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“Our work is more vital today than ever before”
It would be impossible to imagine the modern world without brands. From airlines to computers, from fruit drinks to clothes, from football teams to hair shampoo, our choices are informed by brands. There are many definitions of the word ‘brand’. David Ogilvy, famous advertising copywriter and founder of the influential advertising agency Ogilvy and Mather, defined it thus: “The intangible sum of a product’s attributes: its name, packaging and price, its history, its reputation, and the way it’s advertised.”

The rebrand of *Sight and Life* coincides with the rebrand of *DSM* – the first for forty years. The new DSM brand promises Bright Science. Brighter Living. At *Sight and Life* we strive in our own way to make continually evolving scientific insights available to the ultimate benefit of the poorest and most disadvantaged populations of the world.
Welcome

A new look – an unchanging commitment

This year, 2011, sees the 25th anniversary of Sight and Life. We celebrate this significant milestone in our history with the launch of a new Sight and Life brand – one that illustrates our move from a focus on vitamin A and sight to the vital role played by multiple micronutrients in promoting health and preventing hidden hunger. This is the first issue of our magazine to reflect our new look and feel. As we celebrate 25 years of service in the field of micronutrients, we look back to where we have come from and look forward to where we need to go. For despite our achievements in the first quarter-century of our existence, our work in the world is more vital today than ever before.

The founding of Sight and Life

The Sight and Life Task Force, as it was originally known, commenced operations on 1 April 1986. Its objective was to help combat xerophthalmia – the eye disease caused by vitamin A deficiency from which approximately ten million young children in developing countries suffered at the time. The 1986 Sight and Life Annual Report estimated that every year, one million of these children lost their eyesight. Of these, it noted that two-thirds died after a short period.

A direct response to requests from the World Health Organization, the creation of Sight and Life was part of a much wider approach to tackling vitamin A deficiency, which had been identified by the 37th World Health Conference as one of the five main nutritional problems in the world. The initial activities of Sight and Life included the provision of scientific and technical support, free distribution of vitamin A capsules for emergency situations, and financial support for selected research programs.

“Our work is more vital today than ever before”

Over the past 25 years, our focus has broadened to encompass the entire spectrum of micronutrients, reflecting advances in science on the one hand and the increasingly recognized burden of concurrent multiple micronutrient deficiencies on the other. In 2007, marking our 21st anniversary, I wrote in our Annual Report that we still faced the problem of two billion people worldwide being affected by hidden hunger. Further, I noted that it was unacceptable that approximately one third of all children under five years of age worldwide were stunted and almost 50% anemic, while at the same time some 155 million school-age children were overweight or obese. These problems cannot be addressed by concentrating on vitamin A alone. Hence the widening of our focus to comprise the entire range of micronutrients.

Our new logo

This expanded focus is expressed by our new logo, which symbolizes the multiplicity of micronutrients essential for a healthy life. Whereas our original logo was based on the letter A and the human eye, clearly linking vitamin A with eye health, this new one puts Sight and Life at the nexus of better nutrition and health. Whether this means growing the evidence, sharing information, advocating, promoting partnerships, or capacity building in the micronutrient arena, the message is clear: Sight and Life’s mission is to build bridges for better nutrition focusing on life, using a multiplicity of approaches and interacting with a wide range of stakeholders.

We hope that you too will like the new logo and also enjoy the new look and feel of the magazine. Our intention was to create a publication that retained the scientific rigor for which our organization has always been known while presenting the content in a more accessible and compelling manner. The Sight and Life team welcomes your feedback – please let us know what you think, as the magazine is produced not for us but for you, the reader.
Our history between two covers

While April 2011 is the quarter-centenary of the founding of *Sight and Life*, we will be officially celebrating our birthday in October of this year, to tie in with World Food Day, which is celebrated every year around the world on 16 October, and which I would like to see renamed World Food and Nutrition Day to recognize that food does not automatically mean nutrition providing all the required micronutrients. Our jubilee celebrations will be accompanied by the launch of a book recounting our 25-year history in the context of the global fight against malnutrition. It tells the story of the founding of *Sight and Life*, of our changing focus over the course of time, and of our enduring commitment to combating malnutrition worldwide. Watch this space for more news of the book launch!

As I mentioned in my opening remarks, our commitment to combating global micronutrient malnutrition is more necessary than ever before. I am writing this editorial against the backdrop of extensive political unrest in the Arab world. Tunisia, Algeria, Syria, the Yemen and Egypt have witnessed unprecedented uprisings against long-established governments; Libya is in a state of civil war as we prepare to go to press. While the reasons for these revolts are multi-faceted and vary in their detail from country to country, there can be no doubt that the rising cost of food is one of the main drivers. The populations of North Africa have to dedicate 35 to 50% of their income to food (contrast this with the USA, for instance, where the figure is 7%). From 2010 to 2011, the cost of wheat rose by 73%, that of maize by 88%.

While these figures are already shocking, the future promises to bring even more challenges. Global consumption of cereals in 2010 amounted to two billion tons. This figure will double by 2050 in the light of unprecedented population growth. And while the world’s population is growing, the resources available to feed it are shrinking; the rising sea levels associated with climate change are likely to eliminate vast swathes of land in the course of time, especially in the world’s poorest countries that cannot afford costly flood defenses. At the same time, urbanization continues inexorably: in China alone, half a million hectares of arable land disappear each year as a result of that country’s spectacularly developing infrastructure.

“Our history between two covers”

In 2008 this publication predicted that micronutrient malnutrition would result from the rising price of food. The issue in question was written against the background of the 2008 cyclone that hit Burma and the earthquake that devastated areas of China in the late spring of the same year. The present editorial is written not only against the backdrop of the current political upheavals in the Arab world but also in the light of the appalling scenes following the earthquake and tsunami in Japan that have claimed thousands of lives and left the country battling for survival in the face of a nuclear disaster whose possible consequences can barely be imagined. Already we are hearing reports of food and water that has been contaminated by radioactivity.

“The task before us is greater than ever”

At a moment in the history of our organization that calls for celebration, and for honoring the efforts of everyone who has helped to make *Sight and Life* what it is today, the task before us is greater than ever. Born in response to the famine created by the war in Ethiopia in the mid-1980s, and initially focused on the prevention of xerophthalmia caused by vitamin A deficiency, *Sight and Life* now works across the entire spectrum of micronutrients, creating the bridges that link scientific research, policymaking and programs on the ground. We have more opportunities to influence the world than ever before. We also have more challenges. Our commitment in the face of those challenges is as strong as ever. The spirit of the 1986 *Sight and Life* Task Force lives on in today’s organization, and we are proud to carry it forward with us into the next quarter-century.

Yours sincerely,
“Roche had decided to make a formal commitment to the battle against vitamin A deficiency, building on the ad hoc interventions it had already been supporting for a number of years,” recollects Professor Al Sommer, Dean Emeritus, Johns Hopkins Bloomberg School of Public Health.

“Dr John Gmünder would drop by from time to time to discuss this undertaking and seek advice as to where Roche should be focusing its efforts. We at Bloomberg were aware at the time that vitamin A had a huge influence on physical and mental well-being. The link had not yet been proven, however, and the rest of the world seemed reluctant to accept the theory.

“One day John told me that Roche had decided to sponsor a new organization called Sight or Life – the implication being that if you couldn’t see, you weren’t living. I felt, however, that this sent too negative a message, and that it might be construed as offensive by people who were blind and lived very full lives. I therefore suggested calling the new organization Sight and Life, because vitamin A is important for sight specifically but also for life in general. This little change gave the Task Force a very positive name, and one which was intimately associated with vitamin A.”
Sight and Life Statement

Low Dose Iron Multiple Micronutrient Powder: Rationale for Use in Malaria Endemic Areas

Multiple micronutrient powders (MNPs) are packaged in single or multi-dose sachets. These sachets contain micronutrients in powdered form, and can be added to foods prepared in the household just before consumption. Usually, one dose of MNP provides the full unit of recommended nutrient intake (RNI) of vitamins and minerals.

In 2007, the use of MNPs, particularly in emergency conditions, was endorsed by the World Health Organization (WHO), the World Food Programme (WFP) and the United Nations Children’s Fund (UNICEF) as an effective way of improving the micronutrient status of nutritionally vulnerable sections of the population, such as children under five years of age and pregnant and lactating women.

The risk of untargeted iron supplementation

Based on results from a study conducted in Zanzibar and other bodies of evidence, it was concluded that untargeted iron supplementation may increase child morbidity and mortality from malaria in the absence of monitoring and treatment programs. A sub-study analysis suggested that adverse events occurred in supplemented children who had not been iron-deficient. The WHO Consultation on Prevention and Control of Iron Deficiency in Infants and Young Children in Malaria Endemic Areas concluded that the safety of home fortification, as practiced at that time, is uncertain, whereas food fortification programs are still regarded as safe. In the above-mentioned study in Zanzibar, the negative impact on iron-replete children was demonstrated at levels of 12 mg Fe (as FeSO₄ supplement) per day. The bioavailability of FeSO₄ from a supplement is considerably higher than bioavailability from fortified food, where the amount of available iron depends on the food matrix. The children who showed adverse effects during iron supplementation had therefore been exposed to high doses of absorbed and unabsorbed iron.

As a result, the micronutrient powder mix for malaria endemic areas designed by DSM contains a significantly lower dose of iron (2.5 mg, as NaFeEDTA) in combination with a known enhancer of iron absorption (ascorbic acid). This iron dose is close to or even lower than amounts provided in food fortification programs, and is not comparable to the bolus doses administered in iron supplementation programs. A consequence of the lower iron dose contained in the MNP sachets is the need to ensure that the amount of (bioavailable) iron delivered is high enough to cover the needs of the individual.

Currently the compound used is NaFeEDTA, which belongs to a group of iron compounds with a high relative bioavailability compared to ferrous sulphate (FeSO₄). The main advantage of NaFeEDTA is better bioavailability in the presence of iron absorption inhibitors such as phytic acid and tannins, whereas the bioavailability of FeSO₄ is heavily dependent on the presence or absence of such inhibitors. In particular, home-fortification is linked to the consumption of the local diet or local complementary foods, where starchy staples with a significant amount of iron absorption inhibitors are consumed. In addition, according to the latest recommendations for flour fortification, NaFeEDTA is the recommended compound for flours with high levels of phytates (e.g. maize flour).

Possible explanations for the Zanzibar results

Two possible explanations for the results seen in Zanzibar have been proposed: the formation of non-transferrin-bound iron (NTBI) in plasma, and the stimulation of pathogen growth in the gastrointestinal tract (due to the amount of unabsorbed iron). It has been proposed that administration of bolus doses of iron can result in large amounts of unabsorbed iron, which enters and passes through the intestine. Recently published results indicate that unabsorbed iron from fortified foods modifies the
“The main advantage of NaFeEDTA is better bioavailability in the presence of iron absorption inhibitors.”
colonic microflora in African children to create a potentially more pathogenic profile. If this is confirmed, it could help to explain the reported adverse effects of iron supplementation and bolus doses of iron.

The other potential mechanism discussed is the formation of non-transferrin-bound iron (NTBI). Recently presented data on the formation of NTBI after administration of iron in women with low iron status (NTBI formation monitored over eight hours), showed that the highest NTBI concentrations were produced by a 60 mg dose without food, followed by 60 mg and 6 mg with food. These first data indicate that iron administered with food and through fortification (rather than supplementation) resulted in lower NTBI formation.

"The two-step approach of optimizing the MNP formulation for malaria endemic areas is expected to be safer than typically used iron doses"

In conclusion, based on current knowledge, the two-step approach of optimizing the MNP formulation for malaria endemic areas is expected to be safer than typically used iron doses (12.5 mg). The reduction of the iron dose to levels closer to the amount of iron provided in food fortification helps to reduce the amount of unabsorbed iron in the intestine. Meanwhile, using a highly bioavailable iron compound in combination with iron absorption enhancers is crucial to supplying the individual with the iron needed.

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The “Sight and Life in My Life” Essay Competition

In the last issue of the magazine, we launched the Sight and Life in My Life Essay Competition. Its aim was to find out how Sight and Life has played a part in readers lives, as part of the organization’s 25th anniversary.

The closing date for the competition was 15 March 2011 and we have received many wonderful stories. We have been delighted with the entries we have received and are looking forward to sharing these with you in future issues. We are now in the process of reading and judging the entries and will be contacting the winners and those who sent us highly commended entries later this summer.

We have received entries from many countries, from Nigeria to Sri Lanka. Many fascinating photographs and even some original artwork has come our way, such as the picture here by Dr Narendra Kumar, which is the cover of her booklet that helps children and families in India.

We would like to say a very heartfelt thank you to all you who entered the competition. We appreciate the time you have spent on writing your entries and would also like to thank you for all the amazing good work you do in your communities.

With warmest wishes

The Sight and Life Team
Food prices on the rise again

PERCENTAGE OF TOTAL HOUSEHOLD CONSUMPTION EXPENDITURES GOING TO FOOD

6 – 15%  16 – 25%  26 – 35%  36% +  No data

Introduction

Vitamin A is essential for the growth and development of cells and tissues. In its active form, retinoic acid (RA), it controls regular differentiation as a ligand for retinoic acid receptors (RAR, RXR).1,2 Vitamin A plays a substantial role in the respiratory epithelium and the lung. In the presence of moderate vitamin A deficiency the incidence of diseases of the respiratory tract is considerably increased. Repeated respiratory infections can be influenced therapeutically by moderate vitamin A supplementation.3,4,5 Besides its importance for lung function, vitamin A is also responsible for the development of many tissues and cells, as well as for embryonic lung development. Recent studies have demonstrated that this occurs by various expressions of retinoid receptors, as well as by time-dependent changes of the vitamin A concentration in the tissue. Where maternal vitamin A is deficient fetal lung maturation might be seriously impaired, with consequences for postnatal function.

