


PS&HHS COMMITTEE #2  
March 10, 2011

**MEMORANDUM**

March 7, 2011

TO: Public Safety and Health and Human Services Committees

FROM: Linda McMillan, Senior Legislative Analyst 

SUBJECT: **Briefing and Discussion: Dietary Study for Inmates – Impacts of Omega-3 and Omega-6 Fatty Acids on Aggression and Inmate Behavior**

At this session, the joint Committee will receive a presentation from Captain Joseph Hibbeln, MD, and Acting Chief, Section on Nutritional Neurosciences, at the National Institutes of Health, regarding the impact of Omega-3 and Omega-6 acids on behavior including depression, aggression and crime. This presentation was suggested by Department of Correction and Rehabilitation Director Arthur Wallenstein as Mr. Wallenstein wanted the joint Committee to learn about the results of studies that have implications for changing inmate (including those inmates who are supervised in the community) behavior.

Attached to this memo are several articles. The first (©1-6) is a 2006 article from the Guardian UK that describes a UK prison study at Aylesbury jail, a prison for male offenders aged 17-21 convicted of serious crimes, that showed that when inmate diets were changed to include multivitamins, minerals, and Omega-3 fatty acids, violent offenses in the prison fell by 37%. It also describes a US study started in 2001, led by Dr. Hibbeln, on the effects of Omega-3 fatty acids on repeat offenders (described in the article as aggressive alcoholics). The study participant interviewed for this article describes his violent past and inability to control his drinking and says that since his diet was changed, he is sober and able to control his anger and aggression. The article also describes work done by Dr. Hibbeln that looks at the correlation between the increase in Omega-6 consumption, decrease in Omega-3 consumption and homicides, finding that as consumption of Omega-6 fatty acids (oils from seeds) has increased so has the murder rate. Also notable is that countries with high Omega-3 consumption and low Omega-6 consumption have relatively low murder rates. In a second article on the 2001 study that was published in the New York Times in 2006 (©7-8), Bernard Gesch, a senior researcher at Oxford University who is also studying the impact of diets on behavior says that there should not

be an expectation that diet alone will eliminate violent behavior, “The brain needs to be nourished in two ways. It needs to be educated, and it needs nutrients. Both social and physical factors are important.”

Attached at ©9-12 are two short articles from “Crime Times” that discuss the study of nutrition and Omega-3 and Omega-6 acids on inmates’ antisocial behavior and on broader issues of mental illness.

Lastly, attached is an excerpt from the January 2008 Report of an inquiry held by the Associate Parliamentary Food and Health Forum (UK). This excerpt not only includes recommendations of the Group but at ©20-23 provides a very good summary of the changes in human diet over time and how the need for Omega-3 and Omega-6 fatty acids, which are essential fatty acids that must be acquired through food, impact the development and functioning of the brain. Omega-3 is generally found in fish and leafy green vegetables. Omega-6 fatty acids are found in corn, soybean, and sunflower oil (and others). Omega-6 oils are used in processed and fast foods which has been responsible for the significant increase in the consumption of this nutrient. About 60% of the dry weight of the brain is fat and about 20% of that amount is essential fatty acids. Consuming the correct balance of essential fatty acids is critical to the functioning of neurotransmitter systems.

guardian.co.uk

## Omega-3, junk food and the link between violence and what we eat

Research with British and US offenders suggests nutritional deficiencies may play a key role in aggressive behaviour

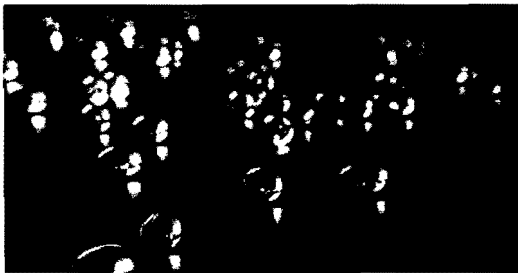
---

Felicity Lawrence  
The Guardian, Tuesday 17 October 2006

---

A [larger](#) | [smaller](#)

---



Cod liver oil capsules with omega

3. Photograph: Graham Turner

That Dwight Demar is able to sit in front of us, sober, calm, and employed, is "a miracle", he declares in the cadences of a prayer-meeting sinner. He has been rocking his 6ft 2in bulk to and fro while delivering a confessional account of his past into the middle distance. He wants us to know what has saved him after 20 years on the streets: "My dome is working. They gave me some kind of pill and I changed. Me, myself and I, I changed."

Demar has been in and out of prison so many times he has lost count of his convictions. "Being drunk, being disorderly, trespass, assault and battery; you name it, I did it. How many times I been in jail? I don't know, I was locked up so much it was my second home."

Demar has been taking part in a clinical trial at the US government's National Institutes for Health, near Washington. The study is investigating the effects of omega-3 fatty acid supplements on the brain, and the pills that have effected Demar's "miracle" are doses of fish oil.

The results emerging from this study are at the cutting edge of the debate on crime and punishment. In Britain we lock up more people than ever before. Nearly 80,000 people are now in our prisons, which reached their capacity this week.

But the new research calls into question the very basis of criminal justice and the notion of culpability. It suggests that individuals may not always be responsible for their aggression. Taken together with a study in a high-security prison for young offenders in the UK, it shows that violent behaviour may be attributable at least in part to nutritional deficiencies.

The UK prison trial at Aylesbury jail showed that when young men there were fed multivitamins, minerals and essential fatty acids, the number of violent offences they committed in the prison fell by 37%. Although no one is suggesting that poor diet alone can account for complex social problems, the former chief inspector of prisons Lord

Ramsbotham says that he is now "absolutely convinced that there is a direct link between diet and antisocial behaviour, both that bad diet causes bad behaviour and that good diet prevents it."

The Dutch government is currently conducting a large trial to see if nutritional supplements have the same effect on its prison population. And this week, new claims were made that fish oil had improved behaviour and reduced aggression among children with some of the most severe behavioural difficulties in the UK.

### **Deficiency**

For the clinician in charge of the US study, Joseph Hibbeln, the results of his trial are not a miracle, but simply what you might predict if you understand the biochemistry of the brain and the biophysics of the brain cell membrane. His hypothesis is that modern industrialised diets may be changing the very architecture and functioning of the brain.

We are suffering, he believes, from widespread diseases of deficiency. Just as vitamin C deficiency causes scurvy, deficiency in the essential fats the brain needs and the nutrients needed to metabolise those fats is causing of a host of mental problems from depression to aggression. Not all experts agree, but if he is right, the consequences are as serious as they could be. The pandemic of violence in western societies may be related to what we eat or fail to eat. Junk food may not only be making us sick, but mad and bad too.

In Demar's case the aggression has blighted many lives. He has attacked his wife. "Once she put my TV out the door, I snapped off and smacked her." His last spell in prison was for a particularly violent assault. "I tried to kill a person. Then I knew something need be done because I was half a hundred and I was either going to kill somebody or get killed."

Demar's brain has blanked out much of that last attack. He can remember that a man propositioned him for sex, but the details of his own response are hazy.

When he came out of jail after that, he bought a can of beer and seemed headed for more of the same until a case worker who had seen adverts for Hibbeln's trial persuaded him to take part.

The researchers at the National Institute on Alcohol Abuse and Alcoholism, which is part of NIH, had placed adverts for aggressive alcoholics in the Washington Post in 2001. Some 80 volunteers came forward and have since been enrolled in the double blind study. They have ranged from homeless people to a teacher to a former secret service agent. Following a period of three weeks' detoxification on a locked ward, half were randomly assigned to 2 grams per day of the omega-3 fatty acids EPA and DHA for three months, and half to placebos of fish-flavoured corn oil.

An earlier pilot study on 30 patients with violent records found that those given omega-3 supplements had their anger reduced by one-third, measured by standard scales of hostility and irritability, regardless of whether they were relapsing and drinking again. The bigger trial is nearly complete now and Dell Wright, the nurse administering the pills, has seen startling changes in those on the fish oil rather than the placebo. "When Demar came in there was always an undercurrent of aggression in his behaviour. Once he was on the supplements he took on the ability not to be impulsive. He kept saying, 'This is not like me'."

Demar has been out of trouble and sober for a year now. He has a girlfriend, his own door key, and was made employee of the month at his company recently. Others on the

trial also have long histories of violence but with omega-3 fatty acids have been able for the first time to control their anger and aggression. J, for example, arrived drinking a gallon of rum a day and had 28 scars on his hand from punching other people. Now he is calm and his cravings have gone. W was a 19th barrel of a man with convictions for assault and battery. He improved dramatically on the fish oil and later told doctors that for the first time since the age of five he had managed to go three months without punching anyone in the head.

### Threat to society

Hibbeln is a psychiatrist and physician, but as an employee of the US government at the NIH he wears the uniform of a commander, with his decorations for service pinned to his chest. As we queued to get past the post-9/11 security checks at the NIH federal base, he explained something of his view of the new threat to society.

Over the last century most western countries have undergone a dramatic shift in the composition of their diets in which the omega-3 fatty acids that are essential to the brain have been flooded out by competing omega-6 fatty acids, mainly from industrial oils such as soya, corn, and sunflower. In the US, for example, soya oil accounted for only 0.02% of all calories available in 1909, but by 2000 it accounted for 20%. Americans have gone from eating a fraction of an ounce of soya oil a year to downing 25lbs (11.3kg) per person per year in that period. In the UK, omega-6 fats from oils such as soya, corn, and sunflower accounted for 1% of energy supply in the early 1960s, but by 2000 they were nearly 5%. These omega-6 fatty acids come mainly from industrial frying for takeaways, ready meals and snack foods such as crisps, chips, biscuits, ice-creams and from margarine. Alcohol, meanwhile, depletes omega-3s from the brain.

To test the hypothesis, Hibbeln and his colleagues have mapped the growth in consumption of omega-6 fatty acids from seed oils in 38 countries since the 1960s against the rise in murder rates over the same period. In all cases there is an unnerving match. As omega-6 goes up, so do homicides in a linear progression. Industrial societies where omega-3 consumption has remained high and omega-6 low because people eat fish, such as Japan, have low rates of murder and depression.

