. Nerves contain thousands of individual nerve cell fibres.



The human nervous system has two parts, the Central Nervous System (CNS) which consists of the brain and spinal cord and the Peripheral Nervous System which consists of the nerves extending from the CNS.

The Peripheral Nervous is also made up of two parts: the somatic system and the autonomic system. The somatic system gathers information about the outside world, transmits it to the CNS and sends signals from there to your body's skeletal muscles causing them to move. The somatic sensory nerve fibres relay information about skin sensations, while the somatic motor nerve fibres cause contraction of skeletal muscles. Basically, information comes in, gets processed by the brain and information leaves the brain and goes to the muscles or glands telling them how to respond.

The autonomic system regulates your body's internal environment. It carries information from inside the body to the CNS and transmits the information to organs, such as the heart, which work automatically. The autonomic system is divided into the sympathetic and the parasympathetic systems.



Sympathetic nervous system works during times of stress (flight or fight) while the parasympathetic dominates during rest. The sympathetic nervous system prepares the body for action in response to stress. Its effects on the body consume energy as food reserves are activated to nourish muscles.

The parasympathetic nervous system promotes and regulates processes such as digestion and growth. By allowing the body to rest and recuperate, its activities save energy. The nerve fibres of these two divisions leave the brain and spinal cord by way of the cranial and spinal nerves to supply organs and other internal structures.

HOW IS THE NERVOUS SYSTEM ORGANIZED?

CENTRAL NERVOUS SYSTEM

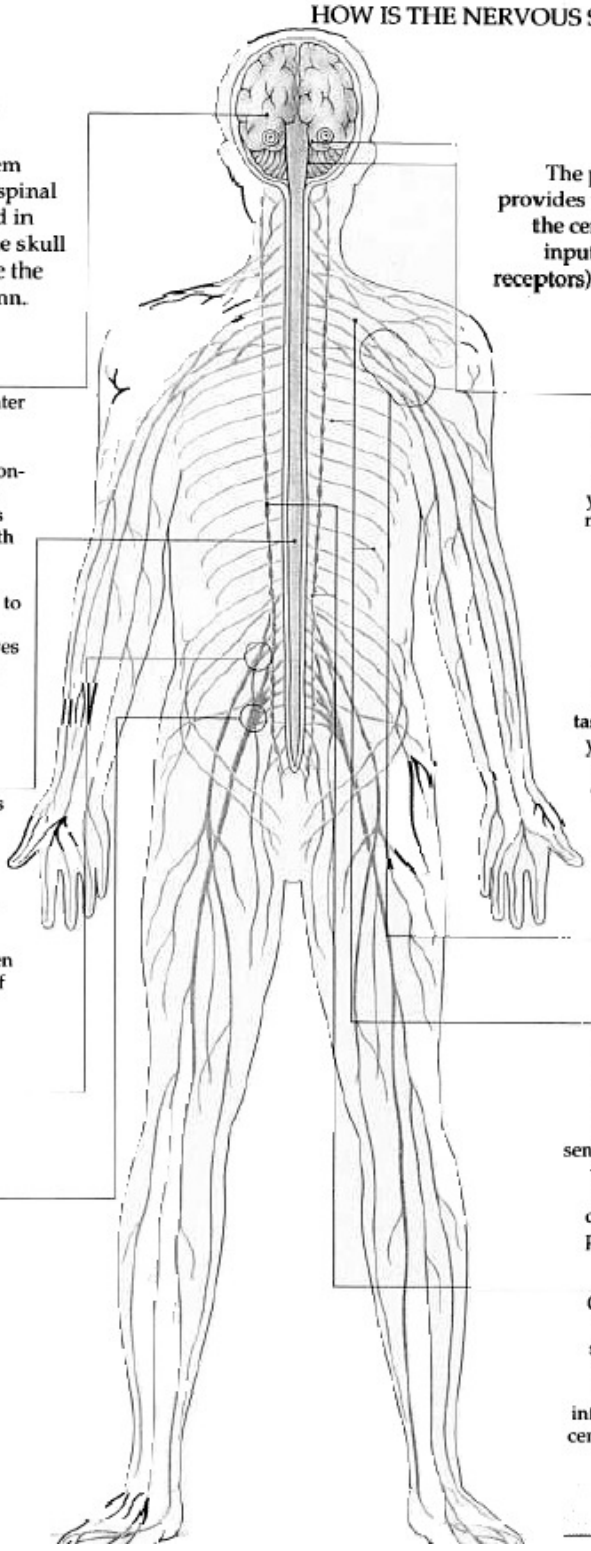
The central nervous system consists of the brain and spinal cord. It is entirely encased in bone – the brain inside the skull and the spinal cord inside the backbone, or spinal column.