The Influence of Vitamin A on the Maturation and Differentiation of the Lung

Vitamin A and its major active metabolite RA have a profound influence on the alveolar development, maintenance and function of the lung. Type II alveolar cells synthesize and secrete surfactant.6 RA is able to stop – dependent on its concentration7 – the expression of the surfactant-protein A (SP-A) in human fetal lung explants. Insulin, TGF-β and high concentrations of glucocorticoids can also down-regulate the expression of SP-A-mRNA,8 but lower concentrations of glucocorticoids stimulate the expression of these genes.9 In contrast, the expression of SP-A-mRNA is increased by hyperoxia in rats10 and by dexamethasone in human fetal lung explants.7

Type PGE₂ prostaglandins are able to increase surfactant synthesis. Under the influence of EGF (epidermal growth factor) the formation of prostaglandins rises, especially that of PGE₂. On the other hand, the expression of the EGF receptor is increased by RA. EGF increases proliferation of the lung tissues, leading to an amplified formation of surfactant phospholipids.11 RA and EGF both lead to an increase (40%, 80%) in the secretion of PGE₂ in fetal lung cells of the rat in vitro.12 The combination of RA and EGF, however, leads to a more than a six-fold increase in the secretion of PGE₂. Consequently, RA can interfere in lung development due to its modulating effect on the expression of EGF and the subsequent PGE₂-induced surfactant formation. Sufficient and continuous availability of vitamin A (either on the blood pathway or from local storage sites) is pivotal, especially
"Repeated respiratory infections can be influenced therapeutically by moderate vitamin A supplementation."
for the timely regulation of lung development and the related formation of the active metabolite RA. During embryonic development, RA regulates cell proliferation and differentiation, and regular morphogenesis. In the postnatal period, RA is important for lung growth, alveolarization, and elastin formation.13, 14

“The combination of RA and EGF leads to more than a six-fold increase of the secretion of PGE₂”

**Vitamin A kinetics during fetal lung development**

Local extrahepatic stores are present in fibroblast-like cells close to the alveolar cells, in type II cells and in the respiratory epithelium retinyl esters. The importance of these retinyl esters as an acute reserve during the development of the lung becomes apparent during the late phase of gestation and the beginning of lung maturation. During this period, rapid emptying of the retinyl ester stores in the lung of rat embryos occurs.15 This depletion is the result of increased RA demand in the lung development process, because RA is instantly needed for the process of cellular differentiation and metabolic work. Indeed, RA is important for the formation of alveoli, and may rescue failed alveolar formation.16,17 The effect of an adequate amount of RA on alveolar formation which starts prior to birth and lasts up to the age of eight years or even longer has recently been documented. Checkley and co-workers18 reported that children of mothers from a region with vitamin A deficiency who were supplemented during pregnancy and for six months after pregnancy with 7 mg preformed vitamin A (7 mg retinol equivalents, RE) as a single oral supplement once a week had significantly better lung function at nine to 11 years old than those of mothers receiving either a placebo or 42 mg  β-carotene (7 mg RE).

“Vitamin A supplementation before, during and after pregnancy improved lung function in offspring”

**Vitamin A kinetics during lung development**

The fact that the  β-carotene group had no benefit regarding lung function may be due to either poor absorption, a lower cleavage rate or polymorphism of the  β-carotene monooxygenase (BCMO), as discussed recently.19,20 Administration of preformed vitamin A will contribute to a more sufficient supply of the lung. The effect of vitamin A on later lung function might be a consequence of adequate alveolar formation during fetal lung development and during early childhood. However, if there was no further supplementation six months after delivery in the vitamin A deficient area, how might improvements of the lung function 10 years later be explained? One explanation might be the sufficient repletion of vitamin A storing cells in the lung of the offspring, which may serve as storage sites for a longer time period. Retinyl ester stores have been described in lipid-laden fibroblasts21 and in the bronchiolar epithelium.22 These lipid interstitial cells deliver RA, which induces alveolus formation.23 In the alveolus, the lipid-laden fibroblast is a major contributor to the formation of the extracellular matrix.24 Following hydrolysis of retinyl esters to form retinol, retinol is oxidized via alcohol dehydrogenase (ADH) followed by irreversible oxidation to retinoic acid. All steps are tightly controlled via intracellular binding proteins. Retinol bound to the cytoplasmic retinol binding protein (holo-CRBP) is protected from degradation and delivered to the lecithin: retinol acyltransferase (LRAT) for esterification.25 Cytoplasmic retinoid binding proteins form a substrate-controlled network, which at least controls the delivery of RA to the nuclear-related metabolic enzymes (LRAT, ADH) via a feedback mechanism.26,27 This feedback network might explain why a

![Figure 1: Decline of retinyl palmitate concentration and increase of retinol in embryonic rat lungs prior to and shortly after birth (Geevarghese and Chytil)](image-url)
The importance of vitamin A

Vitamin A binding proteins

A further component involved in the hydrolysis and formation of retinyl esters is the concentration of CRBP. A high apo-CRBP concentration increases the activity of the retinyl ester hydrolase, which subsequently results in an increase in retinol and, as a consequence, an increase in holo-CRBP. Liganded CRBP is responsible for the delivery of retinol to LRAT for esterification. Indeed, lipid-laden pulmonary interstitial fibroblasts derived from perinatal rat lungs show a high CRBP concentration, which declines following the formation of retinol and, finally, retinoic acid during the early postnatal period. (Figure 2)

Where the supply of Vitamin A is insufficient, inadequate retinyl ester stores due to a shortage in the supply to the fetal lung during late pregnancy mean that glucocorticoids and apo-CRBP cannot act to regulate vitamin A metabolism in the lung cells.

Consequences of marginal deficiency

Masuyama and co-workers demonstrated that a marginal vitamin A deficiency, which is not necessarily detected via low plasma retinol due to homeostatic control, may have an important impact on late lung development. (Figure 3)

They also documented an additional aspect: Retinyl ester increased rapidly to a peak on day 17 of gestation and decreased to a minimum on day 21 of gestation. These data show that there combination of RA and retinyl palmitate, given orally on postnatal days 5–7, significantly increases lung retinyl esters in neonatal rats compared to RA and vitamin A alone. RA increases esterification of retinol and blocks hydrolysis of retinyl palmitate to avoid RA overload of the cells. Liver vitamin A stores, as well as plasma levels of retinol and retinol binding protein (RBP), are relatively low at birth. Consequently, sufficient prenatal pulmonary retinyl ester stores and their metabolization to RA in the lung are the critical component regulating fetal lung maturation, including alveolarization and postnatal function.

Three days prior to delivery, the retinyl ester stores of rat fetal lungs decline and the retinol concentration increases. (Figure 1)

Retinol is metabolized to RA, which serves as a ligand for the nuclear receptors, which control the gene expression of various proteins responsible for late lung development and maturation.

Impact of steroids on lung development

Prenatal lung development is also influenced by glucocorticoids. Steroid hormones have a similar effect on lung development to vitamin A, and the two factors complement each other. This is not surprising, however, as the receptors for steroids and retinoids belong to the same multireceptor complex. The mode of action of glucocorticoids exists not only on the level of gene expression, but seems also to have an impact during a much earlier phase of vitamin release. The application of dexamethasone leads to an increase in the maternal and fetal retinol binding protein, leading to an improvement of the vitamin A supply through a change of the system and clearly diminishes the morbidity and mortality attributable to bronchopulmonary dysplasia in the case of babies born prematurely.

Dexamethasone and glucocorticoids not only lead to an improvement of the total vitamin A supply through a change of the release from the liver; but also influence, as recently described, the metabolism of the vitamin A esters stored in the lung. Following administration of dexamethasone, even without steroid application, a significant reduction of retinyl esters in the maturing lung can be detected, as well as a moderate increase in retinol, the hydrolysis product of retinyl esters. This observation may explain therapeutic successes with steroids, as well as their failures in cases of poor retinyl ester stores, during the therapy of lung distress syndrome of premature infants.

Vitamin A binding proteins

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The importance of vitamin A supply for the post-natal development of the lung in preterm infants

An adequate vitamin A intake during pregnancy is of great importance for the formation of retinyl ester stores in the developing lung. These stores are the basis for RA formation during lung maturation and postnatal function, with long-term benefits as above. However, in the case of early delivery or very low birth weight, an insufficient vitamin A supply during pregnancy might have serious consequences.

A disease observed recurrently in connection with vitamin A supply is bronchopulmonary dysplasia (BPD). The pathogenesis of BPD certainly depends on a multitude of factors. Some of the observed morphological changes are strongly reminiscent of vitamin A deficiency in humans and animals. Of particular note is the focal loss of ciliated cells with keratinizing metaplasia and necrosis of the bronchial mucosa, as well as an increase in mucous secreting cells.

Focal keratinizing metaplasia, such as may occur after vitamin A deficiency, especially strengthens the assumption of an impairment of differentiation on the level of gene expression. Since vitamin A regulates the expression of different cytokeratins and therefore influences terminal differentiation, it seems obvious to assume the existence of common mechanisms. Consequently, premature neonates are dependent on a sufficient supply of vitamin A to ensure adequate lung maturation. The earlier a child is born before its due date, the lower its serum retinol levels.

Retinol serum levels in neonates

It was shown repeatedly that serum retinol level and RBP level depends on birth weight and is significantly lower in premature infants with low birth weight, compared to similar-aged neonates with higher birth weight. In addition, mothers from low income groups had lower levels of serum vitamin A and a higher incidence of prematurity. Significantly lower retinol levels can be found in the liver of premature infants, in comparison to neonates. Plasma values lower than 0.70 μmol/L are not rare in this case, and they should be taken as an indicator of a relative vitamin A deficit.

Very low plasma vitamin A levels can be found recurrently in premature infants compared to term neonates. This can, among other things, be attributed to the relative immaturity of the liver for the synthesis of retinol binding proteins. The neonate is almost exclusively dependent on the mother for its supply: this includes the lung retinyl esters which are either directly absorbed by the cells (from chylomicrons) or by esterification of retinol after uptake into the cells. These lung retinyl ester stores can only be sufficiently filled if the mother guarantees an appropriate vitamin A supply, especially during late pregnancy.

Reduced plasma levels during the first developmental months...
have a considerable influence on the total development of infants, as well as on their susceptibility to infections. In the case of reduced retinol plasma levels, repeated infections are more often described,\textsuperscript{3,4} and are counted among the main complications of a poor vitamin A supply in developing countries. In addition, the serum vitamin A level during infectious diseases, particularly of the respiratory tract, continues to drop.\textsuperscript{5} This can be explained on the one hand by an increased metabolic demand, and on the other hand by renal elimination of retinol and of RBP during the process of acute infections.\textsuperscript{3}\textsuperscript{,}4\textsuperscript{,}6 If the retinyl ester stores of the lung are low at delivery, these storage sites are replenished with difficulty, and as a consequence lung function may be impaired.

Marginal vitamin A deficiency in developed countries

Even in developed countries with a wide variety of food containing preformed vitamin A, low plasma levels (<1.4 μmol/L) occur and result in low umbilical cord blood levels.\textsuperscript{50} The study investigated 23 women with short birth intervals (defined as a second delivery within 24 months) and six women with twins. (Figure 4 and 5)

According to Godel,\textsuperscript{51} a normal range of vitamin A in cord blood should be between 0.7 and 2.3 μmol/L. There is no clear consensus on the cut-off concentration for “vitamin A deficiency” in cord blood. Levels below 0.35 and 0.7 μmol/L are discussed.\textsuperscript{51} Taking 0.35 μmol/L as the cut-off level, 31.4% of newborns in the study by Schulz and co-workers\textsuperscript{50} showed levels below the cut-off. Twins showed the lowest levels.

**FIGURE 4:** Correlation of maternal retinol or β-carotene in plasma with cord plasma and colostrum. Dotted lines show the area of suspected deficiency according to Godel et al.\textsuperscript{51} Dotted lines define the lower level of physiological retinol in plasma. (Schulz et al., 2007)\textsuperscript{50}
Despite low plasma retinol levels, most of the women had high β-carotene levels (80% >0.5 μmol/L). However, the high levels of β-carotene in plasma may be taken as a sign of low conversion to vitamin A due to the recently described BCMO polymorphism. As a consequence, these women are at risk of low vitamin A supply due to a very low intake of preformed vitamin A. This results in very low levels of retinol in blood and breast milk for the newborn.

There is limited data linking the intake of vitamin A during pregnancy to cord blood levels and fetal development. Shah and co-workers demonstrated a strong relationship between low socio-economic status, low cord blood and low body weight of the newborn.

If there is evidence that the vitamin A status of the mother is poor, a parenteral supply (infracutaneous application) is recommended. The impact on the general health of the child including lung function is controversial, however.

**Prevention and therapy**

In view of the importance of vitamin A, as above, the question arises as to possible therapeutic interventions – especially for imminent premature deliveries, but also for premature infants and, in cases of poor maternal vitamin A status, for prevention of potential diseases and/or immaturities of the lung. Where there is a risk of prematurity, vitamin A might be delivered antenatally, regardless of maternal vitamin A status, to ensure sufficient fetal lung retinyl ester stores. Based on US Dietary Reference Intake recommendations, daily vitamin A supplementation during any part of the fertile period should be limited to 3,000 IU. However, a moderate dosage and a short period of supply might not be sufficient to replete lung retinyl ester stores in cases of poor maternal vitamin A status. Higher doses during the last term of pregnancy might be more effective and pose no risk of teratogenicity, but this has not been proven to date.

One solution could be the intravenous administration of vitamin A. However, with the infusion systems used so far it appears that vitamin A is almost completely absorbed by the polyethylene tubes and is damaged by light. One way of improving availability consists of coating the infusion systems with foil to avoid further loss of the vitamin due to light. Since such solutions are no longer available on the market and new parenteral vitamin A preparations are not yet available, the importance of supplying the mother with vitamin A before delivery needs to be highlighted. Parenteral administration of retinyl margarinate (an unphysiological fatty acid ester of retinol) resulted in a rapid increase of retinyl margarinate and further retinyl esters (as a result of hydrolysis and re-esterification) in several tissues, including the lung, in vitamin A depleted rats. The results of this study clearly document that retinyl esters can be taken up into different tissues circumventing the liver and the control of delivery via retinol-RBP. At present there are no data regarding the risk of parenteral vitamin A supply in pregnant women with a high risk of preterm labor (e.g. those on bed rest). However, because teratogenic effects occur during the first term, adminis-
The two panels represent the observed and proposed pathways of retinoid uptake, esterification, and oxidative metabolism in the lungs of neonates treated with RA for 6 h (A) and 12 h (B). Changes in gene expression represent the effects of the acidic retinoids, with and without VA, while retinol uptake and retinyl ester formation represent the treatments that included VA.

A When RA is administered to neonatal rats with a supplement of VA, RA up-regulates the expression of LRAT and CYP26B1 to the same extent at 6 h, with the flow of retinol to RE formation or to polar metabolites kept in balance. More dietary retinol is taken up by lung tissue due to up-regulation of STRA6 and elevated plasma retinol at 6 h.

B At 12 h, RA is metabolized by CYP26B1. Although the biological activity of RA has declined, the pathway is still balanced as STRA6, LRAT, and CYP26B1 have all returned to basal levels.