Of course, all these graphs prove is that there is a striking correlation between violence and omega-6 fatty acids in the diet. They don't prove that high omega-6 and low omega-3 fat consumption actually causes violence. Moreover, many other things have changed in the last century and been blamed for rising violence - exposure to violence in the media, the breakdown of the family unit and increased consumption of sugar, to take a few examples. But some of the trends you might expect to be linked to increased violence - such as availability of firearms and alcohol, or urbanisation - do not in fact reliably predict a rise in murder across countries, according to Hibbeln.

There has been a backlash recently against the hype surrounding omega-3 in the UK from scientists arguing that the evidence remains sketchy. Part of the backlash stems from the eagerness of some supplement companies to suggest that fish oils work might wonders even on children who have no behavioural problems.

Alan Johnson, the education secretary, appeared to be jumping on the bandwagon recently when he floated the idea of giving fish oils to all school children. The idea was quickly knocked down when the food standards agency published a review of the evidence on the effect of nutrition on learning among schoolchildren and concluded there was not enough to conclude much, partly because very few scientific trials have been done.

Professor John Stein, of the department of physiology at Oxford University, where much of the UK research on omega-3 fatty acid deficiencies has been based, agrees: "There is only slender evidence that children with no particular problem would benefit from fish oil. And I would always say [for the general population] it's better to get omega-3 fatty acids by eating fish, which carries all the vitamins and minerals needed to metabolise them."

However, he believes that the evidence from the UK prison study and from Hibbeln's research in the US on the link between nutritional deficiency and crime is "strong", although the mechanisms involved are still not fully understood.

Hibbeln, Stein and others have been investigating what the mechanisms of a causal relationship between diet and aggression might be. This is where the biochemistry and biophysics comes in.

Essential fatty acids are called essential because humans cannot make them but must obtain them from the diet. The brain is a fatty organ - it's 60% fat by dry weight, and the essential fatty acids are what make part of its structure, making up 20% of the nerve cells' membranes. The synapses, or junctions where nerve cells connect with other nerve cells, contain even higher concentrations of essential fatty acids - being made of about 60% of the omega-3 fatty acid DHA.

Communication between the nerve cells depends on neurotransmitters, such as serotonin and dopamine, docking with receptors in the nerve cell membrane.

Omega-3 DHA is very long and highly flexible. When it is incorporated into the nerve cell membrane it helps make the membrane itself elastic and fluid so that signals pass through it efficiently. But if the wrong fatty acids are incorporated into the membrane, the neurotransmitters can't dock properly. We know from many other studies what happens when the neurotransmitter systems don't work efficiently. Low serotonin levels are known to predict an increased risk of suicide, depression and violent and impulsive behaviour. And dopamine is what controls the reward processes in the brain.

Laboratory tests at NIH have shown that the composition of tissue and in particular of the nerve cell membrane of people in the US is different from that of the Japanese, who eat a diet rich in omega-3 fatty acids from fish. Americans have cell membranes higher in the less flexible omega-6 fatty acids, which appear to have displaced the elastic omega-3 fatty acids found in Japanese nerve cells.

Hibbeln's theory is that because the omega-6 fatty acids compete with the omega-3 fatty acids for the same metabolic pathways, when omega-6 dominates in the diet, we can't convert the omega-3s to DHA and EPA, the longer chain versions we need for the brain. What seems to happen then is that the brain picks up a more rigid omega-6 fatty acid DPA instead of DHA to build the cell membranes - and they don't function so well.

Other experts blame the trans fats produced by partial hydrogenation of industrial oils for processed foods. Trans fats have been shown to interfere with the synthesis of essential fats in foetuses and infants. Minerals such as zinc and the B vitamins are needed to metabolise essential fats, so deficiencies in these may be playing an important part too.

There is also evidence that deficiencies in DHA/EPA at times when the brain is developing rapidly - in the womb, in the first 5 years of life and at puberty - can affect its architecture permanently. Animal studies have shown that those deprived of omega-3 fatty acids over two generations have offspring who cannot release dopamine and

serotonin so effectively.

"The extension of all this is that if children are left with low dopamine as a result of early deficits in their own or their mother's diets, they cannot experience reward in the same way and they cannot learn from reward and punishment. If their serotonin levels are low, they cannot inhibit their impulses or regulate their emotional responses," Hibbeln points out.

### **Mental health**

Here too you have one possible factor in cycles of deprivation (again, no one is suggesting diet is the only factor) and why criminal behaviour is apparently higher among lower socio-economic groups where nutrition is likely to be poorer.

These effects of the industrialisation of the diet on the brain were also predicted in the 1970s by a leading fats expert in the UK, Professor Michael Crawford, now at London's Metropolitan University. He established that DHA was structural to the brain and foresaw that deficiencies would lead to a surge in mental health and behavioural problems - a prediction borne out by the UK's mental health figures.

It was two decades later before the first study of the effect of diet on behaviour took place in a UK prison. Bernard Gesch, now a senior researcher at Stein's Oxford laboratory, first became involved with nutrition and its relationship to crime as a director of the charity Natural Justice in northwest England. He was supervising persistent offenders in the community and was struck by their diets. He later set out to test the idea that poor diet might cause antisocial behaviour and crime in the maximum security Aylesbury prison.

His study, a placebo-controlled double blind randomised trial, took 231 volunteer prisoners and assigned half to a regime of multivitamin, mineral and essential fatty acid supplements and half to placebos. The supplement aimed to bring the prisoners' intakes of nutrients up to the level recommended by government. It was not specifically a fatty acid trial, and Gesch points out that nutrition is not pharmacology but involves complex interactions of many nutrients.

### **Prison trial**

Aylesbury was at the time a prison for young male offenders, aged 17 to 21, convicted of the most serious crimes. Trevor Hussey was then deputy governor and remembers it being a tough environment. "It was a turbulent young population. They had problems with their anger. They were all crammed into a small place and even though it was well run you got a higher than normal number of assaults on staff and other prisoners."

Although the governor was keen on looking at the relationship between diet and crime, Hussey remembers being sceptical himself at the beginning of the study. The catering manager was good, and even though prisoners on the whole preferred white bread, meat and confectionery to their fruit and veg, the staff tried to encourage prisoners to eat healthily, so he didn't expect to see much of a result.

But quite quickly staff noticed a significant drop in the number of reported incidents of bad behaviour. "We'd just introduced a policy of 'earned privileges' so we thought it must be that rather than a few vitamins, but we used to joke 'maybe it's Bernard's pills!'"

But when the trial finished it became clear that the drop in incidents of bad behaviour applied only to those on the supplements and not to those on the placebo.

The results, published in 2002, showed that those receiving the extra nutrients committed 37% fewer serious offences involving violence, and 26% fewer offences overall. Those on the placebos showed no change in their behaviour. Once the trial had finished the number of offences went up by the same amount. The office the researchers had used to administer nutrients was restored to a restraint room after they had left.

"The supplements improved the functioning of those prisoners. It was clearly something significant that can't be explained away. I was disappointed the results were not latched on to. We put a lot of effort into improving prisoners' chances of not coming back in, and you measure success in small doses."

Gesch believes we should be rethinking the whole notion of culpability. The overall rate of violent crime in the UK has risen since the 1950s, with huge rises since the 1970s. "Such large changes are hard to explain in terms of genetics or simply changes of reporting or recording crime. One plausible candidate to explain some of the rapid rise in crime could be changes in the brain's environment. What would the future have held for those 231 young men if they had grown up with better nourishment?" Gesch says.

He said he was currently unable to comment on any plans for future research in prisons, but studies with young offenders in the community are being planned.

For Hibbeln, the changes in our diet in the past century are "a very large uncontrolled experiment that may have contributed to the societal burden of aggression, depression and cardiovascular death". To ask whether we have enough evidence to change diets is to put the question the wrong way round. Whoever said it was safe to change them so radically in the first place?

#### **Young offender's diet**

One young offender had been sentenced by the British courts on 13 occasions for stealing trucks in the early hours of the morning.

Bernard Gesch recorded the boy's daily diet as follows:

**Breakfast:** nothing (asleep)

**Mid morning:** nothing (asleep)

**Lunchtime:** 4 or 5 cups of coffee with milk and 2½ heaped teaspoons of sugar

**Mid afternoon:** 3 or 4 cups of coffee with milk and 2½ heaped sugars

**Tea:** chips, egg, ketchup, 2 slices of white bread, 5 cups of tea or coffee with milk and sugar

**Evening:** 5 cups of tea or coffee with milk and sugar, 20 cigarettes, £2 worth of sweets, cakes and if money available 3 or 4 pints of beer.

guardian.co.uk © Guardian News and Media Limited 2011



The New York Times  
nytimes.com



April 16, 2006

IDEA LAB

## Does Eating Salmon Lower the Murder Rate?

By STEPHEN MIHM

Most prisons are notorious for the quality of their cuisine (pretty poor) and the behavior of their residents (pretty violent). They are therefore ideal locations to test a novel hypothesis: that violent aggression is largely a product of poor nutrition. Toward that end, researchers are studying whether inmates become less violent when put on a diet rich in vitamins and in the fatty acids found in seafood.

Could a salmon steak and a side of spinach really help curb violence, not just in prison but everywhere? In 2001, Dr. Joseph Hibbeln, a senior clinical investigator at the National Institutes of Health, published a study, provocatively titled "Seafood Consumption and Homicide Mortality," that found a correlation between a higher intake of omega-3 fatty acids (most often obtained from fish) and lower murder rates.

Of course, seeing a correlation between fatty acids and nonviolence doesn't necessarily prove that fatty acids inhibit violence. Bernard Gesch, a senior research scientist at Oxford University, set out to show that better nutrition does, in fact, decrease violence. He enrolled 231 volunteers at a British prison in his study; one-half received a placebo, while the other half received fatty acids and other supplements. Over time, the antisocial behavior (as measured by assaults and other violations) of the inmates who had been given the supplements dropped by more than a third relative to their previous records. The control group showed little change. Gesch published his results in 2002 and plans to start a larger study later this year. Similar trials are already under way in Holland and Norway.

What would it mean if we found a clear link between diet and violent behavior? To start with, it might challenge the notion that violence is a product of free will. "But how do you exercise that free will without using your brain?" Gesch asks. "And how, exactly, is the brain going to work properly without an adequate nutrient supply?" The belief that people choose to be violent may be irrelevant if the brain isn't firing on all cylinders. This may especially be the case for impulsive acts of violence, which are less a choice than a failure to rein in one's worst instincts.