Brain
Your brain is the control center of your body. It receives a constant barrage of sensory information about the environment and your body's inner functioning. It processes this information, compares it with stored data, and decides whether action is needed to adapt to the environment or to adjust some internal bodily function. The brain also serves as the body's storehouse for data and is the seat of consciousness and emotion.

Spinal cord
Your spinal cord can process and initiate responses to many types of sensory information at an unconscious, automatic level. It also consists of bundles – or tracts – of nerve fibers that transmit information between your brain and other parts of your body.

Lumbar plexus

Sacral plexus



PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system provides the "cabling" that connects the central nervous system to its input sites (sensory organs and receptors) and output devices (muscles and glands).

Cranial nerves
These 12 pairs of nerves connect directly to the brain. Some transmit information from sensory organs such as your eyes or nose, some relay motor information to muscles or glands, and some have mixed motor and sensory functions.

Sensory receptors
(not shown)
Sensory receptors reside not only in your eyes, ears, nose, taste buds, and skin but also in your internal organs. Internal receptors include those that collect information about the internal state of the body, including blood pressure and the state of contraction of each muscle.

Brachial plexus

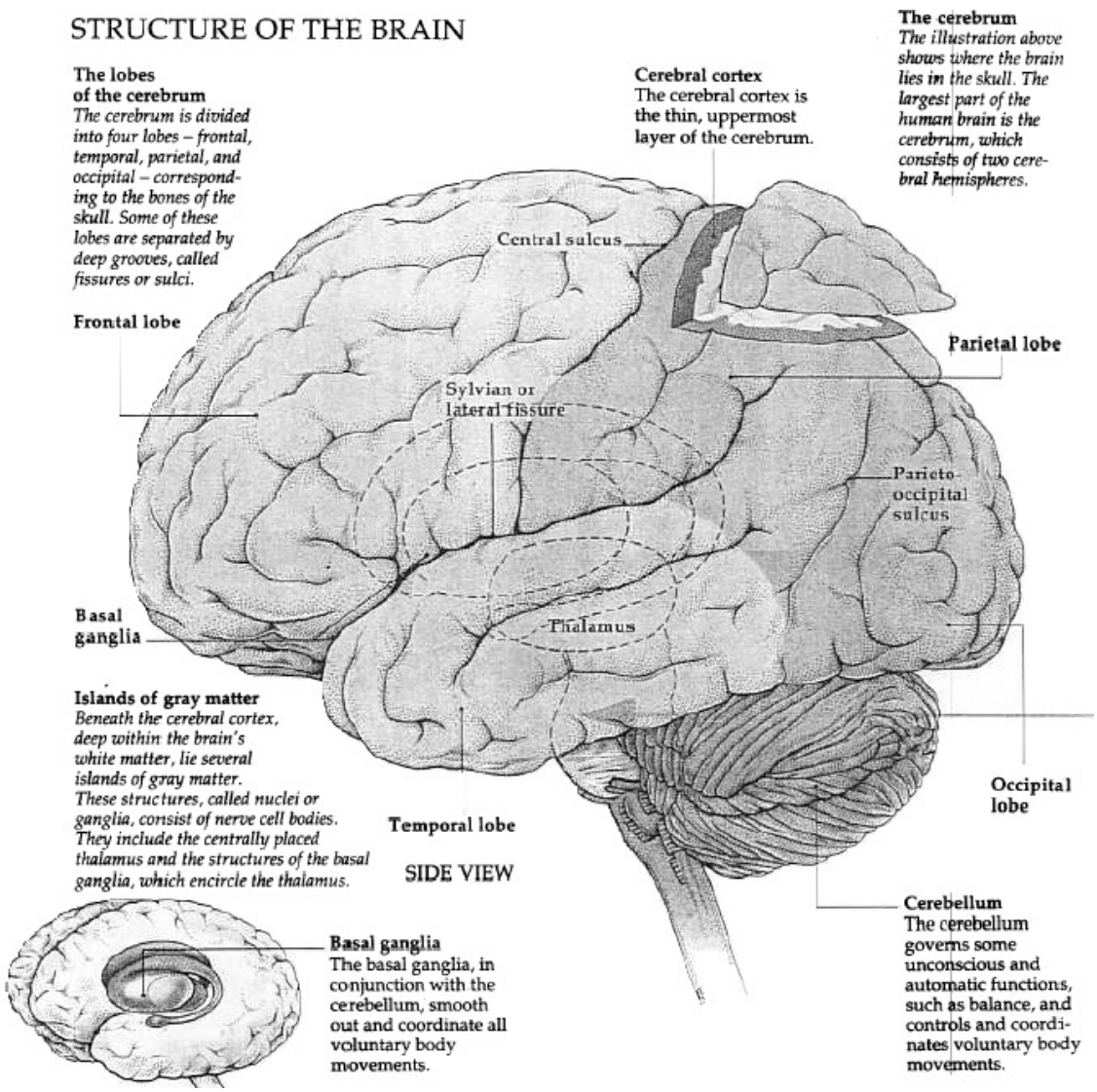
Spinal nerves
The 31 pairs of spinal nerves emerge from the spinal cord and supply all parts of your trunk and limbs. Each of the spinal nerves contains both sensory and motor fibers. In the upper chest and lower abdomen, the nerves join to form concentrated networks called plexuses that serve the limbs.