Vitamin A supply and lung disease
The results of two randomized double-blind controlled studies of premature infants show that supplementation with vitamin A in a study led to a considerable reduction (55%) in the risk of being affected by chronic lung disease of prematurity. In a third study, 12 premature infants received vitamin A intravenously for a period of 28 days (400 IU/d) and during later development vitamin A was also administered orally (1,500 IU/d). During supplementation the initially reduced plasma and RBP values rose significantly. The latter is an indication of an actual vitamin A deficiency of premature infants, because an increase in retinol-RBP is only observed if a vitamin A deficiency really exists (the principle of the relative dose response test).

“The significance of supplying the mother with vitamin A before delivery needs to be highlighted”

A direct effect of plasma concentration on the development of chronic lung disease of prematurity could not be determined. The author has come to the logical conclusion that the plasma level after delivery poorly reflects the supply of the lung with vitamin A before delivery. It should be borne in mind that this study confirmed that relative vitamin A deficiency is characteristic of premature infants, in particular. Thus, attention should be directed to their supply of vitamin A. On the other hand, the vitamin A supply of the premature infant appears to be either insufficient to ensure adequate concentrations in the lung or the availability of the vitamin to the corresponding cells of the lung is not guaranteed.

All trials delivered vitamin A in doses of ≤50,000 IU to the child. The data clearly documented that a late supply in high doses might not work due to the reasons set out above (immaturity of RBP synthesis in the liver, distribution problems and, finally, low accumulation of retinyl esters in the lung). Ambalavanan and co-workers evaluated three different intramuscular dosage regimens in extremely low birth weight infants (5,000 IU three times per week for four weeks, 10,000 IU three times per week and 15,000 IU once per week. They used a water-soluble formulation of vitamin A (Aquasol A) based on polysorbate micelles. As a result, the authors stated, “Compared with the standard regimen, once per week dosing worsened, and higher doses did not reduce, vitamin A deficiency. Therefore the standard regimen is recommended.” However, this conclusion does not consider the metabolism of vitamin A in early newborns and the importance of retinyl esters in the lung. Indeed, they could show that the outcome in the once-per-week group with a high dosage of vitamin A was better, even if not significantly so. A high dose...
leads to higher plasma concentrations of retinyl palmitate and, subsequently, to higher uptake of the retinyl esters into tissues. However, the fact that more cases of retinopathy and necrotizing colitis occurred in the once-per-week dose group, compared with the 10,000 IU three times per week group, may be the consequence of the solubilizer polysorbate. Hale and co-workers evaluated the effect of the solubilizer (polysorbate 80) in neonatal pigs. The authors speculate that "rapid intravenous injection of vitamin E emulsions produces massive accumulation in phagocytic cells of the spleen and to a lesser extent liver and lung, possibly leading to increased susceptibility to sepsis and/or abnormal pulmonary function." The intravenously supplied vitamin E (E-Ferol) led to deaths in 38 cases in 1984 in the US and was consequently stopped. Because a mixture of polysorbate 80 and polysorbate 20 is used as a carrier in E-Ferol, these components were also tested and were found to be responsible for the suppression, especially the polysorbate 80.

Improving lung retinyl ester stores
Ross and co-workers documented a way to improve vitamin A supply to the lung via administration of preformed vitamin A (VA) and RA (VARA) in a ratio of 10:1. Based on their data, Ross and co-workers created a model of how and why retinyl ester stores are formed following delivery of preformed vitamin A plus RA. RA induces CYP26 and LRAT to save the cell from high and potentially toxic concentrations. As a consequence, the supplied preformed vitamin A entering the cell via the Stra6 receptor is stored as retinyl esters and the RA is detoxified; 6 h later, normal RA and ROH levels document the homoeostatic control of the cell. (Figure 6)

Ross and co-workers’ data also demonstrate that an isolated supply with RA might exert a short-term effect on lung maturation, but that, in the long term, the surplus of RA is detoxified and, consequently, without efficacy. In further experiments, James and co-workers showed that the synergistic effect of VARA on lung retinyl ester content was blunted in mice exposed to hyperoxia. Regardless of the mechanism by which RA exert their effects, a sufficient content of retinyl esters or an increase following the VARA application is essential for this benefit. The combination of VA and RA has the therapeutic potential of reducing BPD to a greater extent than VA or RA supplementation alone. (Figure 7)

This data also clearly demonstrates that the usual approach to supply the lung of the newborn with vitamin A (intramuscularly) might be not very successful and explains the moderate and sometimes conflicting results. The proposed mechanism also shows that delivery of RA alone might be counterproductive, and might lead to an up-regulation of the detoxifying enzymes (CYP26) and, in parallel, to an increased expression of CRABP, which may reduce RA action. The intramuscular supply in extremely low birth weight infants with vitamin A might be also of limited success, if it is not ensured that the liver can transport
retinol bound to RBP to the lung. Nevertheless, if an increase in circulating retinyl esters following parenteral application occurs, the retinyl esters are directly delivered to the cells.\textsuperscript{52}

From recent data in two cases of completely impaired RBP synthesis due to a mutation\textsuperscript{61} it can be concluded that retinyl esters delivered to cells and tissues can serve as major vitamin A source.

Inhalation of vitamin A

An alternative solution could be inhaled vitamin A. With this, the lung is directly targeted and retinyl esters administered by inhalation can be absorbed into the cells and metabolized in a controlled way, as shown in various animal studies.\textsuperscript{62} In addition, the inhalative approach results in an increase of vitamin A in plasma and tissues of rats.\textsuperscript{63} We reported successful vitamin A supplementation by inhalation of retinyl palmitate in a placebo-controlled pilot study in 25 pre-school children (two to five years of age) in the rural district of Gondar, Ethiopia.\textsuperscript{64} Pre-school children (n = 161) were randomly selected from 220 households. Out of this cohort, 25 children were randomly assigned to each of two treatment groups: One received retinyl palmitate by inhalation of two puffs of an aerosol containing 1 mg (3,000 IU) per delivery to give a total of 2 mg (6,000 IU); and the other received an aerosol without retinyl palmitate. Both treatments were administered every two weeks for three months. Serum retinol and RBP concentrations in the group treated with vitamin A were 0.68 (SD 0.31) μmol/L and 59.4 (SD 24.2) mg/L before and 1.43 (SD 0.46) μmol/L (P<0.01) and 97.3 (SD 31.2) mg/L (P<0.05) three months after supplementation with retinyl palmitate, suggesting that this novel method of delivery of retinyl palmitate by inhalation is effective in improving vitamin A status. (Figure 8)

Unfortunately, we were not able to follow the development of the children to elucidate whether this approach might contribute to a lower incidence of respiratory tract infections or mortality. However, in patients with chronic obstructive pulmonary disease (COPD), the inhalation of vitamin A improved metaplastic and dysplastic morphological changes.\textsuperscript{65} Nevertheless inhalation of vitamin A results in an immediate delivery of retinyl esters to the lung, independent from hepatic control, and contributes to an improvement of the vitamin A status independent from intestinal absorption. The latter is impaired in cases of diarrhea and parasitical infections, or delivery of vitamin A without fat. Very recently, vitamin A was described as being systemically bioavailable after intratracheal administration with surfactant in an animal model of newborn piglets.\textsuperscript{66} This administration was associated with hepatic uptake of vitamin A, but lung vitamin A was not determined.

We found that administration of vitamin A in the form of an aerosol is an effective, safe and routinely manageable method to elevate vitamin A and RBP levels. Consequently, this procedure
may serve as an alternative method for vitamin A therapy during chronic or acute episodes of malnutrition, malabsorption or in the case of insufficient compliance with other therapies, and it might be useful in treating respiratory diseases associated with vitamin A deficiency.

It should be investigated to what extent the “topical” application of retinyl esters on the respiratory epithelium, especially in those with chronic lung disease of prematurity, can contribute to the replenishment of lung stores and thus lead to an improved clinical outcome.

“Delivery of retinyl palmitate by inhalation is effective in improving vitamin A status”

It should be investigated to what extent the “topical” application of retinyl esters on the respiratory epithelium, especially in those with chronic lung disease of prematurity, can contribute to the replenishment of lung stores and thus lead to an improved clinical outcome.

Conclusion

The results cited show that retinyl esters in respiratory epithelium and in alveolar cells form a pool of vitamin A, which can be used physiologically by the tissue. The formation of retinol and, subsequently, retinoic acid from retinyl esters is strictly controlled. So far, unphysiological formation of retinoic acid and subsequent toxicity do not seem possible. Retinyl esters, however, are biochemically inert with respect to gene expression or vitamin A activity as long as they are not hydrolyzed. Consequently, inhala-
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The Importance of Vitamin A


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Testing the Feasibility of Delivering Vitamin A to Newborns in Nepal and Bangladesh

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Background
Infants are born with small livers and total body stores of vitamin A (VA).1-5 Exclusively breastfed infants depend on adequate breastfeeding and good health to build body stores.6 However, low breast milk vitamin A, inadequate breast milk intake concentration,5-8 poor complementary food quality9 and/or frequent infection10 can all reduce an infant’s ability to achieve normal vitamin A status.

A promising new intervention
Newborn vitamin A supplementation (NVAS) is a promising new intervention that involves supplementing infants shortly after birth with a single, large oral dose of vitamin A (50,000 IU) (Figure 1). The intervention was tested in three field trials in southern Asia (Indonesia, India, and Bangladesh), each of which reported significant reductions of ≥15% in infant mortality in the first six months of life.11-13 When combined, the results suggest that infant mortality can be reduced by approximately 20% in southern Asia by giving newborns a single, oral dose of vitamin A.14 Given previous evidence of safety with respect to short- or long-term side effects,15-20 newborn vitamin A supplementation appears to be a low-cost approach to reducing infant mortality in South and Southeast Asia.

In Africa, however, this intervention had no beneficial effect on early infant survival in an urban setting in Zimbabwe,21 and a peri-urban setting in Guinea Bissau.22,23 All three African studies (two in Guinea Bissau) were done in populations with little, if any, vitamin A deficiency. Mortality in the Zimbabwean study was very low.21 In one study in Guinea Bissau, investigators reduced mortality by excluding the highest risk infants (those with low birth weight) and giving free care and drugs to sick infants.22 A 2008 WHO Technical Consultation on Neonatal Vitamin A Supplementation Research Priorities24 made the following...
“Insufficient evidence exists to recommend a global policy of supplementing newborns with vitamin A.”
recommendation: “Operational research on how to reach most babies in developing countries within two days of birth should be conducted in general, not necessarily in the context of neonatal vitamin A supplementation.” The consultation also reviewed a systematic review of neonatal vitamin A trials. It concluded that insufficient evidence existed to recommend a global policy of supplementing newborns with vitamin A until further efficacy trials in appropriate populations are conducted in Africa and Asia. WHO is currently supporting additional efficacy studies in Africa (Tanzania and Ghana) and South Asia (India), as well as studies investigating potential biological mechanisms through which NVAS may decrease the risk of early infant mortality.

Program implications
Adequate and effective NVAS will require innovative but feasible programs in South Asian settings, where often >80% of infants are born at home. For example, newborn dosing might require identifying and engaging neighborhood “watch” networks to detect births and rapidly dose infants, or using cell phones to contact health workers at the time of birth. The capsule would need to be widely available, perhaps through both the private and public sectors. It could be included as a new component in “safe birthing kits” for women to use themselves (obtained during antenatal care or purchased in local shops), provided at the time of home-delivery by nurse midwives or trained traditional birth attendants or, lastly, at clinic- or hospital-based obstetric care and delivery programs. Newborn VA delivery could be combined with other emerging and effective neonatal care services, such as cord cleaning with chlorhexidine wipes and newborn care intervention packages. It could provide an opportunity to establish birth dates and set the timing for an infant’s “six-month” VA-dosing visit – an idea that is currently gaining interest. Alternatively, in contexts where a high proportion of women attend antenatal clinics, women could be given the supplement and instructed on its use and administration, and then give it directly to their newborn shortly after birth.

NVAS feasibility activities purpose
In both Nepal and Bangladesh, NVAS feasibility activities were to identify, develop, and evaluate feasible models for delivering NVAS integrated within existing antenatal and postnatal interventions at a scalable level within existing delivery platforms and government health services.

Nepal
Background. Nepal is on track to meet its Millennium Development Goal (MDG)-4 to reduce under-five mortality by two-thirds; however, the government is finding ways to make further reductions by seeking efficacious interventions that reduce neonatal and early infant deaths. The Child Health Division, Department of Health Services of the Nepal Ministry of Health and Population formulated a policy to pilot first, and piloted NVAS in 2009 in four districts (Figure 2), in partnership with the USAID-funded Nepal Family Health Program-II (NFHP-II), UNICEF, and the Micronutrient Initiative (MI).

Delivery models. Considering that ~80% of births in Nepal occur in the home, the extensive network of female community health volunteers (FCHVs), and the government’s efforts to intensify and improve access to Antenatal Care services, Nepal selected two distribution models for feasibility testing:

1. The “FCHV Dosing” model, using postnatal home visits by female community health volunteers (FCHVs) to administer vitamin A directly to newborns in two districts (Banke and Nawalparasi) (Figure 3); and
2. The “Mother / Family Member Dosing” model, in which mothers who attend an antenatal clinic at a health facility (HF), or are visited at home by the FCHV after the eighth month of pregnancy, are counseled about NVAS and given a supplement which they give directly to their newborn, also in two districts (Sindhuli and Tanahu) (Figure 4).

Monitoring and evaluation. NVAS implementation is being monitored through the routine government health management and information system. To record information on NVAS receipt, the existing Iron Intensification Register, a record used to track iron and folic acid tablet receipt among pregnant and postpartum mothers, was modified. Data from this record are compiled and sent monthly to the district and national levels. In addition, three to four external monitors per district provide
THE FEASIBILITY OF DELIVERING VITAMIN A TO NEWBORNS

Preliminary findings. Through the initial nine months of implementation in the four pilot districts, >18,000 newborns have been supplemented. Preliminary findings suggest that 62% of newborns are reached in the female community health volunteer (FCHV) and community health worker dosing model, and only 45% in the mother/family member dosing model.

Interesting preliminary observations from monitoring surveys include:

- High NVAS coverage in districts where institutional deliveries are high, and where other community-based services targeting newborns have been well established (e.g. in Banke).
- Low ANC attendance, especially the last visit at eight months’ gestation, appears to lead to low NVAS coverage.
- In the “Mother/Family Member Dosing” model, ~11% of mothers are reluctant to dose their newborns. Instead, they wait for the community health worker (i.e. the FCHV) to visit and dose the newborn.
- Fewer than one percent of mothers and about one percent of health workers reported a bulging fontanel in dosed infants. All cases were transitory and recovered without treatment.