Consider, for example, a study conducted by researchers in Finland. They tested prisoners convicted of violent crimes and found that they had lower levels of omega-3 fatty acids than ordinary, healthy subjects. Why? Omega-3's foster the growth of neurons in the brain's frontal cortex, the bit of gray matter that controls impulsive behavior. Having enough of these fatty acids may keep violent impulses in check. Violent criminals may not be the only ones who would benefit from more fatty acids in their diet. In a recent double-blind trial, when omega-3's were given to people with a history of substance abuse, the symptoms of "anger" fell by 50 percent.

Of course, omega-3's are widely hailed these days as a miracle substance, credited with boosting health in dozens of ways. But Gesch warns against what he calls "silver bullets." The state of the evidence, he says,

①

"doesn't allow us to pinpoint which dietary fat is responsible for changes in behavior." In his new study, he will look into whether several interdependent nutrients may play a role.

Gesch further adds that we shouldn't expect nutrition alone to banish violent behavior. "The brain needs to be nourished in two ways. It needs to be educated, and it needs nutrients. Both social and physical factors are important." Simply throwing fish and vegetables at violent criminals is unlikely to have a lasting effect on its own.

Caveats aside, there's something that many people may find unnerving about the idea of curing violent behavior by changing what people eat. It threatens to let criminals evade responsibility for their actions. Think, for example, of the infamous "Twinkie defense," in which an accused murderer's lawyer suggested that junk food was partly to blame for his client's compromised mental state. More controversial, perhaps, is the brave-new-world idea of using diet to enforce docility and conformity to the rules, a sort of state-sponsored version of that timeless parental demand to children everywhere: "Eat your vegetables."

Then again, we already live in a society in which parents have resorted to drugs like Ritalin to quell unwanted outbursts and impulsive behavior. And when you approach it from that perspective, changing what people eat may not be so radical after all.

*Stephen Mihm teaches history at the University of Georgia.*

Copyright 2006 The New York Times Company

[Privacy Policy](#) | [Search](#) | [Corrections](#) | [XML](#) | [Help](#) | [Contact Us](#) | [Work for Us](#) | [Site Map](#)

8

# CRIME Times

Linking Brain Dysfunction to  
Disordered/Criminal/Psychopathic Behavior

Vol. 8, No. 3, 2002  
Page 1&2

## Dietary supplements slash prisoners' antisocial acts

Dietary supplements can dramatically reduce antisocial acts in a prison population, according to a new large-scale study in the prestigious *British Journal of Psychiatry*. C. Bernard Gesch and colleagues, calling their findings "remarkable," say that the approach "looks to be cheap, highly effective, and humane."

In a double-blind, placebo-controlled, randomized experiment, Gesch et al. recruited 231 young adult prisoners, assigning half to receive dietary supplements and the other half to receive a placebo. The placebo and active-treatment groups were matched according to their number of disciplinary incidents and their progress through the prison system. There were no significant differences between the two groups in IQ, verbal ability, anger, anxiety, or depression.

Subjects remained on the supplements, which contained vitamins, minerals, and essential fatty acids, for an average of 142 days. Compared to the placebo group, the researchers report, prisoners taking the active supplements committed an average of 26.3 percent fewer offenses. Compared to baseline rates, there was a 35.1 percent reduction in offenses in the supplemented group. "The greatest reduction occurred for the most serious incidents including violence," the researchers note, with a 37 percent drop seen in such incidents. No side effects were seen in subjects taking the supplements.

Gesch and colleagues conclude, "If these findings are replicated, a potential implication is that the dietary requirements for good health are also supportive of social behavior." They note that a number of the prisoners they studied lacked even a rudimentary knowledge of nutrition, and that "poor food choices by the prisoners typically resulted in lower nutrient intakes, most notably of minerals." Even though the prisoners were offered a relatively healthy diet while incarcerated, the researchers say, they consumed less than the recommended amounts of several essential nutrients.

"It is not advocated that nutrition is the only cause of antisocial behavior," the researchers say, "but the difference in outcome between the active and placebo groups could not be explained by ethnic or social factors, as they were controlled for by the randomized design."

Gesch et al.'s research supports previous findings by Stephen Schoenthaler and colleagues, whose studies show that nutritional supplementation can reduce antisocial acts by incarcerated children or adults, as well as reducing antisocial behavior and increasing IQ in "at risk" school children (see related article, *Crime Times*, 2000, Vol. 6, No. 2, Pages 3 & 6). Schoenthaler's dietary supplement research on young adult offenders in California revealed a 38 percent lower rate of serious rule violations in the group receiving supplements. Two other large, placebo-controlled studies by Schoenthaler et al., one of a group of "at risk" elementary school children and the other of adolescent delinquents, also revealed

that those receiving dietary supplements showed a marked drop in violent and non-violent antisocial acts.

Schoenthaler says of the Gesch et al. findings, "This is extremely welcome news, because a scientist in Great Britain... has independently confirmed what we've been dedicating ourselves to in studies across the United States for the past 20 years. Thousands of children and adults have now participated in these international studies. The most important finding here is that violent behavior can be reduced significantly at a very low cost, making our schools and correctional institutions much safer."

Similar findings were reported by Richard Carlton et al. (see related article, *Crime Times*, 2000, Vol. 6, No. 3, Pages 1 & 3), who found that supplements improved mood, behavior, and school performance in learning disabled children.

Bishop Hugh Montefiore of Natural Justice, a U.K. research charity that sponsored the new research by Gesch and colleagues, said, "The study is of great importance not only to those who work inside prisons but also more widely in the community."

Sir David Ramsbotham, former chief inspector of prisons, agreed, saying, "If healthy eating is part of a healthy lifestyle, and a healthy lifestyle is a crime-free lifestyle, I hope that [the prison service] will look seriously at exploiting the evidence presented to them." And clinical psychology professor Ron Blackburn, noting that most approaches to reducing offending require extensive resources, says, "This research program promises to have an impact on antisocial behavior with minimal intervention and deserves full support."

-----

"Influence of supplementary vitamins, minerals and essential fatty acids on the antisocial behaviour of young adult prisoners: randomized, placebo-controlled trial," C. Bernard Gesch, Sean M. Hammond, Sarah E. Hampson, Anita Eves, and Martin J. Crowder, *British Journal of Psychiatry*, Vol. 181, July 2002, 22-28. Address: C. Bernard Gesch, University Laboratory of Physiology, University of Oxford, Parks Road, Oxford OX1 3PT, UK.

-- and --

"Healthy eating can 'cut crime,'" BBC News, June 25, 2002.

-- and --

"Professor Schoenthaler's nutrition research reveals link between vitamin supplements and reduced violent behavior," press release, California State University, Stanislaus, July 3, 2002.

-- see also --

"Addiction and criminal behaviour," S. Schoenthaler and I. D. Bier, in *Food Allergy and Intolerance* (2nd edition), edited by J. Brostoff and S. Challacombe, W.B. Saunders Publishing, July 2002, 985-1000; "The effect of vitamin-mineral supplementation on juvenile delinquency among American schoolchildren: a randomized, double-blind placebo-controlled trial," S. Schoenthaler and I. D. Bier, *Journal of Alternative and Complementary Medicine*, Vol. 6, No. 1, 2000, 7-17; and, "The effect of randomized vitamin-mineral supplementation on violent and non-violent antisocial behavior among incarcerated juveniles," S. J. Schoenthaler, S. P. Amos, W. E. Doras, M. A. Kelly, G. D. Muedeking,

# CRIME Times

Linking Brain Dysfunction to  
Disordered/Criminal/Psychopathic Behavior

Vol. 5, No. 1, 1999  
Page 1&2&6

## NIH workshop spurred by findings about omega-3 fatty acids' effects on mental ills

In September 1998, the National Institutes of Health convened a workshop to review preliminary but exciting findings suggesting that omega-3 fatty acids may help treat or even prevent depression, attention deficit hyperactivity disorder (ADHD), and other psychiatric problems.

"I don't know of any other preventive treatments for mental disorders," Jerry Cott, NIH chief of the adult psychopharmacological research program, told the *Milwaukee Journal Sentinel*. "This is in a class by itself. It is extremely promising."

Omega-3 fatty acids are found in fish, leafy green vegetables, nuts, and flaxseed and canola oils. Early humans ate a diet high in these fats, while modern humans eat a diet far lower in omega-3 fatty acids and far higher in the omega-6 fatty acids found in corn, soybean, cottonseed, safflower, and sunflower oils. As a result, researchers speculate, humans may be deficient in several essential fatty acids, obtained only through foods, that are building blocks of synaptic membranes in the brain.

Researchers can't yet say with certainty that omega-3 acid supplementation will be a useful treatment for psychiatric disorders. But early studies suggest that omega-3 deficiencies are associated with aggression, other behavior problems, and several mental disorders, and preliminary trials of supplementation are encouraging. Among the findings:

- Andrew Stoll and colleagues supplemented the diets of patients with bipolar disorder (manic depression) with fish oil. Improvements in the supplemented subjects were so striking that the researchers terminated the study five months earlier than planned. "We saw dramatic differences," Stoll says, noting that 9 of 14 patients taking fish oil responded well, compared to only 3 of 16 patients taking the placebo. He believes that omega-3 fatty acids act in a manner similar to lithium and valproate, drugs commonly used to treat manic depression.
- Tomohito Hamazaki and colleagues gave 41 students either capsules rich in the omega-3 fatty acid docosahexaenoic acid (DHA) or placebo capsules for three months. The study began at a non-stressful time for the students (the end of summer vacation), and concluded during a stressful period in which final exams were given. Psychological tests given at the beginning and end of the study revealed that aggression against others increased significantly in the non-supplemented students when they were under stress, but did not increase in the DHA-supplemented students.
- Studying 6- to 12-year-old boys, L. J. Stevens and colleagues found that "a greater number of behavior problems, assessed by the Conners' Rating Scale, temper tantrums, and sleep problems

were reported in subjects with lower total omega-3 fatty acid concentrations." In addition, they say, more learning and health problems were seen in this group.

