THE

Institute for Food, Brain and Behaviour

IFBB

INAUGURAL LECTURE SUMMARY

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In the inaugural IFBB lecture, Professor Crawford traced the origins of the human brain's nutritional requirements, dispelling various flat earth myths along the way.

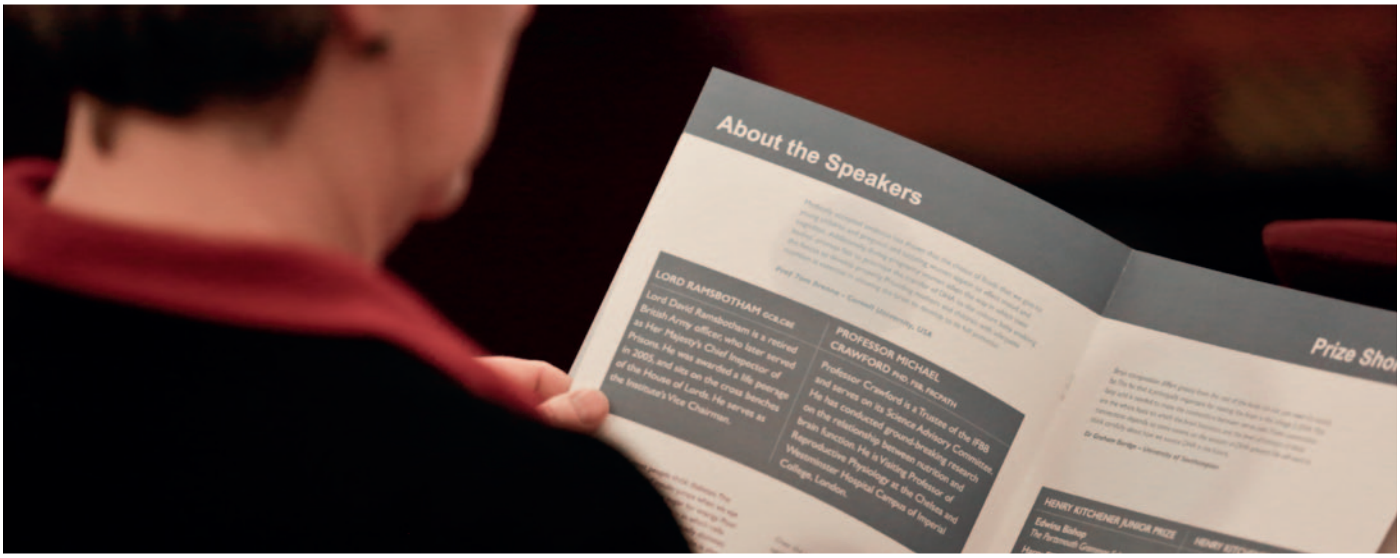
The current mental health crisis started in earnest in the latter half of the last century, leading to mental ill health costs in the UK alone now estimated by the NHS at over £100 billion. Worldwide the number is incalculable. The primary culprit is identified as a dramatic reduction in the diet of the essential fatty acids needed for brain development and maintenance owing to a number of factors. Professor Crawford demonstrated how intensive animal and plant production became land-based, while at the same time marine-based fatty acids from fish and other related nutrients plunged as a dietary source. Over 500 million years ago the first constituents of our brains evolved in the sea through these marine fats and other elements – and yet it is only since the Second World War that the radical changes in food production have deprived the human brain of many of these essential nutrients.

This may appear a simplification of a long and complex evolutionary journey, but there is a remarkable constant throughout: ready access to sources of the nutrients for the brain, especially the right essential fatty acids. Deprived of this historical, evolutionary constant, we now know that the brain operates sub-optimally and mental health suffers.

There are real solutions to the crisis, but these solutions will require a political and social will to achieve. Professor Crawford refers briefly at the end of his talk to the unsustainability of aquaculture as it is generally conducted. But there are other models which must be examined to feed the burgeoning global population, and at the same time providing the nutrients required for the human brain.

These ideas all need development, and they must be attractive to government or business sponsors. But before this can happen, decision-makers must face up to the crisis that we have created by neglecting what our brains need.

Summary of the Lecture



In the twentieth century, as scientists unravelled the genetic code, it became apparent that genes play a huge part in who we are. Francis Crick, who helped decipher the structure of DNA argued that it carried information which was 'translated' into RNA, and from RNA 'transcribed' into proteins: the cell's basic machines and building blocks. Thus information flowed from genes to cells, and not back again. This idea became known as the central dogma.

Later in that same century the human genome project deciphered our DNA 'recipe' – and posed a challenge to the central dogma. Genes cannot explain everything about how our bodies work; there are simply far too few of them. Other factors must be involved. The science of epigenetics began finding ways in which the environment can alter gene expression. Information can flow from cells to genes.

Charles Darwin knew this, although some of his more gene-keen successors seem to have forgotten it. In The Origin of Species (1859) he says that there are two forces in evolution – natural selection and the conditions of existence – and that the latter is the more powerful. However, experiments three decades later by a biologist called Weismann convinced many people that this was not the case. Weismann cut the tails off rats and observed that the next generation of animals still grew tails. He argued that natural selection (i.e. genetics) was the more powerful force, because his alteration of the rats' conditions of existence had no lasting impact – as of course it would not – rather like the docking of sheep's tails.