Bangladesh

Background. The Ministry of Health and Family Welfare (MoHFW) in Bangladesh has extensive experience in considering research findings, establishing a permissive policy, piloting models to test implementation feasibility, and scaling up interventions. In December 2009, the Government of Bangladesh approved pilot feasibility testing activities for NVAS in three districts (Tangail, Pirojpur and Nilphamari), and six sub-districts divided between the Directorate General of Family Planning and Revitalization of Community Health Care Initiative/Community Clinic, Bangladesh (Figure 5).

Delivery models. In Bangladesh >80% of births occur in the home, <18% of deliveries are attended by a professional health worker, and only 20% of women receive a postpartum visit. To identify potentially feasible delivery platforms for NVAS, a
design workshop, including national, district and sub-district level health and family planning managers, was held in October 2010 (Figure 6) and proposed two delivery platforms:

1. The “Mother/Family Member Dosing” model in Bangladesh uses two cadres of community health workers: The “Female Welfare Assistant” (FWA) and the “Health Assistant” (HA), who integrates NVAS into routine home-based pregnancy surveillance and home- or clinic-based antenatal (ANC) visits (Figure 7). In addition to key ANC services and messages, pregnant women receive an individually packaged dose of vitamin A (50,000 IU), and are instructed about why, when, and how to administer the dose to their newborns, and how to manage potential side effects. This information is accompanied by a counseling card and a “Health Worker Contact Card” that includes the name, cell phone number, and address of the local health worker. The potential advantage of this model is that the VA supplement is in the home at the time of delivery, and does not require the notification of or waiting for the arrival of a health worker to administer the dose.

2. The “Health Worker Dosing” model also uses FWAs and HAs; however, the mother or a family member must contact the health worker at the time of birth and the health worker must visit the mother and her newborn to directly administer the vitamin A (Figure 8). To facilitate birth notification, health workers inform pregnant mothers about the importance of early birth notification so that the baby can obtain newborn vitamin A and other essential newborn services. In this model, a “Health Worker Contact Card” is also provided to promote prompt and direct communication with the health worker.

Monitoring and evaluation. Monitoring the pilot activities involves a two-pronged strategy consisting of (1) routine data collection within the MoHFW system; and (2) special monitoring interviews and observations conducted by locally hired “extenders” to assess how well NVAS is being integrated into existing ANC and postpartum visits, and to assess community acceptability (Figure 9). Two cross-sectional surveys in each program upazila, or region, at baseline and at six months after implementation (i.e. end-line), will be conducted among recently delivered mothers to assess coverage and timeliness of the delivery of newborn vitamin A. In addition, community health workers (CHW) will be surveyed at baseline and end-line to assess knowledge, attitudes, and practices about integrating NVAS into existing services.

Conclusions
Both Nepal and Bangladesh have made important strides in bridging the research-to-program gap by examining scientific evidence and its relevance within each country’s context, establishing policies that permit feasibility testing of this new intervention, and closely monitoring and evaluating NVAS implementation before formulating a policy for national scale-up. From preliminary data, implementation challenges facing NVAS are similar to those faced by other interventions that target pregnant women and newborns. These include identifying and reaching a high proportion of pregnant women and their newborns in a timely manner, overcoming geographic, travel and time constraints.
**FIGURE 7: Mother/Family Dosing Model**

**Pregnancy**
- **Contact Points**
  - Home-based pregnancy identification/registration
  - Home-based ANC visit
  - Satellite-clinic ANC visit
  - FWC-based ANC
- **Actions**
  - Antenatal contact with pregnant women
  - Pregnant women given NVAS and instructed on why, what, when, how and who will give NVAS (integrated into usual ANC services/counseling)

**Birth**
- **Phone call**
- **Actions**
  - Mother or family members gives NVAS to newborn within 2 days of birth

**Postpartum (0–2 days after birth)**
- **Contact Points**
  - Postnatal home visit by FWA or HA
- **Actions**
  - FWA or HA confirms newborn dosing and doses baby if missed

**FIGURE 8: Health Worker Dosing Model**

**Pregnancy**
- **Contact Points**
  - Home-based pregnancy identification/registration
  - Home-based ANC visit
  - Satellite-clinic ANC visit
  - FWC-based ANC
- **Actions**
  - Antenatal contact with pregnant women
  - Pregnant women given NVAS and instructed on why, what, when, how and who will give NVAS (integrated into usual ANC services/counseling)

**Birth**
- **Actions**
  - Baby is born, please come!
  - Family member contacts health worker by mobile phone or drops card at clinic

**Postpartum (0–2 days after birth)**
- **Contact Points**
  - Postnatal home visit by FWA or HA
- **Actions**
  - Health worker directly doses newborn
in reaching a health facility or a home, and tracking pregnant women who travel to their parental home to give birth. Lessons learned from these pilot activities will provide useful insights on how to introduce and integrate this new intervention within existing health systems and delivery platforms in South Asia.

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Diversification from Agriculture to Nutritionally and Environmentally Promotive Horticulture in a Dry-Land Area

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Introduction
Cereal pulse-based Indian diets are qualitatively poor in vitamins and minerals due to inadequate consumption of vegetables and fruits – the major source of micronutrients in vegetarian diets. Homestead gardens have been reported to improve access to and consumption of vegetables. Homestead food production also helps with household food security.

This study has attempted partial diversification from the water-intensive cropping pattern (rice and sugar cane) to horticulture using green methods of farming in a dry-land area to improve household access to vegetables and environment security.

Subjects and methods
The study was conducted in 15 villages from 4 mandals (population 24,000), of the Medak district of the South Indian state of Andhra Pradesh. The project was explained in village-level meetings; 222 farmers who had land (marginal or small) and were willing to partially diversify from rice and sugar cane to horticulture (mixed orchards, vegetable gardens), and adopt green methods of farming, were identified. Seeds/seedlings of nutrient-rich varieties of vegetable and fruit were distributed among the farmers identified. Drumstick, papaya, curry leaves (Murraya Koenigii) and creeper spinach (Basilla alba) seedlings were raised by village women in backyard nurseries and then purchased from them, providing them with some income.

Organic fertilizers, such as vermi compost, and botanical pesticides, such as neem kernel and chili garlic decoction, were promoted. Once every two months, experts were invited as faculty and centralized training programs were conducted on the campus of the Dangoria Charitable Trust (DCT) in the village of Narsapur. Hands-on training was also given via village-level meetings and visits to individual farms. In addition to horticulture, and the use of organic methods of farming, education in nutrition, health and environment formed an important part of the training. Focused group discussions (FGD) and slide and sound shows were organized in the evenings. School education was also an important part of creating awareness.

Impact assessment was carried out by making a record of diverted land, crops grown and their survival, the adoption of organic methods of farming etc. A rough estimate of vegetables sold and consumed at home was obtained by visiting households every month and making enquiries.

Baseline and end-line surveys on Knowledge, Attitude, and Practice (KAP) were carried out in four villages, representing three mandals, using a pretested questionnaire to test knowledge on green methods of farming and nutrition. A diet survey using a semi-quantitative method was held to examine the impact on consumption of protective foods such as vegetables, pulses and animal products. This method involves obtaining information on the frequency of consumption of different foods by the family during a typical week (when there are no guests, festivities, or
fasting), the daily quantity cooked and the number of household members above the age of one year (capita).

Based on this information, an estimate of mean quantity in grams of different foods consumed per capita per day was obtained. During the end-line survey, intake per consumption unit (CU), in addition to per capita intake, was also ascertained by obtaining additional information on the sex, age, physiological status and activity of different members of the family (data not reported). However, the difference between per capita and per CU values was negligible. This method of diet survey can be applied in rural households where diets and menus are routine.

The initial survey in the four selected villages included all farmers who had agreed to participate in the project. All of the farmers who actually participated (stakeholders) were also included in the end-line survey (experimental group). This covered 82% of the initial cohort. Some farmers who initially accepted then dropped out, but some who were initially unwilling joined later on. To allow for the impact of time, in the end-line survey 50 farming households from the same villages who had not participated in land diversion were also interviewed (control group).

However, even the control group farmers were allowed to participate in the training programs conducted in the villages. Due to material and human resource constraints, the KAP survey could not be carried out in all 15 villages. In addition, more than 50% of the farmers who joined the project were from the four selected villages. The two interviewers were trained and spoke the local language fluently.

“Monthly inquires suggested sales of 25–50% of the vegetables grown, with the rest being consumed at home”
### Table 1: Knowledge of nutrition. Values are % of respondents. No prompting. Multiple answers.

<table>
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<th>Description</th>
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<th>End-line Experimental March / April 2010</th>
<th>End-line Control March / April 2010</th>
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<td>128</td>
<td>50</td>
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<tr>
<td>Why do we eat food?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Good health</td>
<td>70.4 ***</td>
<td>95.3</td>
<td>80.0 ***</td>
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<tr>
<td>Gives energy</td>
<td>40.0 ***</td>
<td>76.6</td>
<td>64.0 **</td>
</tr>
<tr>
<td>Gives strength</td>
<td>32.8 ***</td>
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</tr>
<tr>
<td>Protects against diseases</td>
<td>3.2 ***</td>
<td>63.8</td>
<td>24.0 ****</td>
</tr>
<tr>
<td>For living</td>
<td>5.6 **</td>
<td>49.6</td>
<td>40.0 ***</td>
</tr>
<tr>
<td>For hunger</td>
<td>12.8</td>
<td>19.5</td>
<td>28.0 *</td>
</tr>
<tr>
<td>Any other</td>
<td>0.8</td>
<td>3.3</td>
<td>4.0</td>
</tr>
<tr>
<td>What are the components of a balanced diet?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>63.2 ***</td>
<td>98.4</td>
<td>100.0 ***</td>
</tr>
<tr>
<td>Roti (dry pancakes from cereals and millets)</td>
<td>49.6 ***</td>
<td>71.1</td>
<td>60.0</td>
</tr>
<tr>
<td>Pulses</td>
<td>23.2 ***</td>
<td>95.9</td>
<td>66.0 ****</td>
</tr>
<tr>
<td>Vegetables</td>
<td>36.0 ***</td>
<td>98.4</td>
<td>70.0 *****</td>
</tr>
<tr>
<td>Fruits</td>
<td>38.4 ***</td>
<td>62.2</td>
<td>42.0 *</td>
</tr>
<tr>
<td>Green leafy vegetables</td>
<td>42.4 ***</td>
<td>81.1</td>
<td>38.0 ***</td>
</tr>
<tr>
<td>Milk</td>
<td>19.2 ***</td>
<td>77.3</td>
<td>56.0 ****</td>
</tr>
<tr>
<td>Eggs</td>
<td>13.6 ***</td>
<td>66.4</td>
<td>36.0 ****</td>
</tr>
<tr>
<td>Meat/fish etc</td>
<td>19.2</td>
<td>39.8</td>
<td>32.0</td>
</tr>
<tr>
<td>What are the functions of fruits and vegetables?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good health</td>
<td>64.0 ***</td>
<td>85.9</td>
<td>76.0</td>
</tr>
<tr>
<td>Gives energy</td>
<td>51.2</td>
<td>57.0</td>
<td>62.0</td>
</tr>
<tr>
<td>Gives strength</td>
<td>47.2</td>
<td>45.7</td>
<td>55.1</td>
</tr>
<tr>
<td>Protects against diseases</td>
<td>5.6 ***</td>
<td>69.6</td>
<td>22.0 ****</td>
</tr>
<tr>
<td>Improves eyesight</td>
<td>4.0 ***</td>
<td>58.0</td>
<td>52.0</td>
</tr>
<tr>
<td>Protects against anemia</td>
<td>0</td>
<td>75.8</td>
<td>34.0 ****</td>
</tr>
<tr>
<td>Makes teeth and bones stronger</td>
<td>0</td>
<td>37.6</td>
<td>16.0 **</td>
</tr>
<tr>
<td>For taste</td>
<td>0</td>
<td>39.1</td>
<td>52.0</td>
</tr>
<tr>
<td>Any other</td>
<td>0.8</td>
<td>3.1</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The Two Proportion Z test was used to see the differences in proportions between two groups.

* P<0.05, ** P<0.01, *** P<0.001 compared to end-line experimental

* P< 0.05, ** P<0.01, *** P<0.001 compared to initial
Statistical methods

The statistical tests used to test significance are given as footnotes under each table.

Results

A total of 222 farmers diverted 62.1 acres of land to horticulture. Monthly inquiries suggested sales of 25–50% of the vegetables grown, with the rest being consumed at home. The impact of the project on participating farmers was marked in terms of knowledge of nutrition (functions of foods and components of balanced diet, particularly protective foods) (Table 1). Responses suggest the contact effect of education. Thus, in the end-line survey, the knowledge of even the control group was better than it had been in the initial survey. Knowledge and the adoption of green farming methods also improved. Acceptance of botanical pesticides and vermi compost was good. Microbial products were introduced, but were not accepted due to lack of access to reliable material.

On average, the families consumed vegetables and pulses three times a week (Table 2). In the end-line survey, families in the experimental group tended to report higher consumption of vegetables (52.3 g) compared to the control group (37.4 g), but not compared to the initial survey (57.7 g). Consumption of green leafy vegetables (GLV) tended to be higher in the end-line survey, compared to the initial survey. Pulse (dal) consumption took place two to three times a week, but only in quantities of about 20 g. Milk was consumed daily, mostly in tea. Milk consumption tended to be lower in the end-line than the initial survey – perhaps due to a price rise over the three-year period. Animal products such as meat (mutton, chicken, and fish) and eggs were consumed once or twice a week, in small amounts. Consumption of animal products tended to be higher in the end-line than the initial survey.