- In another study, Stevens and colleagues tested 53 boys with ADHD and 43 controls who were not hyperactive. The researchers found that subjects with ADHD had significantly lower concentrations of key fatty acids in their blood than other children.
- Malcolm Peet and colleagues reported evidence that chronic schizophrenics have reduced levels of essential fatty acids in red blood cell membranes, and that schizophrenic patients improve when they receive omega-3 supplements.
- Three separate studies show that in societies with a high dietary intake of omega-3 fatty acids, such as Japan, China, and Taiwan, rates of depression are lower than in countries with a low intake of these fats.

Researcher Joseph Hibbeln notes that eating increased amounts of omega-3 fatty acids can raise concentrations of serotonin in the brain. "Such an alteration in serotonergic function may possibly reduce depressive, suicidal and violent behavior," he says, but cautions that "these changes have not yet been demonstrated in clinical trials." Hibbeln and colleagues currently are studying the relationships between omega-3 fatty acids and serotonin and dopamine metabolites in healthy subjects, violent subjects, and early- and late-onset alcoholics. Preliminary research indicates that these relationships are significantly different in healthy subjects than in violent or early-onset-alcoholic subjects.

Researchers also note that the effects of omega-3 fatty acid deficiencies may explain the reported link between lowered cholesterol levels and increased rates of suicide, homicide, and depression. "When your doctor tells you to lower cholesterol," Hibbeln notes, "you usually lower your fat intake"- including the intake of omega-3 fatty acids.

-----

"Conference report: essential fatty acids predict biomarkers of aggression and depression," *PUFA [Polyunsaturated Fatty Acids] Newsletter, Vol. 1, No. 3, June 1997.*

--and--

"The effect of docosahexaenoic acid on aggression in young adults: a placebo-controlled double-blind study," T. Hamazaki, S. Sawazaki, M. Itomura, E. Asoka, Y. Nagao, N. Nishimura, K. Yazawa, T. Kuwamori, and M. Kobayashi, *Journal of Clinical Investigation, Vol. 97, 1996, pp. 1129-1133.*

--and--

"Omega-3 fatty acids in boys with behavior, learning, and health problems," L. J. Stevens, S. S. Zentall, M. L. Abate, T. Kuczek, and J. R. Burgess, *conference abstract, 1995.* Address: L. J. Stevens, Department of Foods and Nutrition, Purdue University, West Lafayette, IN 47907-1264.

--and--

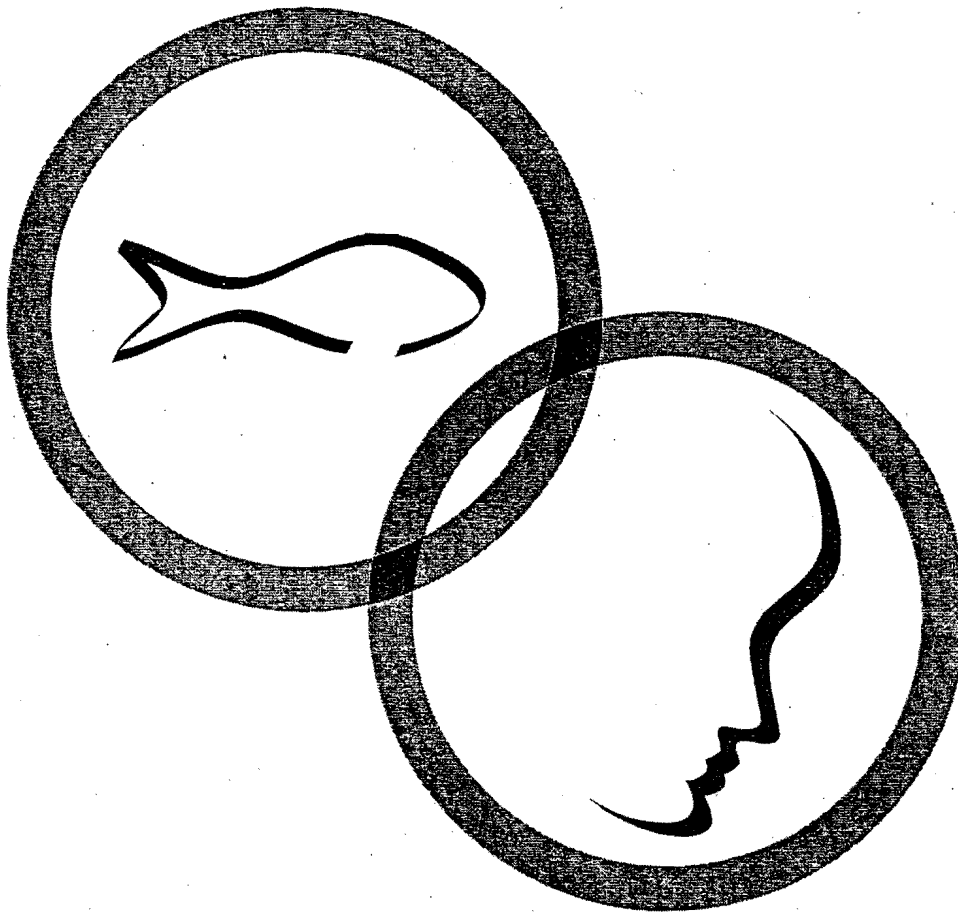
"Essential fatty acid metabolism in boys with attention deficit hyperactivity disorder," L. J. Stevens, S. S. Zentall, J. L. Deck, M. L. Abate, B. A. Watkins, S. R. Lipp, and J. R. Burgess, *American Journal of Clinical Nutrition, Vol. 62, No. 4, October 1, 1995, pp. 761-768.* See address above.



EXCERT:

## The Links Between Diet and Behaviour

The influence of nutrition on mental health



---

Report of an inquiry held by the Associate Parliamentary Food and Health Forum  
January 2008

## Executive Summary and Recommendations

Nutrition is usually taken to be important for physical health, but mental health – brain health in its widest sense – must be considered as equally important.

A diet lacking essential nutrients or containing too many ingredients that are detrimental in excess is likely to have adverse consequences for brain function and thus mental health and behaviour. It is widely agreed that a balanced diet is required to support physical health – and there is good scientific evidence suggesting that the Mediterranean diet is a good model. It is likely that a balanced diet of this kind is also beneficial for the healthy functioning of the brain.

It is now established that certain essential fatty acids (EFAs) especially Arachidonic Acid (AA) and Docosahexaenoic Acid (DHA) form an important part of the cellular structure of the brain and in maintaining its normal functions. But there is no nutritional magic bullet. No nutrient works in isolation; a deficiency in one leads to sub optimal functioning of others. The lack of certain nutrients, however, may be associated with a range of mental and behavioural disorders as this report describes. A deficiency of omega-3 EFAs is associated with certain mental and behavioural disorders, such as ADHD, depression, dementia, dyspraxia, greater impulsivity and aggressive behaviour, but the association is still only partly understood.

We believe that on-going research into the nutritional aspects of brain structure and function should be supported and further expanded. This should be funded, and new research commissioned, by the Food Standards Agency (FSA) and the Department of Health, but also by the Department for Children, Schools and Families and the Ministry of Justice because they are responsible for the areas of policy where public benefits are most likely to accrue, if the evidence emerging from recent trials is confirmed by further research. The Medical Research Council and universities will undertake much of this research.

Public policy should be based on sound science and the evidence we have seen and heard endorses the widely held view among those working in this field that more research is needed and worth undertaking. However, what is already known about the importance of nutrition for the development of the brain and mental health has significant public policy implications. The key conclusions and recommendations that emerged from the series of inquiry meetings held by the Forum in Parliament between March and October 2007 and the written evidence submitted to the inquiry are as follows.

1. We recommend that the Government – principally the Department of Health, the Department for Children, Schools and Families and the Ministry of Justice, working with the FSA and the Medical Research Council – commission and support further research in the areas highlighted in this report.
2. We recommend that the Scientific Advisory Committee on Nutrition (SACN) should be asked to define further the optimum intake of omega-3 polyunsaturated fatty acids (PUFAs) in different stages of life, especially for pregnant women and children.
3. We also recommend that in the meantime, on a precautionary basis, the FSA should reconsider its advice to pregnant women about fish consumption, with a view to encouraging them to eat two portions of oily fish, or the equivalent in omega-3 PUFAs, a week (rather than that people should eat two portions of fish a week, of which one should be oily).<sup>1</sup>

<sup>1</sup> Scientific Advisory Committee on Nutrition (SACN) / Committee on Toxicity (COT). Advice on fish consumption; benefits and risks. 2004; The Stationary Office, London.



4. We also recommend that the FSA continues to monitor closely levels of mercury, dioxin and dioxin-like polychlorinated biphenyl (PCB) in the different species of oily fish available in the UK.

The scanty training for GPs and other medical professionals in nutrition and diet detracts from their ability to support their patients' physical and mental health; this issue should be addressed by the Royal Medical Colleges and the General Medical Council if we are to tackle the problems and costs associated with mental as well as physical ill health.

5. We recommend that the Royal Medical Colleges and the GMC consider upgrading the role of nutrition in the medical curriculum.
6. We recommend that Primary Care Trusts (PCTs) should increase the number of posts for dietitians working in the community and that GP practices should be fully reimbursed if they employ a dietitian to whom patients can be referred for nutritional advice.

The campaigns by the Department of Health and FSA to increase the consumption of fruit and vegetables and reduce consumption of sugar, salt and saturated fat are welcome, but they do not make explicit the emerging link between diet and mental well-being and the role of essential fatty acids, which appear to be crucial to children's life chances particularly *in utero* and in early childhood.

7. We believe the Government should take further action to raise public awareness of the significance of good nutrition in pregnancy and to tackle the incidence of low birth-weight in the UK.

The evidence which has emerged to date of the links between nutritional status and childhood disorders, depression, aggressive and anti-social behaviour merits further publicly funded research.

8. We recommend that more research to test the effect of selected essential fatty acids on the cognitive skills, mood and behaviour of both "healthy" children (that is, children suffering from no known disorders), as well as children suffering from a range of behavioural disorders should be undertaken.
9. We recommend that regulations should be introduced to prohibit all artificial colours and non-essential preservatives in food products and soft drinks.
10. We recommend that the Government includes financial support to School Breakfast Clubs as part of the package set up to improve school meals. We strongly recommend that all children entitled to free school lunches should be entitled also to a free school breakfast whose content, like school lunches, should be subject to quantified nutritional standards.
11. We recommend that the Department of Health encourages NHS Trusts to adopt an approach similar to that pursued by the Doncaster and South Humber Healthcare NHS Trust which undertakes a nutritional assessment of patients suffering from depression and patients with early symptoms of psychosis and provides dietary advice to them.
12. We recommend that consideration of the outcome of the next trial of nutritional supplements in Young Offender Institutes should be a priority for the National Offender Management Service (NOMS) given that our prisons are overcrowded and there is continuing concern about the mental health of prisoners, particularly young offenders at risk of self-harm and suicide.