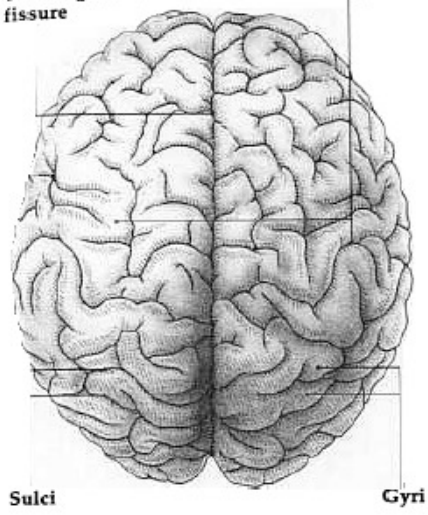
Sympathetic nerve trunks
Chains of ganglia (clusters of nerve cells) form part of the sympathetic division of your autonomic nervous system. They act as relay stations for information passing from your central nervous system to body organs such as the salivary glands, heart, lungs, and digestive organs.

Nerve cells are the building blocks of the nervous system. Neurons receive, analyze, coordinate and transmit information inside your body. There are approximately 100,000,000,000 neurons in the human brain. Nerve cells are structurally similar to other cells in the body having a membrane, cytoplasm and nucleus but they have become extremely specialized so they can transfer information.

Nerve cells account for only 5 to 10 percent of all cells in the nervous system. Far more numerous is a second group of cells, known as glial cells, which cannot transmit information. Instead, glial cells provide protection, nutrition, and structural support for nerve cells. Several types of glial cells (oligodendroglial and Schwann cells form the myelin sheath, and astocytes form the blood brain barrier and scar tissue) occur in both the CNS and peripheral nervous system. Some glial cells produce proteins, called neurotrophic factors that stimulate the growth of nerve cells during normal development and after injury. Researchers are attempting to find out whether these proteins could be used to prevent degeneration of injured nerve cells in disorders such as Parkinson's and Alzheimer's and perhaps in Rett Syndrome.

The brain and its blood vessels lie completely enclosed inside three layers of membranes called the meninges. The outer layer forms a tough, protective coat. The adult brain weighs about 3lbs and contains a tremendous number of nerve cells and supporting glial cells.