Over 95% of families in both surveys mentioned that they obtained their requirement of rice from their own farms or from the same village. In addition, in the end-line survey 90% of farmers mentioned that they obtained rice and pulses from the Public Distribution System (PDS) of the government, as compared to 10% in the initial survey. For other food grains, such as wheat, maize, sorghum, finger millet, pulses and vegetables and fruits,

### Table 2: Food consumption: Weekly frequency and quantity consumed per capita per day.

<table>
<thead>
<tr>
<th>Description</th>
<th>Initial March / April 2007</th>
<th>End-line Experimental March / April 2010</th>
<th>End-line Control March / April 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of respondents</td>
<td>125</td>
<td>128</td>
<td>50</td>
</tr>
<tr>
<td><strong>Food</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables: frequency</td>
<td>3.85 ± 1.04</td>
<td>3.4 ± 0.631</td>
<td>3.1 ± 0.340</td>
</tr>
<tr>
<td>g/capita/day</td>
<td>57.7 ± 31.11</td>
<td>52.3 ± 21.7</td>
<td>37.1 ± 10.34</td>
</tr>
<tr>
<td>GLV: frequency-mean</td>
<td>2.2 ± 0.72</td>
<td>2.9 ± 0.75</td>
<td>2.5 ± 0.614</td>
</tr>
<tr>
<td>g/capita/day</td>
<td>36.0 ± 20.8</td>
<td>51.6 ± 24.3</td>
<td>57.1 ± 24.4</td>
</tr>
<tr>
<td>Pulses: frequency-mean</td>
<td>2.63 ± 1.08</td>
<td>2.8 ± 0.74</td>
<td>2.7 ± 0.519</td>
</tr>
<tr>
<td>g/capita/day</td>
<td>20.4 ± 13.03</td>
<td>19.0 ± 8.62</td>
<td>17.9 ± 5.52</td>
</tr>
<tr>
<td>Milk: frequency-mean</td>
<td>6.76 ± 1.30</td>
<td>6.9 ± 0.621</td>
<td>7.0 ± 0.000</td>
</tr>
<tr>
<td>g/capita/day</td>
<td>95.8 ± 138.68</td>
<td>71.3 ± 46.75</td>
<td>47.7 ± 18.78</td>
</tr>
<tr>
<td>Eggs: frequency-mean</td>
<td>1.3 ± 0.87</td>
<td>2.0 ± 1.458</td>
<td>1.9 ± 0.274</td>
</tr>
<tr>
<td>number/capita/day</td>
<td>0.15 ± 0.119</td>
<td>0.41 ± 1.16</td>
<td>0.3 ± 0.079</td>
</tr>
<tr>
<td>Meat: frequency-mean</td>
<td>1.02 ± 0.297</td>
<td>1.35 ± 0.685</td>
<td>1.64 ± 0.485</td>
</tr>
<tr>
<td>g/capita/day</td>
<td>18.49 ± 8.745</td>
<td>27.8 ± 44.62</td>
<td>27.3 ± 9.36</td>
</tr>
</tbody>
</table>

Means with different superscripts a, b, c are significantly different at P<0.05 using one way analysis of variance with post hoc LSD method. Where necessary, the data was log-transformed and subjected to ANOVA to stabilize the variations in the groups.

---

**Table 1**

<table>
<thead>
<tr>
<th>Description</th>
<th>March / April 2007</th>
<th>March / April 2010</th>
<th>March / April 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of nutrition</td>
<td>125</td>
<td>128</td>
<td>50</td>
</tr>
<tr>
<td>Knowledge of protective foods</td>
<td>125</td>
<td>128</td>
<td>50</td>
</tr>
<tr>
<td>Contact effect of education</td>
<td>125</td>
<td>128</td>
<td>50</td>
</tr>
</tbody>
</table>
over 50% of families depended on sources outside the village for their household requirements. In both the surveys, over 90% of families mentioned that they ate all of the above food grains, except maize, which a third of the families did not eat despite cultivating it.

“For poor households, economic compulsions outweigh nutritional wisdom”

Discussion

Diets were poor with regard to foods such as pulses, vegetables and animal products. The marked reduction in the mean consumption of vegetables in the control group in the end-line survey, as compared to the initial survey, demonstrates the adverse impact of the price rise. The experimental group seems to have been shielded against this effect, stressing the need to promote the homestead production of protective foods. An almost 44% increase in the consumption of GLV in the end-line, as compared to the initial survey, suggests the positive impact of nutrition education. The increase, which occurred even in the control group, is not surprising; growing GLV is easy and all of these were included in the community education efforts. Despite the fact that vegetable consumption was far below the recommended level, all of the farmers mentioned that they sold 25–50% of the vegetables grown. For poor households, economic compulsions outweigh nutritional wisdom. Village-level security for rice was better than that for other foods which had to be procured from outside sources. The fact that most families consumed cereals and millets other than rice suggests a healthy traditional practice of consuming mixed-grain diets. This needs to be nurtured, particularly since, in recent years, the preference for millets has declined due to easy access to rice and wheat.

In earlier studies, aimed at promoting home gardens to combat vitamin A deficiency in the Medak district, it was observed that home gardening alone may not be adequate to prevent vitamin A deficiency. Other methods, including the promotion of animal husbandry and poultry, would be needed to complement this food-based approach. In the authors’ experience, diversification to horticulture from other crops requires considerable advocacy and persuasion, since farmers with marginal and small land-holdings hesitate to diversify from traditional crops. On the other hand, acceptance of back-yard poultry was good (unpublished).

In conclusion

Homestead gardening can have a positive impact on the consumption of horticultural produce, but this by itself will not meet the daily requirements in a small-farm-holding family where income is a priority. Poverty alleviation measures are needed to improve household food security.

Acknowledgements

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References

Building bridges for better nutrition.
Iron Fortification – New Revelations?

David Thurnham
Northern Ireland Centre for Food and Health,
University of Ulster, Coleraine, United Kingdom

The results of the recent randomized controlled trial (RCT) in Pemba, where there was more severe child morbidity and mortality in the group receiving supplements of iron and folic acid, brought to a halt the unsupervised use of iron supplements to remove iron deficiency anemia – especially in malaria-endemic areas. However, there is uncertainty whether the adverse effects of the supplements were due to interactions between iron and malaria, iron and enteric infections, impaired effectiveness of anti-malarial treatment due to the folate, a combination of all three, or some other explanation. In this issue of *Sight and Life*, I will discuss the issue of iron and its apparent effects on enteric bacteria, following a recent article in which the authors described the impact of poorly bioavailable fortification iron on the profile of the gut microbiota of African children. In this study, the additional iron appeared to increase the proportion of pathogenic bacteria and act as a biomarker of inflammation in the feces. Nevertheless, there was no evidence of any increase in systemic infection in the children receiving the iron. To try to understand the meaning of the observations, I will also describe some results from two other papers where the authors examined individual sub-strains of commensal *Clostridium* bacteria and showed that they had both individual and collective effects on immune cells within the lining of the gut, and can have both pro- and anti-inflammatory effects in different circumstances.

Such results indicate that quantitation of the major bacterial strains within the microbiota may, in fact, tell us very little about...
Iron-deficiency anemia is a common problem among the world’s population, affecting over 2 billion people and being more prevalent in developing countries. Public health nutritionists are acutely aware of iron deficiency’s connection to maternal and child mortality, as well as its role in cognitive development, school performance, and work capacity. Unfortunately, there are health risks associated with iron. An overdose of iron-containing products is a leading cause of fatal poisonings in healthy children under six years. Diets rich in iron have been linked to a higher risk of colon cancer. Additionally, iron supplementation programs have come to a halt around the world, potentially putting millions of children at risk of the adverse impacts of iron-deficiency anemia.

Iron fortification can be an effective strategy to control iron deficiency anemia, and the foodstuffs most often used for mass fortification are cereal flours. Worldwide, the most commonly used fortificants for flours are elemental iron powders such as hydrogen-reduced iron or electrolytic iron, despite their low bioavailability, which can often be as low as <2–3%. Low absorption of iron fortificants results in >90% of unabsorbed iron passing unabsorbed into the colon. Iron is able to undergo reduction and oxidation, making it important in many physiological processes. This inherent redox property of iron, however, also renders it toxic when it is present in excess. Iron-mediated generation of reactive oxygen species via the Fenton reaction, if uncontrolled, may lead to cell damage as a result of lipid peroxidation, oxidation of DNA, and protein damage. Most iron in the blood and tissues of the body is tightly bound to various proteins to control its reactivity, but there is no similar system for sequestration of dietary iron in the gut lumen. Instead, the human gut is packed with resident bacteria, collectively known as the microbiota, and the multiple strains vigorously compete for unabsorbed iron, which they need in order to grow. Growth of some pathogenic species of bacteria, however, (e.g. Salmonella or Shigella) was associated with increased virulence and colonization. Animal experiments have shown that increasing dietary iron increased the incidence of diarrhea, and increased the proportion of pathogenic bacteria within gut lumen. Mindful of the uncertainty about what caused the higher risks of severe illness and mortality in the iron/folate group in Pemba, the WHO consultation that followed cautioned about whether the risks associated with iron supplementation were specific to malaria or applied to other infections, including sepsis and enteric bacteria.

Iron fortification
The best way to prevent micronutrient malnutrition is to ensure consumption of a balanced diet that is adequate in every nutrient. Unfortunately, this is far from being achievable everywhere, since it requires universal access to adequate food and appropriate dietary habits. From this standpoint, food fortification has the dual advantage of being able to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns. In fact, fortification has been used
for about 80 years in industrialized countries as a means of restoring micronutrients, in particular some of the B vitamins, lost by food processing, and has been a major contributory factor in the eradication of diseases associated with deficiencies in these vitamins.\(^7\)

The study to investigate the effects of iron on gut bacteria was carried out in Côte d’Ivoire. The study was nested within a larger intervention trial that tested the interactions of the intermittent treatment of malaria (IPT), anthelmintic treatment and iron fortification,\(^2\) and was a six-month, randomized, double-blind, controlled trial, enrolling 591 six to 14 year old school children.

The interventions were: (1) iron-fortified biscuits providing an additional 20 mg iron/d as electrolytic iron (A-131, Dr Paul Lohmann GmbH, Emmerthal, Germany) 4 times/wk; (2) intermittent treatment of malaria with sulfadoxine-pyrimethamine at 0 and 3 months; (3) anthelmintic treatment at 0 and 3 months; and (4) a placebo of unfortified biscuits in several combinations. The prevalence of anemia (hemoglobin ≥80 g/L and ≤115 g/L), iron deficiency, malaria parasitemia, and helminth infection was 70.4, 9.3, 57.7, and 54.8%, respectively. The usual wet season is from March to November and the field studies were carried out from November 2006 to July 2007. The biochemical results for the microbiota sub-groups (taken from treatments 1 and 4, above) were no different to those of the whole groups, except for small, unimportant differences in ferritin.

The results for hemoglobin and anemia are shown in Table 1. Estimated daily mean intakes of iron ranged from 12.2 to 14.5 mg for the boys and girls, and the authors estimated that the additional iron from the biscuits amounted to 8.8 ± 1.2 (SD) mg fortificant iron/day. Alternatively expressed, the iron intervention increased the overall dietary intake ~60–70%. The data in Table 1 show that more than 70% of the children in the study were anemic at baseline and the prevalence increased to more than 90% at six months. If the anemia was, in fact, due to iron deficiency, you would expect the combined dietary and fortificant iron to have reduced the level of anemia, unless, of course, the anemia was due to the high exposure to infection, and other causes (e.g. vitamin A deficiency). Table 2 shows the concentrations of the two acute phase proteins C-reactive protein (CRP) and α1-acid glycoprotein (AGP) in the African children. The authors calculated from these figures that 16–19% of the children had systemic inflammation. However, if these were apparently healthy children, the cut-offs used by the authors were high (CRP 10 mg/L and AGP 1.2 g/L). In my opinion, and those of

---

**TABLE 1:** Anemia and hemoglobin concentration (mean ± SD) in children in Côte d’Ivoire at baseline and following 6 months of iron supplementation\(^1,2\)

<table>
<thead>
<tr>
<th></th>
<th>Iron Group (n=69)</th>
<th>Control Group (n=70)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>6 months</td>
</tr>
<tr>
<td>Hemoglobin g/L</td>
<td>110.7 ± 10.5</td>
<td>107.1 ± 10.5</td>
</tr>
<tr>
<td>Anemia %</td>
<td>75.4</td>
<td>88.4</td>
</tr>
</tbody>
</table>

\(^1\) Anemia defined as hemoglobin >80 g/L and <115 g/L  
\(^2\) Iron supplement was 20 mg electrolytic iron per day per child, 4 times per week

**TABLE 2:** Concentrations of C-reactive protein (CRP) and α1-acid glycoprotein (AGP) (median and range) in Ivorian children at baseline and following 6 months iron supplementation\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>Iron Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>6 months</td>
</tr>
<tr>
<td>CRP mg/L</td>
<td>2.7 (0.2 – 47.5)</td>
<td>2.1 (0.2 – 86.3)</td>
</tr>
<tr>
<td>AGP g/L</td>
<td>1.0 (0.4 – 2.6)</td>
<td>0.8 (0.4 – 1.5)</td>
</tr>
</tbody>
</table>

\(^1\) For details of iron supplement see Table 1
my colleagues,22,23 the cut-offs should be lower (CRP 5 mg/L; AGP 1.0 g/L), which would suggest that more like 40% of the children had systemic inflammation on the basis of AGP alone. Furthermore, the underestimates of inflammation will also have produced underestimates of iron deficiency, which were derived on the basis of serum ferritin concentrations. However, there was no significant difference in these inflammation biomarkers between the two groups at baseline or after intervention, so the underestimate in systemic inflammation is unlikely to have affected any difference in iron deficiency between the groups.

Detection and quantitation of gut microbiota
The main aim of the Ivorian sub-study was to determine what effect, if any, the additional iron in the fortified biscuits had on the gut microbiota. Thirty children were randomly selected from groups 1 and 4 (see above). None of the children had unusual dietary habits or had received antibiotics in the three months before the baseline survey. During the survey, the number of days of antibiotics did not differ between the two groups. No child was given antibiotics in the three weeks before the six-month sample. In the mornings at school, fecal samples were collected into pre-labeled beakers with lids and stored for the rest of the morning in an ice chest, and then aliquots were frozen at -30° C until analysis. Total bacterial DNA was extracted from 200 mg fecal samples (Fast DNA SPIN kit, MP Biomedicals, Illkirch, France) and DNA was measured at 260 nm, before storing the samples at -24° C until further analysis.

The polymerase chain reaction (PCR) was used to quantify the total bacterial content and individual species in the fecal DNA sample. In the PCR, short nucleotide sequences (= primers), originally obtained from the 16S ribosomal ribonucleic acid (rRNA) sub-units of specific bacteria, attach to complementary DNA sequences in the fecal DNA sample, together with a DNA polymerase enzyme. 16S rRNA gene primers are used, as they contain many highly conserved primer binding sites and, in addition, hyper-variable regions that can provide species-specific signature sequences useful for bacterial identification. The DNA polymerase enzymatically assembles new DNA strands from each primer using deoxy-nucleotide triphosphates, the building blocks from which the new DNA strand is synthesized. As the PCR progresses, the DNA generated attaches to more primer and is itself used as a template for replication. This sets in motion a chain reaction in which the DNA template is identified or targeted by the primer and exponentially amplified. The pro-cess is precisely temperature regulated and timed to enable the products to be quantitatively related to the starting amount of fecal DNA.