13. We recommend that any dietary intervention that can be used to improve the behaviour and mental well-being of offenders held in custody should be given serious consideration by the NOMS.
14. We recommend that the NOMS looks positively at the case for introducing nutrient-based standards for meals in prisons, similar to those introduced for schools, but based on recommended daily intakes for adults.
15. We also recommend that effective measures should be taken in all prisons to inform prisoners about the benefits of a good diet and to enable them to make healthy choices both while they are in custody and after their release.
16. We recommend that in all women's prisons national nutritional standards should be introduced to ensure that the basic dietary needs of pregnant women prisoners are achieved.
17. Because of the major potential benefit for the fields of education, crime, health and the well-being of vulnerable sections of society, we believe that more research is urgently needed in the area of nutrition and behaviour and we recommend that the Government devotes more resources to this, especially in corrective institutions and care homes.
18. We recommend that Department of Health messages on a healthy diet should emphasise the importance of a balanced diet for optimum mental as well as physical health.
19. While research continues to identify and produce alternative sources of omega-3 PUFAs, we recommend that all people in the UK should be encouraged to eat more fish, some of which should be oily fish, or its equivalent in omega-3 PUFAs.

## Introduction

### 1. The Associate Parliamentary Food and Health Forum

1. As an "Associate Parliamentary Group", the Forum has Parliamentary and non-Parliamentary members, including a wide range of consumer groups, the food and drink industry and organisations with an interest in food and health issues, such as the Institute of Food Research, the Nutrition Society, the National Heart Forum, the Royal College of General Practitioners and trade associations. We exist to facilitate discussion between Parliamentarians and non-Parliamentarians on food and health issues. Further information about us is available on our website at: [www.fhf.org.uk](http://www.fhf.org.uk)

2. The members of the Forum inquiry team were: Lord Rea, Chairman of the Food and Health Forum; his fellow Officers, Earl Baldwin of Bewdley, Dr Ian Gibson MP, Baroness Gibson of Market Rasen and Baroness Miller of Chilthorne Domer, and the Countess of Mar.

### 2. Acknowledgements

3. We are indebted to all the individuals and organisations who have given us oral and written evidence and advice. We take full responsibility, however, for the conclusions we have drawn and our recommendations to Government. The inquiry team would like to thank Patricia Constant of Central Lobby Consultants (CLC) for her assistance in drafting this report. CLC provides the Secretariat for the Associate Parliamentary Food and Health Forum. We are also grateful for the detailed scrutiny and criticism of an early draft by Ms Anne Dillon-Roberts, Lord Krebs, Professor Tom Sanders and Dr Lindy Williams. We would also like to thank Andrea Ross for designing the front cover.

4. We would like to acknowledge the general support of the Forum's sponsors: currently, Marks & Spencer, Princes Food and Weetabix, whose financial support for the Forum helps to make our work possible.

### 3. Background

5. The Officers of the Food and Health Forum decided in late 2006 that it would be potentially valuable to consider in more detail the influence of diet on mental health and behaviour and the public policy implications of current knowledge in this field. Recognising that this is a large and complex field and that our time and resources were limited, we decided that the primary focus of our inquiry would be the influence of essential fatty acids (EFAs) on mental health and behaviour (especially mood, memory, ability to concentrate, impulsivity and aggression). Our reason for this choice was that emerging evidence in this field holds out the promise of significant potential benefits (see section 4.1). We were also interested in exploring the science behind the sometimes sensational media reports which have generated much public interest in recent years.

6. The influence of diet on behaviour, while of growing academic and public interest, is not a new subject. Researchers in the UK, for example Bryce-Smith, Crawford and Peet, have been drawing attention to this subject since the 1960s.

7. In recent years there has been growing concern about increasing problems of anti-social behaviour and violence, as well as the impact of mental ill health among adults and children. A study in 2003 found that some 66,000 reports of anti-social behaviour were made to agencies

each day.<sup>2</sup> Depression is now the most commonly diagnosed mental health problem in the developed world and appears to be on the increase.

8. It is generally accepted that social and economic factors play a major part in these trends. However, over the same period a number of peer reviewed scientific trials in the UK and elsewhere have suggested that some people, including children with a range of behavioural/mental health disorders, benefit from a diet containing adequate omega-3 long chain polyunsaturated fatty acids (LC PUFAs). Other studies have demonstrated the significance of other micronutrients such as iron, zinc, folic acid and other vitamins.

#### 4. Methods

9. In order to explore what is currently known about the role of nutrition and diet in influencing mental health and behaviour in certain areas - chiefly the behaviour of school children, individuals suffering from depression and offenders in custody - we issued two public calls for evidence in January and September 2007 (which are available on the FHF website at: [www.fhf.org.uk/inquiry](http://www.fhf.org.uk/inquiry)). Our call for evidence was sent to all Parliamentary and non-Parliamentary members of the Forum (including organisations such as the Nutrition Society, the British Nutrition Foundation and the Food Standards Agency), the Royal Society and the Academy of Medical Sciences. It was also posted on the FHF website and drawn to the attention of the national media.

10. Our call for evidence sought information on the effect of the consumption of essential fatty acids (EFAs) and other nutrients on mental health and behaviour. In particular it asked for evidence on which aspects of brain function were influenced by the consumption of EFAs (for example, mood, memory, ability to concentrate, impulsivity or aggression); the optimum daily intake of EFAs for the average adult or child; the ideal balance of omega-3 and omega-6; what role there might be for foods fortified with these; whether increased consumption of EFAs would be beneficial for the general population; and what policy recommendations should be made to Government concerning the consumption of EFAs in the UK.

11. We then held a series of meetings with researchers with published work in this field as well as public policy analysts and officials, to discuss what is known about the effect of diet on mental health and behaviour. We also discussed with these experts the public policy implications of this knowledge - what could, or should, be the next steps? The full minutes of these meetings are available on the Forum's website at: [www.fhf.org.uk/inquiry](http://www.fhf.org.uk/inquiry). The contributors of oral and written evidence are listed in Appendix 1.

12. We are grateful to the Academy of Medical Sciences and others for drawing our attention to experienced scientists who take a more sceptical view of the impact of EFAs on mental health and behaviour and we have taken these views into account. We were also glad to receive evidence from scientists who drew our attention to strong evidence for the influence of other nutrients on mental health and behaviour, such as iron and glucose.

13. For those not familiar with the literature in this field, we have described briefly the relevant biochemistry of brain structure and function to indicate why omega-3 LC PUFAs are of importance for the brain (see Box 2, p.11). This has been extensively covered in many peer reviewed scientific papers and in a well referenced report produced in 2005 for non-scientists by Sustain.<sup>3</sup>

14. This report has been written by Parliamentarians primarily for Parliamentarians, most of whom are not scientists. We have tried to pull together the currently accepted scientific thinking as presented to us by our witnesses and published in the literature with an emphasis on the importance of EFAs in a healthy diet, but this is not a systematic review. We have tried to

<sup>2</sup> One day count of anti-social behaviour: September 10 2003, Home Office.

<sup>3</sup> Changing Diets, Changing Minds: how food affects mental well being and behaviour, 2005.

achieve a balance in our consideration of the issues under discussion, focusing in particular on research that investigated links between diet and behaviour. We fully acknowledge that more research is needed in these areas; indeed that is the primary message of this report. We recognise that dietary effects differ according to genetic disposition. Behaviour is also influenced by many other factors such as peer pressure, family attitudes, and sub-cultural and societal norms.

### **Research methods - a hierarchy of evidence [Box 1]**

15. Several of our witnesses referred to the concept of a hierarchy of evidence, which flows from the least well established to the most. Research usually starts with a hypothesis, which may be the result of an epidemiological association or the result of direct case based observations. Although these associations may be statistically significant, in cross sectional or longitudinal cohort studies, there is always the possibility that confounding factors may explain the association, even when care is taken to rule these out as, for example, in the ALSPAC study used by Hibbeln. Having developed a hypothesis, researchers may postulate a plausible biological mechanism, which can then be tested in open (non-blinded) intervention trials. However, randomised, double-blind, placebo-controlled trials carry more weight. Still greater credence will be placed in the results of large scale trials. A meta-analysis of all or most known research studies in a particular field will be influential, but only if care is taken to include studies with negative as well as positive findings and if strict quality criteria are applied. Finally, a thorough systematic scientific review will produce the most credible results because of its transparency and the care taken to avoid bias and to assess all studies for their validity and methodology. The results of such a systematic scientific review can then provide the basis for well-justified decisions on treatment or community interventions.

16. Many earlier studies in the field of diet and behaviour were not randomised double-blind, placebo-controlled trials. Many have been small and covered a short time-span only. As a result we need to take care not to exaggerate the significance of preliminary or poorly designed studies. We also recognise that double-blinding is particularly crucial when investigating traits such as behaviour, which rely on assessments that are partly subjective. We believe therefore that the Government should provide adequate resources to enable well planned randomised controlled trials (RCTs) into nutrition and behaviour to be carried out.

17. When more research has taken place, policy makers will be faced with the task of applying information gathered from RCTs, which may have required the use of supplements in order to "blind" the study and ensure the consumption of the nutrients concerned, to recommendations about food and how to change dietary habits.

## 1. Nutrition and brain development

18. In the second half of the last century a rapid increase in the prevalence of coronary heart disease and stroke occurred in the developed world. This stimulated epidemiological and laboratory based research which has greatly increased understanding of the underlying factors which promote or interfere with the healthy development of the cardiovascular system.

19. Nutrition is one of these – an adequate intake of necessary nutrients (for example, micronutrients, essential fatty acids (EFAs), amino acids and anti-oxidants) is beneficial, whereas an excessive intake of some others (for example, saturated fat, sugar or salt) is detrimental.