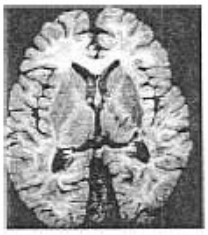

STRUCTURE OF THE BRAIN
The lobes of the cerebrum
The cerebrum is divided into four lobes – frontal, temporal, parietal, and occipital – corresponding to the bones of the skull. Some of these lobes are separated by deep grooves, called fissures or sulci.
Cerebral cortex
The cerebral cortex is the thin, uppermost layer of the cerebrum.
The cerebrum
The illustration above shows where the brain lies in the skull. The largest part of the human brain is the cerebrum, which consists of two cerebral hemispheres.
Central sulcus
Frontal lobe
Parietal lobe
Sylvian or lateral fissure
Parieto-occipital sulcus
Basal ganglia
Thalamus
Islands of gray matter
Beneath the cerebral cortex, deep within the brain's white matter, lie several islands of gray matter. These structures, called nuclei or ganglia, consist of nerve cell bodies. They include the centrally placed thalamus and the structures of the basal ganglia, which encircle the thalamus.
Temporal lobe
Occipital lobe
SIDE VIEW
Cerebellum
The cerebellum governs some unconscious and automatic functions, such as balance, and controls and coordinates voluntary body movements.
Basal ganglia
The basal ganglia, in conjunction with the cerebellum, smooth out and coordinate all voluntary body movements.



TOP VIEW

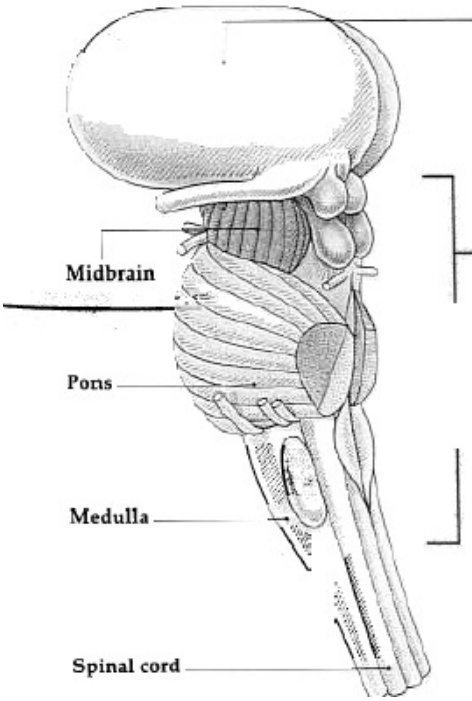
Gyri and sulci
The surface of the cerebrum is heavily folded, forming numerous ridges and deep clefts. A raised area is called a gyrus and a single groove is known as a sulcus. Some of the larger sulci are called fissures.

Corpus callosum
The two halves of the brain are connected by the corpus callosum, a massive communication trunk that contains more than 200 million nerve fibers. Surprisingly, cutting the corpus callosum has little effect on personality, intellect, or other brain functions.



Gray and white matter
Parts of the brain are gray, others are white. Gray matter consists of nerve cell bodies. White matter is composed of nerve fibers that connect the brain and nervous system.

Cerebral cortex
A thin shell of gray matter, the cerebral cortex, covers the entire surface of the cerebrum. It is here that the brain performs many cognitive functions, such as thinking and remembering. Numerous infoldings of the cortex allow its large surface area to fit inside the skull.



Thalamus
The thalamus relays information about bodily sensations to the cortex and sends information about what is going on in the body to many other parts of the brain.

Brain stem
The brain stem, composed of the midbrain, pons, and medulla, contains the tracts of nerve fibers that connect the brain to the rest of the body by way of the spinal cord. The brain stem contains the nerve cell bodies for some of the nerves that supply the face and head. It also houses centers responsible for breathing, heart rate, and controlling the levels of wakeful consciousness and sleep.