Several types of PCR were used on the fecal DNA at baseline and six months, to (1) investigate the whole bacterial diversity; (2) identify the species of Lactobacillus; (3) quantify the major bacterial species; and (4) detect bacterial gut pathogens. Baseline and six-month samples from the same volunteer were always run together where gel electrophoresis was involved, for accurate comparisons.

Influence of the fortification iron on the gut microbiota
The authors investigated whole bacterial diversity by using two universal primers for the polymerase chain reaction that attached to variable regions 2 and 3 on the bacterial 16S ribosomal RNA genes, in conjunction with temperature gradient electrophoresis of the resultant products. These qualitative results suggested that there was no difference between baseline and six months in the absolute number of bands revealed in the electrophoretic gels, i.e., the number of bacterial types or groups in the fecal samples. However, when the consistency (or comparability) in band behavior between baseline and six months was compared, consistency in band behavior was significantly greater in the control than the iron-treated group. That is, band distances differed by only 15 ± 7.5% in the controls, whereas bands differed by 32.3 ± 12.5% (Dice coefficient analysis, P<0.0001) in the iron-treated group, indicating that bacterial diversity was much greater after iron supplementation.22,23

The authors also carried out similar experiments to the above, but used primers that specifically targeted Lactobacillus species. They noted that, in the iron group, the microbiotic profile at six months strongly differed from that at baseline for each volunteer, but the responses were variable and no specific band pattern could be related to iron fortification.

In addition to looking at diversity, the authors also used quantitative real-time PCR, using a universal primer pair to obtain the total bacterial count and specific primers to measure Bacteroides, Enterobacteria, Bifidobacteria and Lactobacillus spp (Table 3). The mean log numbers of bacteria per g feces for all 60 children at baseline are shown in Figure 1. During the intervention, there were no significant changes in the total numbers of bacteria (log numbers, control 11.29 ± 0.67 and 11.28 ± 0.81; iron group 11.62 ± 0.70 and 11.78 ± 0.59) but in the iron group there was a significant increase in Enterobacter spp and a decrease in Lactobacilli spp (Figure 2). The population of enterobacteria includes many of the enteric pathogens and 26.6% of the children had positive fecal samples for Shigella spp and enteroinvasive E. coli and/or Salmonella spp at baseline, although the counts of these pathogenic species were generally low, namely ≤10³/g feces. This number is small, when one report suggested that 10¹⁴ bacteria reside in the large intestine alone.25 Salmonella was the predominant bacterial pathogen in the fecal sample occurring in ~79% of the positive samples and, after six months, more children were positive for Salmonella in the iron group (23%) than in the controls (16.6%), but this difference was not significant. Furthermore, there were no significant correlations between any
of the bacterial counts or changes in the fecal bacteria and baseline serum ferritin, transferrin receptors or zinc protoporphyrin concentrations.

**Gut inflammation in the Ivorian children**
The authors measured fecal concentrations of the inflammatory protein, calprotectin. Calprotectin is a calcium-binding protein that is found in all body fluids, in proportion to the level of inflammation present. Calprotectin is derived predominantly from neutrophils and, to a lesser extent, from monocytes and reactive macrophages. The presence of calprotectin in the feces is directly proportional to neutrophil migration towards the intestinal tract. Fecal calprotectin is remarkably stable and a useful marker of gastrointestinal inflammation. Inflammation in the bowel implies a loss of barrier function and a loss of tolerance against luminal and self antigens, and both these phenomena cause the recruitment of leukocytes in the intestinal wall. Activated leukocytes infiltrating into the intestinal mucosa are detected in the feces due to epithelial shedding in the intestinal lumen. The most important leukocyte population in the mucosal wall is polymorphonuclear neutrophils; hence, there is an increase in fecal calprotectin when there is intestinal inflammation. Several studies have shown that a cut-off of 30 mg/L had 100% sensitivity and 94% specificity for screening irritable bowel syndrome, but the calprotectin threshold predictive of systemic inflammation (CRP >6 mg/L) was 284 mg/L. Thus, inflammation in the bowel will not necessarily be detected systemically until intestinal inflammation is severe.

Fecal calprotectin concentrations in the Ivorian children who received additional iron for six months were significantly higher than those in the control group. The authors measured fecal concentrations of the inflammatory protein, calprotectin, in both groups. The results showed a significant increase in fecal calprotectin concentrations in the iron-deficient group compared to the control group. These findings suggest that iron deficiency may contribute to gut inflammation, which may have implications for the development of gastrointestinal diseases.
Iron fortification – new revelations?

Ginal intestinal inflammation. Furthermore, the authors found a correlation between the changes in calprotectin and the changes in numbers of enterobacteria ($r = 0.32, P < 0.05$). However, there was no increase in systemic inflammation (Table 2), confirming the mild nature of the intestinal inflammation and/or that the duration of increased iron intake might not have been long enough.

**Bacterial composition of the microbiota in the Ivorian children**

The authors reported that the composition of the gut microbiota was markedly different at baseline from that reported in European populations. The colonic microflora is generally viewed as being adult-like after the age of two years, and once the major bacterial groups in the feces become established they remain relatively constant over time. Total bacterial counts per g feces in the Ivorian children ($10^{11.5}$, Figure 1) were similar to those of European children ($10^{10.9}$), adults ($10^{11}$) or elderly persons ($10^{10.4}$) but there were some big differences in the composition. Bacteroides spp were the major group in both Ivorian and European feces but in the Ivorian children, there were $100$ million ($10^8$) enterobacteria/g feces, whereas in young European adults there were $<1$ million ($<10^6$)/g feces. In the case of bifidobacteria, the situation was reversed; Ivorian children had $25$ million compared with $1,600$ million/g feces respectively. In the case of lactobacilli, the numbers were very similar: around $3–5$ million bacteria cells/g feces (Table 5).

In addition to there being more enterobacteria in the gut of the Ivorian children than Western persons at baseline, supplementation with iron for three months increased the proportion increased (Figure 4). The authors used a more sensitive assay than that described above, in which the median calprotectin concentrations in healthy persons was $25 \mu g/g^{29}$ or below a cut-off of $50 \mu g/g^{26}$. Hence, the calprotectin concentration in the children who received iron, viz. $75 \mu g/g$ feces, indicated evidence of increased intestinal inflammation.

![FIGURE 1: Profile of fecal bacteria in Ivorian children before iron supplementation](image1)

![FIGURE 2: Influence of iron supplement on profiles of fecal bacteria](image2)
Iron Group

6.5

9.2

8

9.2

11.78 (0.59)

7.5

11.62 (0.94)

6.7

5.9

10

11.28 (0.81)

7 Data shown are mean (SE) log number of bacteria/g feces

**TABLE 4:** Total numbers of bacteria in control and iron group after 6 months iron supplementation

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Iron Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>11.29 (0.67)</td>
<td>11.62 (0.94)</td>
</tr>
<tr>
<td>6 Months</td>
<td>11.28 (0.81)</td>
<td>11.78 (0.59)</td>
</tr>
</tbody>
</table>

**TABLE 5:** Comparison of main bacterial groups in feces of Ivorian children and young European adults

<table>
<thead>
<tr>
<th>Bacterial group</th>
<th>Ivorian children</th>
<th>Young European adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log number bacteria/g feces</td>
<td>Log number bacteria/g feces</td>
</tr>
<tr>
<td>Bacteroides</td>
<td>10</td>
<td>9.2</td>
</tr>
<tr>
<td>Enterobacteria</td>
<td>8</td>
<td>5.9</td>
</tr>
<tr>
<td>Bifidobacteria</td>
<td>7.5</td>
<td>9.2</td>
</tr>
<tr>
<td>Lactobacilli</td>
<td>6.5</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Data for Ivorian children from reference and for European adults from reference.

...of enterobacteria by a further 100 million (log numbers 7.8 to 8.3 bacteria/g feces) while reducing the proportion of lactobacilli (Figure 2). If these changes in enterobacteria and lactobacilli are expressed as percentages of the total number of bacteria in the microbiota, there is a four-fold increase in enterobacteria from 0.01 to 0.039%, while there is a fourfold fall in the proportion of lactobacilli from 0.004% to 0.001%. There was also a fall in bifidobacteria, but this was not significant.

Reasons why iron favored the growth of enterobacteria over lactobacilli

Iron is a nutrient which is essential for the growth of most bacteria, but not in the case of most Lactobacilli spp (Table 3). Most enteric gram-negative pathogens, including Salmonella spp, E.coli and Shigella spp, take up iron-siderophore complexes by specific outer membrane receptors and display increased virulence in situations of increased iron availability. It is also interesting to note that fecal lactoferrin is as good an indicator of gut inflammation as calprotectin. Lactoferrin is a powerful iron-binding protein that is particularly effective under acid conditions and is derived from the polymorphonuclear neutrophils that are drawn into the gut lining at the onset of inflammation. Whether the neutrophil lactoferrin depresses pathogen growth at the mucosal lining is not known, but bacterial growth in the microbiota will be limited by iron availability, and the additional iron provided by the supplement may have provided a growth advantage for the enterobacteria, which enabled them to increase cell numbers at the expense of the lactobacilli and possibly the bifidobacteria.

The potential hazards of iron loading are well recognized. Not only do we have the results of the recent study in Pemba but it has previously been noted that iron given to patients with quiescent tuberculosis appeared to reactivate the disease. In addition, Murray and colleagues noted that, in areas of hyperendemic Plasmodium falciparum, patients with clinical iron deficiency enjoyed an attenuated incidence and severity of malaria but when such subjects were fed an iron-replete diet, many exhibited a recrudescence of malaria and when iron-deficient Maasai pastoralists were treated with iron, there was an increase in amebiasis in the iron group.

The significant correlation between the increase in enterobacteria and fecal calprotectin concentrations (r = 0.32, P <0.05) suggests that the increased inflammation in the Ivorian children was a consequence of increased enterobacterial growth stimulated by the supplemental iron. According to the authors, other factors which are known to raise fecal calprotectin such as gastroenteritis, fecal blood, non-steroidal anti-inflammatory drug use and helminth infection were unlikely to be relevant in these children. However, it was known that 27% of the children had Shigella spp, enteroinvasive E.coli or Salmonella spp at baseline, and that more children were positive for Salmonella spp in the iron group than the controls at six months. We are not told whether these specific-pathogen-infected children were the ones with the highest calprotectin concentrations, so we have to assume that inflammation was proportionally increased in response to the entire enterobacterial load. It is known that gut bacteria interact with mucosal cells lining the intestinal wall, and signals are transmitted into the lamina propria which illicit immune responses (Figure 4). These will be discussed below.

Interactions between the microbiota and the mucosal cells lining the gut wall

Research suggests that the relationship between gut flora and the digestive tract in the healthy person is not merely commensal (a non-harmful coexistence), but rather a symbiotic relationship. Microorganisms perform a host of useful functions, such as fermenting unused energy substrates, metabolizing food toxins, preventing growth of harmful, pathogenic bacteria, regulating the development of the gut, producing vitamins for the host (such as biotin and vitamin K), and many other functions. In particular, the composition of the intestinal microbiota is particu-
Iron Fortification – New Revelations?

The large number of bacteria ensures the stability of the composition, as all bacteria are constantly competing with one another for nutrients with which to grow and multiply. In these circumstances, it is difficult to demonstrate individual effects of specific bacteria on immune cells.

To determine the effects of individual bacteria on mucosal immunity, bacterial composition of the microbiota has to be altered. Two recent papers have investigated the effects of Clostridium-related bacteria on immune cells in the tissues lining the gut. In the first of these, the composition of commensal bacteria in the mouse was changed by introducing a Clostridium-related, gram-positive, segmented filamentous bacteria (SFB). SFB attached itself to mucosal cells and shifted immune status by increasing production of T helper (T_h)17 cells in the lamina propria layer of the intestinal lining. T_h17 cells are one of the subsets of T helper cells that are formed from CD4^+ T cells on activation and expansion. Colonization of healthy mice with SFB caused no observable immune pathology but, in conditions that favor chronic inflammation, the presence of SFB promoted inflammation. The increased production of T_h17 cells increased production of pro-inflammatory effector cytokines interleukin (IL)-17 and IL-22, which stimulated the mucosal epithelial cells to produce antimicrobial peptide to augment the host’s ability to fight intestinal pathogens. However, the generation of the potentially harmful cytokine IL-17 may increase the risk of autoimmune inflammation in susceptible hosts, illustrating the importance of a large number of bacteria to prevent the over-induction of one particular immune cell.

Clostridium bacteria are a large component of mammalian microbiota and, very recently, another group of workers demonstrated that indigenous species of Clostridium bacteria promote anti-inflammatory immune responses by expanding and activating regulatory T (T_reg) cells. We normally associate Clostridium bacteria with the pathogenic species that cause food-poisoning, tetanus and botulism, but there are ~100 species, and two clusters, IV and XIVa (C. leptum and C. coccoides resp.) have been implicated in the maintenance of mucosal homeostasis and the prevention of inflammatory bowel disease (IBD). This makes the report particularly interesting, since IBD is a common

**FIGURE 3:** Profile of fecal bacteria in Ivorian children before iron supplementation

Calprotectin concentrations were measured by immunoassay and expressed as μg/g feces. Median calprotectin level in healthy subjects was described as 26 μg/g. Concentration in the children who received additional iron increased significantly (*, ANOVA with post hoc t-tests, P <0.01)

**FIGURE 4:** Regulation of immune homeostasis

Figure shows different signals (arrows) from different components of the microbiota in the lumen of the gut regulating different branches of the mucosal T cell response in the lamina propria. Modified from reference
Iron fortification – new revelations?

Iron supplementation study identified an increase in the gram-negative enterobacterial fecal fraction as being positively associated with calprotectin, a biomarker of inflammation. There were also increases in several species of pathogenic bacteria in this group and some were identified in several of the children. In addition, there was a reduction in the gram-positive Lactobacillus group of bacteria.