20. The ideal “balanced diet” promoted by the Food Standards Agency (FSA) not only helps to prevent heart disease and stroke, but also reduces the risk of cancer, diabetes and other chronic diseases. Good nutrition promotes the normal healthy development and functioning of all systems. The brain and central nervous system are no exception. As human brain development is most rapid in late pregnancy and early childhood, nutritional factors have a particularly important role during these phases.

21. The eye, nervous system and the brain evolved in the marine environment of the Cambrian era some 600 million years ago in early forms of life. Although some of the original DNA of these life forms has changed over 600 million years, a significant proportion remains as it was in all forms of life today. The composition of the lipids critical for the signalling processes that eventually led to the development of the human brain, has hardly changed. Specifically Docosahexaenoic acid (DHA) has been structurally and functionally fixed in photoreceptors and synapses since that time<sup>4</sup> (see Box 3).

22. Arachidonic acid (AA) from omega-6 fatty acids and DHA from omega-3 fatty acids each make up some 8% of the dry weight of the brain.<sup>5</sup> DHA is also a vital component of the photoreceptors responsible for receiving light photons and sending image messages to the brain.<sup>6</sup> Some 30%-50% of the retina is made from DHA; severe DHA deficiency can reduce the efficiency of the initial stage of retinal signalling by more than a thousand-fold.<sup>7</sup> Omega-3 deficiency is associated with poor night vision and other problems with visual and spatial processing and focussing attention.

### 1. The effect of the changing human diet over time

23. Man became distinguished from the great apes about 7 million years ago, but we are only 1.2% different from the chimpanzee in our genetic make-up.<sup>8</sup> We are still adapted for a wild food diet that differs enormously from modern food. There are fewer calories and less fat in the wild forms of currently farmed animals and fish and what fat there is consists of a much higher proportion of polyunsaturated fatty acids (PUFAs). As we have moved from the wild to extensive animal husbandry, to selection for fast growth and intensively fed systems, the proportion of visible fat, and fat within the muscle tissue of the animals we eat, which is mostly saturated fat, has increased. Over this period the total proportion of calories derived from all fats has doubled to some 40%. Intake of saturated fats has increased, and coronary artery disease has soared since the 19<sup>th</sup> century. Similarly the annual intake of sugar (sucrose) per person in England

<sup>4</sup> Professor Crawford, written evidence 22 March 2007.

<sup>5</sup> MRC Vitamin Study Research Group. Prevention of Neural Tube Defects: Results of the Medical Research Council Vitamin Study. *Lancet* 1991; 338: no. 8760

<sup>6</sup> Neuringer M et al. The essentiality of n-3 fatty acids for the development and function of the retina and brain. *Annual Review of Nutrition* 1988; 8:517-41.

<sup>7</sup> Dr Alexandra Richardson, oral evidence 28 March 2007

<sup>8</sup> Fujiyama A et al. Construction and analysis of a human-chimpanzee comparative clone map. *Science* 2002; 295: 131-134.

increased from 6.8 kg in 1815 to nearly 54.5kg in 1970. In the USA it increased from 55.5kg in 1970 to 69.1 kg in 2000.<sup>9</sup>

24. The approximately equal presence of omega-3 and omega-6 fatty acids in the brain has led to the view among some researchers that dietary intake of the two should ideally also be balanced equally. However, the current intake ratio of omega-3 to omega-6 varies from 1:15 to 1:30 depending on diet and other factors. A number of scientists working in the field of nutrition believe this "imbalance" has important consequences for our mental health.

25. In the last century, average height in the UK rose by about 0.4 inches per decade. Cardiovascular disease rose from a rarity, alongside several cancers, to be a major cause of mortality by the end of the century. Obesity is now a major health issue. Western man has thus changed in shape, size and disease pattern in one century. In the evolutionary timescale this is the "blinking of an eye". Professor Crawford and others believe that the changing lipid composition of the diet has been a major contributor to this change in body shape and disease pattern.<sup>10</sup>

### Consumption of omega-6 and omega-3 fatty acids

26. The evidence for changes in the European food chain has been reviewed by Sanders.<sup>11</sup> Overall there has been a shift in the balance between omega-6 and omega-3 fatty acids over the past 30 years. He found that intake of Linoleic acid (LA) (omega-6) has risen in many northern European countries. In the UK, intakes have increased from ~ 10g/day in the late 1970s to ~ 15g/day in the 1990s. The intake of Alpha-Linolenic acid (ALA) (omega-3) is estimated to be ~1-2g/day, but varies with the culinary oil used. Soybean and rapeseed oils are currently the most plentiful liquid vegetable oils used. However both are commonly partially hydrogenated for use in commercial frying. This process leads to selective losses of ALA (omega-3). The increased use of intensive, cereal-based livestock production systems has resulted in a lower proportion of omega-3 fatty acids in meat compared with traditional extensive production systems.

27. There has been a rapid increase in soybean oil consumption from 0.12 kg/year to 12kg/year - a hundred-fold increase - in the USA food supply over the last century. Soybean oil consumption now accounts for 20% of calories in the average US diet<sup>12</sup> and half of these calories are derived from LA (omega-6), which creates Arachidonic acid (AA), (see Box 2, p.11) an important component of cell structures but which has inflammatory properties.

28. This dramatic change in the human diet during the last century has important implications because LA (omega-6) inhibits the conversion of ALA (omega-3) to the longer chain polyunsaturated fatty acids (PUFAs), Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), because they compete for the same desaturase and elongation enzymes.<sup>13</sup> Thus, higher amounts of LA (omega-6) mean greater amounts of omega-3 PUFAs are required to have the same effect. The exact effect of an increased ratio of omega-6 to omega-3 is an area of ongoing research and some controversy.

### Links between omega-3 consumption and health

29. Hibbeln compared consumption of omega-3 from fish sources in different countries with mortality from various diseases and homicide. Japan and Iceland, with relatively high per capita consumption of omega-3 from fish sources, have the lowest premature mortality rates from

<sup>9</sup> Cordain L et al. Hyperinsulinemic diseases of civilisation: more than just Syndrome X. *Comparative Biochemistry & Physiology Part A* 2003; 136: 95-112.

<sup>10</sup> Fischer AG Fossils, Early Life, and Atmospheric History. *Proceedings of the National Academy of Sciences USA* 1965; 53 (6): 1205-1213.

<sup>11</sup> Sanders TAB Polyunsaturated fatty acids in the food chain in Europe. *American Journal of Clinical Nutrition* 2007 (71) s: 176S-178S

<sup>12</sup> Gerrior S & Bente L Nutrient content of the US food supply, 1909-1999: a summary report. Washington DC, US Department of Agriculture Centre for Nutrition Policy and Promotion, 2002.

<sup>13</sup> Commander Joseph Hibbeln and Dr Alexandra Richardson, oral evidence March 2007

these diseases. Hibbeln also related omega-3 consumption from fish sources to post-natal depression, (omega-3 is rapidly depleted from mothers during pregnancy) and found high omega-3 intake was related to better outcomes, as in the mortality rates described above.<sup>14</sup>

30. Having calculated a dose response curve (see Box 3, p.17) for omega-3 intake and each of twelve diseases and all cause mortality, Hibbeln and colleagues calculated the percentage of a vulnerable population that could be protected from various illnesses by different omega-3 intakes. They found, for example, that some 48% of cardiovascular disease was potentially modifiable in this way. However, only at levels of 750mg/day of omega-3 from all food sources, as is typically the case in Japan, could 98% of the population be protected. This is far above the level currently recommended by the Scientific Advisory Committee on Nutrition (SACN) in the UK (two portions of fish per week, one of which should be oily).

31. Omega-3 intakes in the UK and US populations may need to be even higher than those of Japan to meet body tissue levels equivalent to those of Japan, because we consume higher amounts of LA (omega-6). Thus a healthy dietary allowance for omega-3 fatty acids for current US diets was estimated at 3.5g/day for a 2000-kcalorie diet.<sup>15</sup>

32. If high omega-6 intake is shown conclusively to inhibit EPA and DHA absorption or synthesis, an alternative to increasing fish and seafood consumption would be to reduce the intake of LA (omega-6) as each would result in more equal tissue ratios of EPA and DHA.

**Biochemical factors in brain composition: why some fatty acids are essential [Box 2]**

33. Appropriate nutrition is essential for the development and health of the brain, the largest organ in the human body. At least 39 essential nutrients must be provided by our food. These include vitamins and minerals, essential amino acids, and omega-3 and omega-6 fatty acids.

34. 60% of the dry weight of the brain is fat, mostly in the form of polyunsaturated fatty acids (PUFAs), whose molecules are most flexible. Moreover, essential fatty acids (EFAs) make up some 20% of dry brain mass. It would seem unsurprising, therefore, that the amount and type of fat in our diets influences brain structure and health. However it is only in recent years that this view has become more widely accepted.

35. Fatty acids are essential for the structure of all cell membranes - these omega-3 and omega-6 PUFAs increase the flexibility and fluidity of membranes. They affect brain growth and connectivity and are essential for the maintenance of optimal brain function throughout life. Cell signalling depends on membrane fluidity and omega-3 and omega-6 fatty acids and their derivatives affect many aspects of cell signalling. The substances we make from them can profoundly affect hormone balance, blood flow and immune system function.

36. Fatty acids from two "families" are called 'essential', because humans cannot make them - so they must come from the diet: Linoleic acid (LA) (omega-6) and Alpha-linolenic acid (ALA) (omega-3). Within the omega-3 and omega-6 series, it is the longer chain polyunsaturated fatty acids (PUFAs) that the brain really needs. They are not always called "essential" because humans can synthesise them from the "parent" essential fatty acids (EFAs).

37. Four PUFAs are particularly important for brain development and function: Dihomogammalinolenic acid (DGLA) and Arachidonic acid (AA) from the omega-6 series and Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) from the omega-3 series. AA and DHA are major structural components of neuronal membranes (making up 20% of the dry mass of the brain and more than 30% of the retina). EPA and DGLA are also crucial, but they play signalling rather than structural roles.

<sup>14</sup> Hibbeln J et al. Healthy intakes of n-3 and n-6 fatty acids: estimations considering worldwide diversity. *American Journal of Clinical Nutrition* 2006; 83: 1483S-93S.

<sup>15</sup> Hibbeln J et al. (2006) op. cit.