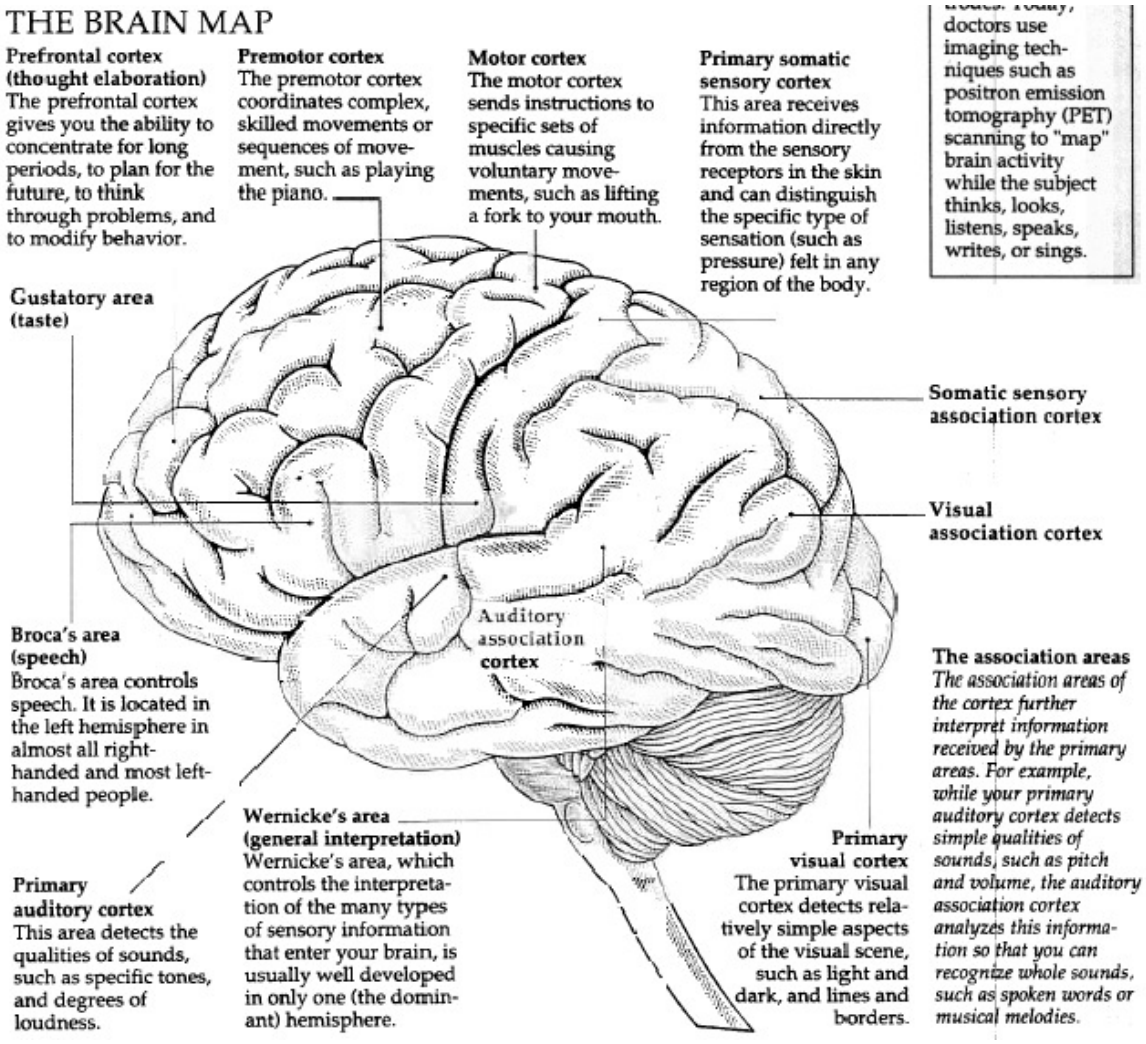
DIVISIONS OF THE BRAIN

For descriptive purposes, the parts of the brain are often divided as follows:

FOREBRAIN
- **Cerebrum**
  - Cortex
  - Basal ganglia
- **Diencephalon**
  - Thalamus
  - Hypothalamus

MIDBRAIN
HINDBRAIN — BRAIN STEM
- **Pons**
- **Medulla**
- **Cerebellum**

Researchers have mapped much of the cerebral cortex into areas that serve known functions.