Treg cells are also derived from CD4+ T cells. Their importance lies in their ability to suppress the immune responses of other cells – that is, to keep the immune responses in check. The authors showed that the increase in Treg in response to oral inoculation with Clostridia spp during the early life of conventionally reared mice promoted anti-inflammatory immune responses and were more resistant to experimental models of allergy and experimental colitis – the murine equivalent of IBD. The paper is a fascinating piece of investigative murine microbiology but, unfortunately, there is not space to discuss it in detail. Interestingly, the ability to stimulate Treg was not blocked by SFB bacteria or Lactobacilli. A cocktail of 45 strains of Clostridia was more effective in raising Treg production than three strains indicating, possibly, that a number of stimuli is necessary for a full response.5 Clostridium species appear to be specialized in their ability to promote Treg cell accumulation in the colon.25 Adherence to the intestinal epithelium did not appear to be necessary, as in the case of SFB bacteria, possibly because Clostridia spp promoted the release of the transforming growth factor-β that stimulated CD4+ T cell differentiation.25 The effects of these bacteria on T-cell development give us a clear indication that, potentially, many fecal bacteria may have an important influence on immune defenses in the gut and on the systemic health of the host. We currently have little idea of the specific role of iron in this “orchestra.”

Concluding remarks

Three papers have been discussed in this report, which describes interactions between diet, the microbiota and the immune system. The paper by the Zimmermann group illustrates that an increase in a poorly available form of iron was associated with alterations in the colonic microbiota and evidence of inflammation in the intestinal lining.3 The two other papers illustrate that specific, or groups of, gram-positive bacteria can have stimulatory effects on the immune system and promote potentially inflammatory and anti-inflammatory immune responses. The iron supplementation study identified an increase in the gram-negative enterobacterial fecal fraction as being positively associated with calprotectin, a biomarker of inflammation. There were also increases in several species of pathogenic bacteria in this group and some were identified in several of the children. In addition, there was a reduction in the gram-positive Lactobacillus group of bacteria.

Host protection against bacterial pathogenicity is partly afforded by the large number of commensal bacteria in the microbiota, many of which will occupy important niches within the intestinal lining and so prevent occupancy by incoming pathogenic strains.40 Dietary requirements will also determine which bacteria can propagate themselves at the expense of others. Iron is an important regulator of bacterial growth and pathogenicity. Supplemental iron may well have been responsible for the four-fold increase in the numbers of enterobacteria and the associated inflammation. The particular bacterial species and mechanism causing the inflammation are not known, but the marked effects that SFB bacteria and Clostridia spp can have on T-cell regulation indicate the type of mechanism that may have been involved. As the authors suggest, minimizing the inflammatory effects of supplemental iron may be possible with a lower dose of more bioavailable iron to promote iron uptake and reduce the amount available to the microbiota.

In the last issue of Sight and Life, Barbara Troesch, from the same group, reported on the successful use of low-dose iron from NaFeEDTA, in combination with ascorbic acid and phytase, to increase body iron stores and reduce iron and zinc deficiency in South African school children.64 It should also be remembered that the study in Côte d’Ivoire was intended to show the potential effects of food fortified with iron. In fact, the iron load was 18.2 mg/day, given in a biscuit four days/week. The equivalent daily dose of fortified iron would have been 8.8 mg iron/day, but this amount may not have had the same microbiological or inflammatory effects as the higher dose. Currently, the selection of the type and quantity of vitamins and minerals to add to flour, either as a voluntary standard or a mandatory requirement, lies with national decision-makers in each country. As a result, the choice of compounds as well as quantities should be viewed in the context of each country’s situation. Recommended amounts of electrolytic iron are only given where the daily consumption of flour is >150 g (60 ppm) or >300 g (40 ppm) for low extraction flour or 20 and 15 ppm resp. for those amounts of high extraction flour.43 Three hundred grams of flour containing 40 ppm Fe is equivalent to a daily intake of 18 mg iron, i.e. comparable to the amount used in the Ivoirian children. Thus, the effects of the iron supplement reported by Zimmermann and colleagues3 are applicable to those countries where flour is fortified with electrolytic iron, and there is a high consumption of wheat flour.

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41. Troesch B. Optimized micronutrient powder containing low levels of highly bioavailable iron and zinc together with EDTA, phytase and ascorbic acid improves the nutritional status of children. Sight and Life 2010;3:9–11.

**Erratum:** Optimized Micronutrient Powder

In the article Optimized Micronutrient Powder in *Sight and Life Magazine* 3/2010, the figures in Table 2 were incorrect. The table to the right has the correct figures. We apologize for any confusion this error may have caused.

**Table 2:** Composition of the micronutrient powder used in the intervention study

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Pro serving</th>
<th>Pro kg premix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (RAE)</td>
<td>400 μg</td>
<td>80 mg</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>5 μg</td>
<td>1 mg</td>
</tr>
<tr>
<td>Vitamin E (TE)</td>
<td>5 mg</td>
<td>1 g</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.5 mg</td>
<td>100 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.5 mg</td>
<td>100 mg</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>0.5 mg</td>
<td>100 mg</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>90 μg</td>
<td>18 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>6 mg</td>
<td>1.2 g</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>2.0 mg</td>
<td>400 mg</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>0.9 μg</td>
<td>180 μg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>60 mg</td>
<td>12 g</td>
</tr>
<tr>
<td>Iron (as NaFeEDTA)</td>
<td>2.5 mg</td>
<td>500 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>200 mg</td>
<td>40 g</td>
</tr>
<tr>
<td>Copper</td>
<td>0.34 mg</td>
<td>68 mg</td>
</tr>
<tr>
<td>Iodine</td>
<td>30 μg</td>
<td>6 mg</td>
</tr>
<tr>
<td>Selenium</td>
<td>17 μg</td>
<td>3.4 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.5 mg</td>
<td>500 mg</td>
</tr>
<tr>
<td>Phytase</td>
<td>190 FTU</td>
<td>38,000 FTU</td>
</tr>
<tr>
<td>Carrier</td>
<td>Ad 5g</td>
<td>ad 1000g</td>
</tr>
</tbody>
</table>
Opinion 1: Comments on “Iron Fortification – New Revelations?”

Glenn Gibson
Department of Food and Nutritional Sciences, University of Reading, United Kingdom

The decision to withdraw iron supplementation in certain malaria-affected areas was the subject of David Thurnham’s objective assessment of recent science findings. David has outlined some of the thinking behind this decision and input his own evidence-based views.

As with so many current nutritional concepts, the drift of attention has been drawn to the gut microbiota. This is not surprising, given the vast numbers of bacteria that use the human alimentary tract as their home and their concomitant major impact upon metabolism. I especially like David’s conclusion that it is not enough nowadays to simply measure predominant gut flora components without an assessment of the functional or physiological impact. Perhaps some bacteria not present in large numbers can exert a major impact upon health. In this context, I have always been struck by the fact that it is easily accepted, by science and medical communities, that just a few cells of a pathogen like *E. coli* 0157 can exert destructive effects, yet the impact of a larger number of probiotic microbes gets written off, more often than not. The science of metabonomics recently entered the gut microbiology arena and offers a similar “revolution” in our understanding of the impact of gut microbes to that generated by molecular-based assessments of composition in the last decade.¹

On that note, David cites an extensive study which led to the contentious decisions on iron supplementation. High throughput and accurate PCR-based technologies were used to assess the gut microbiota in Ivorian populations.² These were seen to differ markedly from European profiles, although parallel studies were clearly not feasible and differing techniques may have been used. That aside, it seemed that the Ivorians harbored higher levels of enterobacteria and lesser populations of Gram positive bacteria said to be beneficial (*bifidobacteria*). The iron use was said to fortify the enterobacteria, and that led to health issues. It is worth noting that these are facultative, rather than strict, anaerobes whose enhanced growth rates are likely able to allow better scavenging of iron. I was also struck by the detection of *salmonellae* and *shigellae*.* These are clear pathogens which often only exist in a transient manner. In European trials they are hardly ever reported unless in association with a food safety outbreak. Perhaps this is the key to the health difficulties seen, and maybe those few probiotics that boost *bifidobacteria* and consequently decrease pathogens are worth trying.³ Microbiota modulation through probiotics or prebiotics is popular in Europe, North America and Asia, but it seems to me that the Ivorian children studied here could be major benefactors of a harmless intervention.

David also gives us an example of how functional microbial assessments are needed rather than just compositional. The clostridia were seen to exert varying effects upon inflammation

“It is not enough nowadays to simply measure predominant gut flora components without an assessment of the functional or physiological impact”
Opinion 2: Venturing into the Jungle of Multiple Interactions between Iron, Modulating Influences, and Human Health

Klaus Schuemann
Technische Universität München, Zentralinstitut für Ernährung und Lebenswissenschaften, Germany

Over the last 10 years it has become a truism that iron is a double-edged sword. It is essential for bacteria, parasites and host organisms, but can also cause oxidative damage. Dr Thurnham’s contribution is on the crest of present day efforts to widen the scope from such direct iron effects to the increasing number of mutual interactions and cross-talks, such as those between iron, the composition of intestinal flora, and the well-being of the host. We congratulate Sight and Life on recognizing this new trend and inviting this article.

We must stay aware, however, that the subject under discussion here is only the tip of an iceberg which might be termed “modulation of health-related iron effects.” Some examples may illustrate how complex the scene has become. Extracellular bacteria, indeed, merrily hijack each other’s iron-fishing siderophores by imitating the siderophore-receptors of competing species. The host organism does the same in trying to recuperate part of its iron. Playing this game more or less successfully modulates the expansion of, for example, pathogenic germs and thus the prevalence of corresponding disease. Some bacteria even hijack entire heme molecules to an extent permitting them to abolish endogenous heme biosynthesis.1 Above a certain level, sulphides are destructive to colonocyte function, resulting in typical inflammatory patterns of UC. They are also volatile, and can be rendered innocuous by binding to metals – such as iron!

References

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Depending upon species type and experimental conditions. Noting David’s cited implications of some clostridia with IBD, this story could have an added twist. Research has shown elevated levels of microbially generated sulphides in the fecal stream of ulcerative colitis (UC) sufferers (one of two major types of IBD).4 Above a certain level, sulphides are destructive to colonocyte function, resulting in typical inflammatory patterns of UC. They are also volatile, and can be rendered innocuous by binding to metals – such as iron!
of protein folding. Injecting the missing dietary iron quantities parenterally did not re-induce ileal Crohn symptoms, showing that the underlying pathology depends on luminal iron concentrations. Iron also mutually interacts with immunological responses in multiple ways, as illustrated in Crohn’s disease in a corresponding comment. All these events illustrate that the role of iron in the underlying pathology is extensively modulated by a considerable number of interfering processes.

With the wide application of powerful genetic and biochemical tools, the number of examples of such interactions is likely to expand exponentially in the near future. Their clinical implications will serve to judge the relevance of such novel modulating effects. Some of these may be academic in nature, but others may yield ground-breaking new therapeutic principles or impulses for public health and nutrition. We hope that *Sight and Life* will continue to report on such developments.

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03. Sazawal S, Black RE, Ramsan M et al. Effects of routine prophylactic supplementation with iron and folic acid on admission to hospital and mortality in preschool children in a high malaria transmission setting; community-based, randomised, placebo-controlled trial. Lancet 2006;367:133–43.
Johann C Jerling (PhD) is the Director of TReNDS – Centre of Excellence for Nutrition at North-West University (Potchefstroom Campus), South Africa. He talks about his work at TReNDS, as well as his involvement in initiatives such as the African Nutrition Leadership Program (ANLP).

Sight and Life (SAL): Johann, what does your work as the Director of TReNDS involve?

Johann Jerling (JJ): I became the director fairly recently, on January 1, 2011. I see my role as developing and leading a team, which in this case is a team of nutrition scientists. In general, as a group, we spend 40 percent of our time on undergraduate student training, 40 percent on research, and 20 percent on the implementation of expertise.

SAL: What do you do in the course of a working day, and what impact does it make?

JJ: I aim to create an environment where team members excel at what they do. I also believe that we should really enjoy what we do, which is something that is sometimes neglected in our world. I aim to create an environment where people enjoy what they are doing. I try to achieve this on different levels; the first thing is to listen to what people have to say, and to try and solve problems. I have access to resources, so I try to use these wisely. If you can throw money at a problem, that’s fine, but very often it’s about supporting someone, creating energy, and then, sometimes, putting a little bit of fun into it, so we don’t take ourselves too seriously!

We are a group of about 18 academic staff members, as well as about 30 graduates and postgraduates, who form a central part of our research effort. We carry out research in various fields at a level ranging from molecular to societal. The first is in the area of diet and hemostasis, or blood clotting. We have a research program in nutrigenetics that is fairly new and together they form the basis of our molecular work. We also do research in the area of micronutrients and cognition; in body composition, both overweight and underweight; and we have a research program on nutrition transition, which is an overriding theme that we have. As with most parts of the developing world, in South Africa nutrition transition already has a huge impact on the health systems of our and other countries. We also have a very strong research program in fatty acids and lipids, which is linked to cognition, micronutrient status, and under- and over-nutrition. Another theme is best described as nutrition in exercise and sport. This is fairly new and we are investigating the possibility of a postgraduate specialization degree in this area.

We try to develop track records in all of these areas. I really believe in teamwork. I don’t believe that, as academics, we can do everything well – I’m a big fan of getting strong teams together and pooling the expertise that is necessary to do the job and do it well. We develop trans-disciplinary research teams around important health themes and steer clear from developing research areas focused on individual capabilities. Sometimes you are a team member, sometimes you are a leader; it all depends on where you are at.

SAL: Is there such a thing as a “normal” day for you?

JJ: Not at all! Every once in a while, I wish I could have a day where I could say, “Now it’s finished,” but that’s not the case in my role. I work long hours, and every day is a mixture of all sorts of things. Some are administrative, others might be research-related, but a lot of them are people-related. People come to me...
“Although it’s something that I haven’t done for three or four years, I really enjoy fly fishing, as it takes my mind off everything.”
A DAY IN THE LIFE OF JOHANN C JERLING

for advice and a chat, so I do spend a lot of my time on this. If the team is doing well, I'm happy and think I’ve done my bit.

**SAL:** What do you look forward to in your working day, and what do you find challenging?

**JJ:** Seeing people grow gives me a huge amount of satisfaction. I enjoy solving problems, and seeing the end result of solving a problem. I also greatly enjoy discovering new things, which might be really complex ... or really simple. Overall, I really enjoy the enthusiasm in the group. We have some more senior researchers, plus a fairly large batch of 30-somethings, who are fun to work with, as they are all developing careers, and are energetic, adaptable and eager to try to do things in a new way. It really adds to the feeling of the whole job being worthwhile.