Weismann lived before the era of thalidomide. We now understand much more about how organisms grow and develop, and the contributions that both genes and environmental factors – such as drugs or diet – can make to that process. Animal studies have shown that, for instance, changing maternal diet can affect the physiology of the offspring, their brain function and their behaviour.

Although well protected the brain is nonetheless dependent on diet. Its hugely complex structure is 60% fat, and to build it we need two types of fatty acids: long chain omega-3s and omega-6s. The published evidence to support this discovery appeared as early as 1972 and has been fully accepted ever since. These are unsaturated fats: that is, the carbon chains of which they are built contain several carbon-carbon double bonds. The number and position of these bonds determines how the fatty acid is used in building and maintaining brains and indeed to the signaling that translates into vision, thought and action.

Omega-3s and omega-6s are called essential fatty acids because they cannot be made by the body. They must therefore be eaten, in the form of alpha-linolenic acid (ALA, found in leaves and marine flora) and linoleic acid (LA, found in seeds/grains). Omega-6s are also found in grain products and the meat of grain-fed animals, whereas the omega-3 DHA is predominantly found in fish and sea foods, where it is associated with other essentials such as iodine and vitamins A and D. There is robust evidence that DHA is irreplaceable in vision and the brain.

In the body, ALA is converted into other omega-3s like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). LA is converted into omega-6s like arachidonic acid (AA). These conversions are slow and inefficient, with the synthesis of DHA being the slowest to convert. Hence there would be, and is, an evolutionary advantage to eating the pre-formed acids, i.e., DHA and EPA rather than ALA.

The same biochemical mechanisms are involved in both processes, so the more omega-6 rich foods you eat, the less omega-3 the body can obtain, arguing for a well-considered balance.

There is robust evidence that fatty acids are essential to the brain. Their levels are tightly controlled and growing brains obviously have a high demand for them. Modern diets supply extremely plentiful omega-6, but are deficient in omega-3s like DHA, the most abundant fatty acid in a healthy brain.

Why are fatty acids so crucial? They are essential building blocks of cell membranes. All life depends on these fatty layers, which allow cells to keep themselves separate from their environment and to maintain distinct compartments within cells. This allows, for example, electrical charges to differ inside and outside a neuron – the basis of brain activity. Studies have shown that brains deficient in DHA do not form or function normally, and their gene expression is altered. (Thus information flows from diet to genes.)

Human brains are unusually large for their body size, and to evolve in this way they must have had an abundance of dietary DHA. Where could these have come from? There are two main ideas. The dominant

'savannah' hypothesis argues that humans evolved on the great plains of Africa, obtaining their fatty acids primarily from the meat of prey animals. However, such meat contains little DHA.

The second idea, the 'aquatic ape' or 'waterside' hypothesis, argues that humans were both hunters and swimmers. Living mainly in coastal regions, they might kill and eat large prey, but they also had available copious amounts of fish and shellfish, rich in omega-3s, iodine and trace elements. Recent archaeology has now 'identified the earliest appearance of a dietary, technological and cultural package that included coastal occupation, bladelet technology, pigment use and dietary expansion to marine shellfish, and is dated to a time close to the biological emergence of modern humans (160-180kya)'. It would be folly to dispute these findings.

We know that at the coastline, emerging Homo sapiens would have had DHA, iodine, vitamin D and A rich foods at every meal. Moreover, the lakes, rivers and estuaries would have had a superb abundance of aquatic foods. Modern science shows that such a diet would have altered gene expression and at the same time provided the 'conditions of existence' for the brain to enlarge, generation by generation, until Homo sapiens emerged. Today, however, the escalation of land-based, intensively reared foods has been eclipsing that very aspect of diet which was responsible for the evolution of our brains from 350g of a chimpanzee to the 1,400g of modern Homo sapiens.

There is a strong case to suggest that the declining brain size we are now seeing, coupled with an amply recorded rise in disorders of the brain are a consequence of the fundamental change in diet that has occurred in the past 50-60 years, leading to suboptimal brain function.

This has resulted in a well-documented steep escalation in mental health issues such as anxiety and depression. Numerous studies have linked high levels of these conditions to low levels of omega-3 intake. Importantly, they have also shown that fatty acid levels in mothers' diet in pregnancy can predict verbal IQ, social and behavioural scores in their offspring eight years later.

But unfortunately eating more fish and seafood is not a solution for the global population, as both population growth and reduction of fish stocks through overfishing and pollution mean a mismatch in supply and demand. There simply aren't enough

fish to provide the requisite amount of DHA without other means. Moreover, the Foresight Think Tank in its 2011 report claims there is not enough available arable land or new land that can be brought into production to feed a world population escalating to a predicted nine billion. The Food and Agricultural Organization of the United Nations reports that hunger is rising and that to feed the nine billion equably, food production needs to increase by 70%. But it is not just food; it is what is in the food that will matter: DHA, Iodine and other nutrients essential to the brain must be factored in.

There are solutions: Japan, Indonesia, China and other countries in the East are developing marine agriculture with marine grass meadows, artificial reefs and kelp forests. Putting our efforts into farming the sea as we have farmed the land could provide adequate brain-specific nutrients and reverse the rise in mental ill health and brain disorders. We have a responsibility to act now to protect our children's and our children's children's future.