### The essential fatty acid conversion sequence (simplified)

#### Omega-3 Conversion

Alpha-Linolenic acid (ALA) (18 carbon atoms)  
 ↓  
 Eicosapentaenoic acid (EPA) (20 C atoms)  
 ↓  
 Docosapentaenoic acid (DPA) (22C atoms)  
 ↓  
 Docosahexaenoic acid (DHA) (22 C atoms)

#### Omega-6 Conversion

Linoleic acid (LA) (18 C atoms)  
 ↓  
 Gamma-linolenic acid (GLA) (18C atoms)  
 ↓  
 Dihomo-gamma-linolenic acid (DGLA)  
 (20 C atoms)  
 ↓  
 Arachidonic acid (AA) (20 C atoms)

38. However, the conversion of shorter-chain EFAs to longer-chain PUFAs in humans is poor. It is also affected by many diet and lifestyle factors including excessive consumption of saturated fats, hydrogenated fats and trans fatty acids; lack of co-factors, such as zinc, magnesium, vitamins B3, B6 and C; viral infections and the presence of hormones released in response to stress; and the consumption of alcohol and smoking which help strip EFAs from the body. The conversion of EFAs to PUFAs is also affected by constitutional factors, such as ageing, atopic eczema and being male.

39. Omega-6 is available in vegetable oils, nuts, seeds and grains. The essential omega-3 fatty acid ALA is found in green leafy vegetables, seaweed (a rich source), soya, flax, some nuts and seeds (walnut and pumpkin), but the key long chain omega-3 PUFAs - Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) - are mostly found pre-formed in appreciable quantities in fish and other seafood.

40. The terms 'saturated' and 'polyunsaturated'/'highly unsaturated' are derived from organic chemistry, the chemistry of carbon compounds, which includes all living substances. Carbon tends to link to four other atoms. Very many chemical compounds (including fatty acids) consist of long chains of carbon atoms. Compounds with all four links around each carbon atom, occupied by another atom, usually hydrogen or other carbon atoms, are called saturated. But sometimes there is a double link between two carbons in the chain and such compounds are called unsaturated. The double link changes the chemical properties in quite a fundamental way, making the substance more reactive. A polyunsaturated compound simply has several of these double links. The position of the double-link is important. For example, omega-3 is so-called because the first double bond between carbon atoms is three away from the methyl (omega) end (DHA has 22 carbon atoms) and this affects the way it works. Membranes are made of layers and the closer the double bond is to the methyl end of the chain, the more flexible it is. The other reason omega-3 is important is that the eicosanoids form the substrate for signalling molecules and they depend on the double bond between the third and fourth carbon atoms.

41. The omega-3 long chain PUFAs can be synthesised slowly from shorter omega-3s such as Alpha-linolenic acid (18 Carbon atoms) derived from plant sources (rapeseed, flax, walnut), but the longer chain omega-3 PUFAs, EPA (20 C) and DHA (22C) that are required by the brain, are obtained much more efficiently from oily fish. However, even these fish do not synthesise them themselves; they derive them from algae including sea weed. Some companies are now using genetically engineered seaweed and simpler forms of algae to produce DHA and EPA.

42. All unsaturated chemical compounds are vulnerable to attack by peroxide free radicals. These can damage most living systems and are responsible for initiating many diseases, including cancer. Polyunsaturated fatty acids in the body need protection. Antioxidants such as the tocopherols (E306-9, also known as Vitamin E) can do this. Vitamin E is highly polyunsaturated and it mops up the dangerous free radicals before they can attack the fatty acids. Thus, many of the supplements used in trials in which omega-3 has been an active ingredient have also included small amounts of vitamin E. Oleic acid, a mono-unsaturated omega-9 fatty acid, is also easily oxidised and can act as a free radical barrier for EFAs.

## 2. Significance of the maternal diet for the development of the brain

43. At birth babies' heads are much closer to their final size than are their bodies, which suggests that the brain takes priority in the early development of humans. In fact brain development starts early in pregnancy and is largely finished by two years after birth. So the stage is set for life during this early developmental period. Damage or developmental restriction at this time cannot be repaired later. The cost of neuro-developmental disorders in early life is thus disproportionately high because they are life-long.<sup>16</sup>

44. There is evidence that the development of a child's brain is significantly affected by the mother's diet during pregnancy. Supplementing infant formula with pre-formed polyunsaturated fatty acids (PUFAs) (both omega-3 and omega-6), found naturally in breast milk, has been shown to improve visual and cognitive development.<sup>17</sup>

45. The consumption of pre-formed DHA in a mother's diet affects the amount present in breast milk.<sup>18</sup> Although this might appear to have important implications for the babies of vegetarian and vegan mothers, who have lower levels of DHA,<sup>19</sup> studies by Professor Sanders and others have concluded that these differences in fatty acid composition were not statistically related to differences in birth weight, head circumference or length.<sup>20</sup> Professor Tim Key suggested to us that "there is an absence of evidence" as to any effect on the mental development of these babies.

46. More recently, however, a consensus statement from the international Perinatal Lipid Intake (PERLIP) Working Group and the Early Nutrition Programming Project<sup>21</sup> concluded that intake of fish or other sources of long chain omega-3 fatty acids results in a slightly longer pregnancy duration. It found that a "higher DHA supply to the fetus (sic) during pregnancy and to the infant after birth was associated with beneficial effects on the development of visual acuity, cognitive functions and attention, maturity of sleep patterns, spontaneous motor activity and immune phenotypes, in cohort studies and in a limited number of randomised controlled trials."

47. Professor Alan Jackson advised us that, where maternal dietary supply of DHA is only marginally adequate and intake is not changed during pregnancy and lactation, meeting the increased requirement for DHA for the healthy development of the infant brain depends on conservation of PUFAs by reduced oxidation; the amount of pre-formed EPA and DHA which can be accessed from adipose tissue reserves; and the ability to increase the formation of DHA from precursors such as Alpha-linolenic acid (ALA) (omega-3).

48. A recent study<sup>22</sup> found evidence to support the hypothesis that breastfeeding benefits long-term stereoscopic (binocular vision) development, and an effect of DHA cannot be excluded, but the lack of difference in stereoacuity (visual function) between infants randomly assigned to DHA-containing formula and those assigned to control formula suggests that factors in breast milk other than DHA account for the observed benefits.

49. In another recent study,<sup>23</sup> scientists at King's College London studied the effect of breastfeeding on IQ. By looking at more than 3000 children in Britain and New Zealand they

<sup>16</sup> Professor Michael Crawford, written evidence 22 March 2007.

<sup>17</sup> Makrides M et al. Effect of maternal docosahexaenoic acid (DHA) supplementation on breast milk composition. *European Journal of Clinical Nutrition* 1996; 50(6): 352-357.

<sup>18</sup> Sanders TAB & Reddy S The Influence of a vegetarian diet on the fatty acid composition of human milk and the essential fatty acid status of the infant. *The Journal of Paediatrics* 1992; 120: S71-77.

<sup>19</sup> Sanders TAB et al. The influence of maternal vegetarian diet on essential fatty acid status of the newborn. *European Journal of Clinical Nutrition* 1994; 48: 358-368.

<sup>20</sup> Sanders TAB & Reddy S (1992) op cit. Sanders TAB et al. (1994) op cit.

<sup>21</sup> Koletzko B et al Dietary fat intakes for pregnant and lactating women. *British Journal of Nutrition* 2007 doi: 10.1017/S0007114507764747.

<sup>22</sup> Singhal A et al. Infant nutrition and stereoacuity at age 4-6 y. *American Journal of Clinical Nutrition* 2007; 85(1):152-9

<sup>23</sup> Caspi A et al. Moderation of breastfeeding effects on the IQ by genetic variation in fatty acid metabolism. *Proceedings of the National Academy of Medical Sciences* 2007; (10.1073/pnas.0704292104).

found that it raised intelligence by an average of 7 IQ points, but only if the children had the "C" version of the FADS2 gene, which is involved in the genetic control of fatty acid pathways. Fortunately some 90% of children have this "C" version of the FADS2 gene. This study shows the intellectual development of children is influenced by both genetic inheritance and environmental experiences, in this case breastfeeding. These issues merit further investigation and some is already underway.

#### **Low birth weight and risk of future ill health**

50. The UK has the highest incidence of low birth-weight of any Western European country.<sup>24</sup> Although low birth-weight is only a crude marker of pregnancy outcome, it is a powerful predictor of future ill health: heart disease, stroke, diabetes, poor learning abilities, mental ill health and crime. At the extreme end, very pre-term, low birth-weight infants are at high risk of central nervous system disorders such as Cerebral Palsy. These outcomes are worst in lower socio-economic groups. The Little Foundation's European Cerebral Palsy study concluded that the majority of cases arise from adverse prenatal conditions and thus are potentially preventable.<sup>25</sup>

51. There is evidence that lower DHA levels are associated with a shorter gestation length<sup>27</sup> and a greater risk of risk of preterm delivery.<sup>28</sup> The lower the birth-weight the greater is the risk of brain disorders. This increases from 1 or 2 per 1,000 normal live births to over 200 per 1,000 in extremely low birth-weight infants - "the tip of an iceberg of poor mental development and risk of chronic ill health."<sup>29</sup>

#### **Maternal intake of EFAs - risk of exposure to toxins in fish versus children's IQ**

52. In 2004 the Scientific Advisory Committee on Nutrition (SACN) and the Committee on Toxicity of Chemicals in Food, Consumers Products and the Environment (COT) published a report, *Advice on fish consumption: benefits and risks*.<sup>30</sup> They recommended maximum levels at which the health benefits of preventing heart disease clearly outweigh the possible risks from dioxins. The FSA has advised us<sup>31</sup> that their recommendations represented a "minimal and achievable average population goal, which does not correspond to the level of fish consumption required for maximum nutritional benefit." The COT report concluded that the evidence to suggest an improvement in cognitive function of the developing foetus with increasing levels of fish consumption was inconclusive. The FSA continues to hold this view, despite the publication of more recent research findings which indicate a positive benefit, such as Hibbeln et al in *The Lancet*, February 2007 (see below).

53. The FSA advised us that: "Studies investigating the effects of diet on cognitive function are hard to interpret, as factors influencing brain development are complex and multi-factorial." The FSA acknowledges that: "A range of epidemiological data suggests that low intakes or poor nutritional status is associated with poor development (including a range of cognition and other

<sup>24</sup> Professor Michael Crawford, written evidence 22 March 2007

<sup>25</sup> Bax M et al. Clinical and MRI correlates of cerebral palsy: the European Cerebral Palsy Study. *The Journal of the American Medical Association* 2006; 296(13):1602-1608.