The limbic system is the part of the brain that governs subconscious instincts and emotions. It is referred to as the primitive brain because its functions appeared early in the evolution of the brain. The limbic system links higher brain centres, used to think or remember, with lower structures that coordinate automatic bodily functions, such as breathing. The limbic system encircles the top of the brain stem. It consists of hidden areas of cortex and deeper brain structures. The areas of the limbic cortex sit on the inner sides of the cerebral hemispheres around the corpus callosum. An important part of the limbic cortex is the arch-shaped cingulated gyrus, which lies directly above the corpus callosum. The cingulated gyrus controls emotional responses, such as rage and fright.

The hypothalamus is the site at which the nervous and hormonal systems interact. Brain signals, including those associated with thought and emotion, cause the hypothalamus to send chemicals to the pituitary gland. These chemicals adjust the release of hormones that regulate bodily functions.

Enclosed within the parts of your brain that govern conscious activity, principally the outer layers of the cerebrum, are many regions that control unconscious functions. These regions work with little or no control by the higher brain centres. They include regions in the centre of the brain, such as the hypothalamus and other parts of the limbic system; the pituitary and pineal glands and parts of the brain stem and its connections to the autonomic (literally self-governing) nervous system.

These regions form the most primitive parts of your brain in terms of evolutionary development. In fact, the unconscious, primitive parts of your brain differ very little from those of other mammals. The unconscious brain is vitally important to humans. All the functions of your body, such as your breathing, digestive process, heart rate, body temperature and blood pressure are controlled by the unconscious brain. So are the actions of your body's hormonal system. The brain receives signals about your body's internal state and adjusts its functions without your conscious awareness. The unconscious brain also governs instinctive reactions, such as anger, fear and cyclical behaviour patterns such as sleep.

The brain controls your body's involuntary internal processes through two mechanisms: the nervous system and the hormonal system. The hypothalamus near the base of the brain lies just above the pituitary gland and governs the hormonal system through its stimulating and inhibiting influence in the pituitary gland and the hormones this gland secretes. The hypothalamus also controls the autonomic nervous system and regulates body temperature. Other functions under its complete or partial control include heart rate, blood pressure, regulation of sleep, sexual behaviour and emotion and food and water intake.

The brain stem is the lowest section of the brain. The brain stem helps control coordinated eye movements, facial movement and sensation, hearing and swallowing. It also serves as a pathway for messages traveling between other parts of the brain and the spinal cord. Finally, the brain stem contains vital centres involved in the control of your

heart rate, breathing, blood pressure and sleep/wake cycles. The brain stem consists of three parts, called the midbrain, pons and medulla.

As you can interpret from the above information our girls have problems in a number of areas. Until further advances in Rett research are made a caregiver must maintain their own health and the health of the Rett patient, this is accomplished through therapies and if they are unable to manage physical, occupational therapy or speech pathology maintaining proper nutrition will help them for the future.

References:

Clayman, Charles ed. The American Medical Association The Brain and Nervous System. The Reader's Digest Associaiton, Inc., 1991.

Appendix
Hidden Sources of MSG

Additives that always contain MSG:
Monosodium Glutamate
Hydrolyzed Vegetable Protein
Hydrolyzed Protein
Hydrolyzed Plant Protein
Plant Protein Extract
Sodium Caseinate
Calcium Caseinate
Yeast Extract
Textured Protein
Autolyzed Yeast
Hydrolyzed Oat Flour

Additive that frequently contain MSG:
Malt extract
Malt Flavouring
Bouillon
Broth
Stock
Flavouring
Natural Flavouring
Natural Beef or Chicken Flavouring
Seasoning
Spices

Additives that may contain MSG or excitotoxins:
Carrageenan
Enzymes
Soy Protein Concentrate
Soy Protein Isolate
Whey Protein Concentrate

Protease enzymes of various sources can release excitotoxin amino acids from food proteins.

References:
Blaylock, Russell. Excitotoxins: The Taste that Kills. Health Press, 1997.