<sup>26</sup> Crawford MA et al. Arachidonic and Docosahexaenoic Acids in Protection Against Central Nervous System Damage in Preterm Infants. *Lipids* 2003; 38(4): 303-315.

<sup>27</sup> Olsen SF et al. Gestational age in relation to marine n-3 fatty acids in maternal erythrocytes: a study of women in the Faroe Islands and Denmark. *American Journal of Obstetrics and Gynecology* 1991; 164:1203-1209. Olsen SF et al. Randomized clinical trials of fish oil supplementation in high risk pregnancies. Fish Oil Trials In Pregnancy (FOTIP) Team. *BJOG: An International Journal of Obstetrics and Gynaecology* 2000; 107: 382-395. Smuts CM et al. A randomized trial of docosahexaenoic acid supplementation during the third trimester of pregnancy. *Obstetrics and Gynecology* 2003; 101:469-479.

<sup>28</sup> Olsen SF & Secher NJ Low consumption of seafood in early pregnancy as a risk factor for preterm delivery: prospective cohort study. *British Medical Journal* 2002;324:447.

<sup>29</sup> Professor Michael Crawford, oral evidence 28 March 2007.

<sup>30</sup> SACN/COT report 2004 op cit. See: [http://www.sacn.gov.uk/pdfs/fics\\_sacn\\_advice\\_fish.pdf](http://www.sacn.gov.uk/pdfs/fics_sacn_advice_fish.pdf)

<sup>31</sup> FSA letter, 1 October 2007

performance outcomes relating to learning) in early childhood. Potential confounding and bias in these studies, however, makes it difficult to draw firm conclusions.”<sup>32</sup>

54. As a result of the SACN/COT report, the FSA advises that “girls and women who might have a child in the future and women who are pregnant or breastfeeding can eat up to two portions of oily fish (280g) a week; other women, boys and men can consume up to four portions of oily fish a week.” This FSA advised us that “this recommendation has been set as some oily fish contain chemicals such as dioxins and polychlorinated biphenyls (PCBs), which accumulate over time in the body and could have adverse health effects on the developing foetus if consumed at high levels over a long period of time. However, the majority of the UK population does not consume enough fish, particularly oily fish, and should therefore be encouraged to increase their fish consumption.”<sup>33</sup>

55. The US Food and Drug Administration issued recommendations in 2004 advising pregnant women that while they should eat fish and seafood because it contains high quality protein and omega-3 fatty acids, nearly all fish and shellfish contain traces of mercury and that higher levels of mercury “ may harm an unborn baby or young child's developing nervous system.”

56. Commander Joseph Hibbeln stated that the adverse effects of methyl-mercury resulting from the consumption of pilot whales substantially influenced the USA advice. However, they have relatively high levels of mercury and low levels of omega-3 fats in comparison with oily fish. Salmon, for example, has high levels of omega-3 and no significant level of mercury.<sup>34</sup>

57. Hibbeln believed this official advice was in error because it did not take into account the balance of risks associated with deprivation of the beneficial nutrients in fish. He therefore used data from the Avon Longitudinal Study of Parents and Children (ALSPAC) initiated by Professor Jean Golding, the largest epidemiological study of pregnancy and its outcomes in the world,<sup>35</sup> to evaluate the efficacy of the Federal Government's advice.

58. The results, published in *The Lancet* in February 2007, showed that increased intake of omega-3 from fish and seafood during pregnancy was associated with an increase in the IQ of the child at age eight.<sup>36</sup> The IQ of the children was highest in the group whose mothers had consumed more than the recommended amount of fish. The benefit was greater than any theoretical risk from mercury contamination. This positive effect also applied to fine motor skills and social development.

59. The findings from the ALSPAC study were that: maternal fish and seafood consumption of less than 340g/week during pregnancy did not protect children from adverse outcomes; there were beneficial effects on child development when maternal seafood intakes exceeded 340 g/week; and these improved further among those who had eaten well above this level (up to 700g/week). These findings persisted after adjustment for multiple potential confounders. The study concluded that advice for women to limit seafood intake to the FSA recommended level of up to 280g (two portions)/week (which the FSA advises equates to 0.45g/day of long chain omega-3) during pregnancy – is set too low.<sup>37</sup>

**60. We believe these findings from a large, carefully conducted longitudinal study are of importance in public policy terms and therefore recommend that the Scientific Advisory**

<sup>32</sup> FSA written evidence, October 2007.

<sup>33</sup> FSA written evidence, October 2007.

<sup>34</sup> Commander Hibbeln, oral evidence 28 March 2007.

<sup>35</sup> For more detailed information about the ALSPAC study see the 25 April 2007 inquiry meeting minutes.

<sup>36</sup> Hibbeln et al. Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood (ALSPAC study): an observational cohort study. *Lancet* 2007; 369: 578–585.

<sup>37</sup> Current FSA advice for pregnant women is to avoid eating shark, swordfish and marlin and to limit the amount of tuna eaten to no more than two fresh tuna steaks (280gm) or four medium-size cans of tuna a week because of the risk of mercury contamination. The FSA also advises pregnant women to avoid having more than two portions of oily fish a week, such as salmon, trout, mackerel and herring, because it can contain pollutants such as dioxins and PCBs (polychlorinated biphenyls).

Committee on Nutrition (SACN) should be asked to further define the optimum intake of omega-3 polyunsaturated fatty acids (PUFAs) in different stages of life, especially for pregnant women and children.

61. We also recommend that in the meantime, on a precautionary basis, the FSA should reconsider its advice to pregnant women about fish consumption, with a view to encouraging them to eat at least two portions of oily fish, or the equivalent in omega-3 PUFAs, a week. We believe that pregnant women who do not wish to eat oily fish should be encouraged to consider taking fish oil supplements during pregnancy and while they are breast-feeding. In this context we note the advice we have received from other contributors to our inquiry that it is virtually impossible to overdose on omega-3 PUFAs. We noted the conclusions adopted by the PERLIP Working Group, in partnership with the Early Nutrition Programming Project, that pregnant and lactating women should aim to achieve an average daily intake of at least 200mg/day of DHA.<sup>38</sup> We have also taken into account the views (recently published in English)<sup>39</sup> of the Norwegian Scientific Committee for Food Safety (VKM). Like the 2004 SACN/COT report, this assessment sought to bring together evidence of the nutritional benefits and toxicological risks associated with seafood consumption. It recommended that fertile women should not eat more than two portions of fatty fish per week (with the current levels of dioxins and dioxin-like PCBs), but added: "However, the equivalent of over two meals of fatty fish per week must be consumed from childhood and continue throughout the entire fertile period in order for a woman to accumulate and exceed the body burden of dioxins and dioxin-like PCBs against which the tolerable intake is intended to protect." It also noted that the "tolerable intake level represents a safety level, not a limit for when adverse health effects will necessarily occur"... "Even if the safety limit is moderately exceeded, the risk is likely to be modest."

62. We also recommend that the FSA continues to monitor levels of mercury, dioxin and dioxin-like polychlorinated biphenyl (PCB) contamination in the different species of oily fish available in the UK. We believe this is important if mothers, and others, are to be encouraged to eat more oily fish, in order to assess and put into context any concern there may be about the risk of mercury contamination.

63. We believe the Government should take further action: to raise public awareness of the significance of good nutrition in pregnancy and to tackle the incidence of low birth-weight in the UK. These efforts would most usefully be focused initially on deprived mothers. We hope the Government will consider driving such an initiative forward, for example through an expansion of the SureStart<sup>40</sup> scheme with a greater involvement of registered nutritionists, registered dietitians and health visitors.

64. Against this background, we welcome the Government's decision to pilot in ten areas of the UK a version of the American "Nurse-Family Partnership" programme.<sup>41</sup> We hope that the Government will ensure that nutritional advice – based on the most up to date research – forms an important part of this programme. This advice should emphasise to pregnant women and new mothers that their diet will have a crucial effect on the physical and mental wellbeing of their children as they develop in the womb and thereafter.

<sup>38</sup> Koletzko B et al. 2007 op cit. NB. The authors report that 200 mg DHA/d can be reached by consuming one to two portions of sea fish per week, including oily fish.

<sup>39</sup> A comprehensive assessment of fish and other seafood in the Norwegian diet. English translation published 2007. Vitenskapskomiteen for mattrygghet (VKM) (The Norwegian Scientific Committee for Food Safety) ISBN: 978-82-8082-207-9.

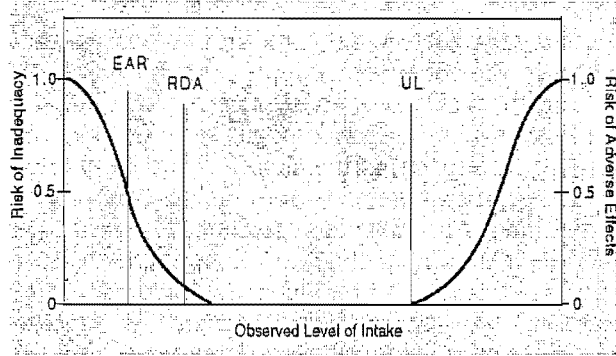
<sup>40</sup> Sure Start is a Government programme which aims to deliver the "best start in life for every child". It brings together early education, childcare, health and family support (for more information see: <http://www.surestart.gov.uk/>).

<sup>41</sup> Hansard 18 April 2007, col. 643-645W.

27

### Calculation of Recommended Dietary Intakes [Box 3]

65. Recommended daily intakes (RDI) are calculated so as to protect the majority (>98%) of a population from increased risk of chronic illnesses (for example vitamin C and scurvy) whilst also protecting against a risk of adverse effects. Response curves of this kind need to take account of the sensitivities of a diverse population.<sup>42</sup>



EAR- estimated average requirement, RDA, recommended daily allowance, UL – upper limit (not to be exceeded)

<sup>42</sup> Dietary Reference Intakes: Guiding Principles for Nutrition Labelling and Fortification Committee on Use of Dietary Reference Intakes in Nutrition Labelling. National Academies Press USA, 2003.