**SAL:** Which aspect of your work is most important to you?

**JJ:** The activity I find most rewarding is the leadership development program that I am director of – the African Nutrition Leadership Program, or ANLP. Every year about 120 candidates apply from all over Africa. Thirty get selected and join a 10-day leadership development course. To me, this is the single most worthwhile thing that I have done in my whole life. It’s a lot of really hard work, but the rewards that I get in many ways are just fantastic. It’s great to see how people discover things about themselves that they never knew before, how they change in environments where they are challenged in all sorts of ways. It’s also wonderful to see how we can get 30 people together from 17 different countries for 10 days, and discover how irrelevant the differences between nations become. I can see how strongly religious Christians and devout Muslims can work together, despite the fact that we have seen conflict along religious lines in many African countries. Above all, it’s great to see how people develop and progress in their careers, and as part of this Africa-wide network. I find it really satisfying.

**SAL:** What does *Sight and Life* mean to you in the context of the global fight against malnutrition?

**JJ:** Maybe six years ago, if I heard someone talk about *Sight and Life*, I would have thought about vitamin A. Now, however, I think it is about people who create awareness, stir, and build capacity. For me, the whole transition that has been undergone by *Sight and Life*, at least in my lifetime, has built that enthusiasm. This is an organization that gets all sorts of things done. Although I do not believe that there is one single organization that will ever win the battle against malnutrition, *Sight and Life* plays a really important role in the whole movement. I have great respect for it because it actually delivers.

As for the magazine, it contains articles, inspiring stories, and news, and its content is strikingly different from what many other organizations do. I also appreciate that it is not simply so focused that it’s only interested in its own small area, perhaps because it is positioned to be fairly broadly interested in malnutrition. I get the impression that it’s an organization that’s genuinely interested in solving issues.

**SAL:** How do you switch off from work? Do you have interests outside your professional existence?

**JJ:** Although it’s something that I haven’t done for three or four years, I really enjoy fly fishing, as it takes my mind off everything. I also enjoy mountain biking and photography. I’m probably something of an undercover artist! I can’t do it very well, but I do have the urge to create... I love putting together slide shows, manipulating photographs and video editing.

**SAL:** Thank you, Johann, and good luck with everything you do.

**JJ:** Thank you.

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Interview by Susie Lunt
Growing the evidence base for micronutrients.
Fourth Africa Nutritional Epidemiology Conference (ANEC 4)

Nutrition and Food Security: Successes and Emerging Challenges

Maffo Tazoho Ghislain
University of Dschang, Cameroon

Last year, courtesy of Sight and Life, I attended the Fourth Africa Nutritional Epidemiology Conference (ANEC 4) on Nutrition and Food Security: Successes and Emerging Challenges. The five-day event took place from October 4 – 8, 2010 in Nairobi, Kenya and provided me with an excellent opportunity to share, learn and network.

Adequate nutrition is key to health and general well-being

In recent decades, nutritional science has clearly demonstrated the importance of nutrition for health and general well-being. Adequate nutrition means when people have access to, and consume enough, food which their body is then able to absorb to meet all its nutritional requirements. It is a combination of food security, food availability, food access, food use, food safety, food quality, and food utilization.

The evidence of the impact of food on health and human productivity is well established in infants and young children, and scientific data shows the impact of malnutrition on infant and young children’s growth. Given the complexity of food security, nutritionists, food scientists and healthcare workers must work together to fight malnutrition in developing countries.

“ANEC 4 was an important opportunity for researchers to discuss the best strategy for overcoming malnutrition in Africa and other developing regions”
The Fourth Africa Nutritional Epidemiology Conference was therefore an important opportunity for researchers to discuss the best strategy to overcome malnutrition and promote food security in Africa and other developing regions.

As a young researcher, attending this outstanding scientific event was an important opportunity for me to present the latest findings from our research group in the area of nutrition and food security. It was also an opportunity for me to learn how others are contributing to this field in their own countries, and to be updated on what is happening in the field of nutrition on a global scale.

The discussion around the theme and sub-theme of this conference was to be instrumental in helping me improve my knowledge of food security, and equipping me in better orienting my efforts to contribute to the fight against malnutrition as an inevitable cause of disease.

**Participation with fascinating insights**

On Day 1, after registration, I took part in a sponsored preconference symposium entitled “Iron interventions in malarious areas: where are we now?” This was followed by the opening ceremony, during which the chair and the co-chair of the local organizing committee presented their welcome message and a summary of the co-organizer of the conference, the Africa Nutrition Society (ANS).

The following day, I participated in several plenary sessions, including the parallel oral session “Climate change, food security and nutrition”. This was followed by a Nestlé symposium and a poster session, during which I presented my research work on “Effect of folere juice (dried calyx of Hisbiscus sabdariffa L) on some biochemical parameters in humans”. The results showed hemoglobin increased significantly (P=0.021), suggesting a potentially positive effect of folere juice consumption in increasing hemoglobin concentration. Serum iron, however, decreased (P=0.042), suggesting the utilization of iron in the synthesis of hemoglobin.

The third and fourth days brought much, in the form of sessions on “Maternal and child health and nutrition”, “School health and nutrition”, “Nutrition, immunity and communicable diseases in developing countries”, “Current management strategies for nutritional disorders”, and “Nutrition, immunity and communicable diseases in developing countries”. There were also fascinating symposia from Unilever and World Vision.

Finally, on Day 5, after a couple of plenary sessions focusing on “Nutrition in emergency situations” and “ANS capacity building for nutrition in Africa”, I enjoyed the closing ceremony during which the Nairobi declaration was read.

The week was not all work. A number of social events were organized, including a gala dinner at the Nyama Chioma Ranch, during which traditional African music was played, and a safari Njema lunch.

**A valuable visit with future implications**

Overall, the Fourth Africa Nutritional Epidemiology Conference enabled me to meet and talk with leading scientists and experts in nutrition, as well as other students working in my field of research. I also made many new contacts whom I plan to stay in touch with as I continue my studies – in particular Ngozi Nnam of the University of Nigeria Nsukka, who is working on the same biological material as me.

Such contacts, and the knowledge I gained will be translated to other researchers in my institutions for the scientific development of our young university in Cameroon.

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The First Global Conference on Biofortification was the first in a series of potentially three biofortification-focused conferences over the next few years. HarvestPlus convened the conference to bring together the many organizations and individuals conducting biofortification research over the past decade.

The conference took place in Washington, DC on November 9–11, 2010, attended by 300 scientists, researchers, practitioners, decision-makers, and students. Its main objectives were to:

- determine the current state of biofortification, taking stock of research, global investment, and experience in biofortification;
- raise the visibility of biofortification as a promising agricultural intervention for public health; and
- chart the future for biofortification, identifying synergies and gaps in knowledge and how to forge partnerships and collaborations.

“Biofortification, and its potential benefits to those who are malnourished, clearly should have a prominent place in our research, in our advocacy, and in our global development goals.”

Spanning two and a half days, it featured a keynote address and panel discussion each morning and technical symposia in the afternoons. The gala dinner, on the first evening, included biofortified maize on the menu and a keynote address by David Nabarro, Special Representative on Food Security and Nutrition to United Nations Secretary-General Ban Ki-moon. The dinner also featured a letter from Senator George McGovern of the US, a strong supporter of hunger and nutrition issues for the past four decades, who has shown interest in biofortification. He wrote, “Biofortification, and its potential benefits to those who are malnourished, clearly should have a prominent place in our research, in our advocacy, and in our global development goals.”

Summary of keynote speakers
The conference opened with a keynote address by Ambassador William Garvelink, US Government Deputy Coordinator for Development at the Feed the Future Initiative, who focused his
remarks on the need to build momentum around linking agriculture and nutrition to address food insecurity. While funding for agricultural interventions has been on the decline in recent decades, Ambassador Garvelink reiterated the US Government’s recent commitment to increasing funding for agricultural and nutrition interventions, and to continuing the advancement of biofortified crops.

Dr Howarth Bouis, Director of HarvestPlus, presented an overview of biofortification progress. He identified five major challenges:

1. Identifying optimal delivery strategies for getting biofortified foods to people;
2. Ensuring and measuring the public health impact of biofortification;
3. Developing a better understanding of how foods impact human nutrition;
4. Getting the agricultural sector to prioritize improving nutrition; and
5. Getting the nutrition community to prioritize agriculture in order to improve nutrition.

Figure 1 shows a proposed framework for establishing biofortification as a sustainable solution for micronutrient malnutrition. Conference participants were encouraged to provide their feedback on the framework through an online forum: http://biofortconf.ifpri.info/

Nicholas Kristof, Pulitzer Prize-winning columnist for the New York Times, delivered day two’s keynote address. He encouraged participants to think about ways to raise the visibility of micronutrient malnutrition in the media, by doing a better job of “selling their story” and building emotional connections to the issues.

Navyn Salem from Edesia Global Nutrition Solutions delivered the keynote address on day three. She focused on the link between the private and public sectors, given Edesia’s work on delivering ready-to-use therapeutic foods for the treatment of acute malnutrition. Her comments provided potential strategies on how biofortification must use multiple disciplines and channels to promote and disseminate crops.

**Commissioned papers and moderated panel discussions**

Two papers had been commissioned for the conference. The first, *From HarvestPlus to harvest driven: How to realize the elusive potential of agriculture for nutrition?* by Lawrence Haddad of the UK’s Institute of Development Studies, focused on how agriculture can be used, more effectively, to improve nutrition.

He answered three questions: 1) What are the pathways between agriculture and nutrition? 2) Is the potential being realized? and 3) What can be done to increase the realization of this potential? After presenting his paper, Roger Beachy of the USDA, Shenggen Fan of the International Food Policy Research
The afternoon symposia (Table 1), featuring the work of 50 scientists and researchers, focused on the technical aspects of breeding, nutrition, and delivery of biofortified crops. It also focused on biofortification through agronomic practices, building trust around transgenic biofortified crops, and climate change’s role in diminishing the nutritional quality of foods.

Highlights included a session on a recent project that disseminated orange-fleshed sweet potato to 24,000 households in Uganda and Mozambique. By researchers from HarvestPlus and the International Food Policy Research Institute, this also presented strategies used by the project to promote new sweet potato varieties.

All videos, presentations, and papers from the conference can be downloaded at: http://biofortconf.ifpri.info.
http://www.flickr.com/photos/48533839@N05/sets/

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Institute, Iain MacGillivray of the Canadian International Development Agency, and Ruth Oniang’o of the African Journal of Food, Agriculture, Nutrition, and Development discussed his findings and took questions from the audience.

Keith West of the Johns Hopkins Bloomberg School of Public Health presented the second commissioned paper, *Biofortification as a complementary approach to controlling micronutrient deficiencies in the developing world*. This discussed how biofortification fits into already existing nutritional strategies of dietary diversification, food fortification, and supplementation. Panelists included Shawn Baker of Helen Keller International, Mahabub Hossain of the Bangladesh Rural Advancement Committee, MG Venkatesh Mannar of Micronutrient Initiative, and Meera Shekar of the World Bank.

On the final day, Dr Bouis summarized the conference keynotes, panel discussions, and symposia, looking back at the framework proposed on day one (Figure 1). A panel discussion followed, including Pamela Anderson of the International Potato Center, Arun Joshi of the International Wheat and Maize Improvement Center, Denis Kyetere of the National Agriculture Research Organisation – Uganda, and Francisco Reifschneider of Embrapa (Brazil). Panelists discussed ideas for moving biofortification forward. The conference concluded with a strong call to action by moderator Roger Thurow of the Chicago Council on Global Affairs.

**Table 1: The afternoon symposia presented findings on:**

- Progress, challenges, and the way forward in nutrition research on biofortified crops: vitamin A
- Progress, challenges, and the way forward in nutrition research on biofortified crops: iron and zinc
- Progress, challenges, and the way forward in breeding and gene development for vitamin A: taking stock, gaps, and solutions
- Progress, challenges, and the way forward in breeding and gene development for iron and zinc: taking stock, gaps, and solutions
- Delivering vitamin A crops: a visible nutrient
- Delivering iron and zinc crops: an invisible nutrient
- Biofortification for the developed world: progress with antioxidants and other nutrients
- Biofortification through agronomic practices
- Breeding for bioavailability
- Building public trust in transgenic biofortified crops: a dialogue
- Climate change and the nutritional quality of foods
- Orange-fleshed sweet potato is making a difference
- Weaving biofortification into the global development agenda
- What about protein?
New Developments in Carotenoids Research

Conference at Tufts University, Boston, USA, 11–12 March 2011

Peter Engel
DSM Nutritional Products on behalf of Sight and Life, Basel, Switzerland

Introduction
With its copious research and development (R&D) activities and passion for innovation, DSM is an authority on nutrition science, supporting multiple activities dedicated to the field of nutrition. The company regularly brings together scientists from academia and industry, as well as experts from health authorities, to communicate and advocate for the role of micronutrients in human health. In March 2011, an international group of leading researchers in the growing field of carotenoids met at Tufts University, Boston, USA, for an information-packed, two-day conference on “New Developments in Carotenoids Research.” Jointly organized by Tufts University and DSM, and presented by The Jean Mayer USDA Human Nutrition Research Center on Aging (HNRCA), the conference featured keynotes from global experts on the role of β-carotene, lycopene, lutein and zeaxanthin, as well as vitamin A in human health. The about 150 participants experienced a high-level conference where the “Who’s Who” in carotenoid and vitamin A science shared latest research findings.

DSM is continuing to support carotenoid science events with the “Macular Carotenoids & AMD” conference in Cambridge, UK (www.macularcarotenoids.org) and the “16th International Symposium on Carotenoids” in Krakow, Poland (www.carotenoid.pl).

Summary of selected key lectures
In his keynote lecture, Alfred Sommer (Johns Hopkins University, USA) gave a global clinical overview on vitamin A and carotenoids. The clinical importance of vitamin A as an essential nutrient has become increasingly clear. Adequate vitamin A is required for normal organogenesis, immune competence, tissue differentiation and the visual cycle. Deficiency, widespread throughout the developing world, is responsible for a million or more instances of unnecessary death and blindness every year. β-carotene is an important, but insufficient source of vitamin A among poor populations, which accounts for the widespread nature of vitamin A deficiency. It has only recently become apparent that the bioconversion of traditional dietary sources of β-carotene to vitamin A is much less efficient than previously supposed. The other major carotenoids, particularly lycopene, lutein and zeaxanthin, have been found to have important

“The use of systematic reviews will be essential to provide harmonization and transparency in the process of developing intake recommendations”
biologic properties, including antioxidant and photo-protective activity. In observational studies, high intake of these has been linked with the reduced risk of a number of chronic diseases.

Focusing on the role of β-carotene as a safe source for vitamin A, Robert M Russell (National Institutes of Health, USA) gave perspectives on vitamin A and carotenes with regard to defining their dietary requirements. In 2001, the old ratio of 6:1 β-carotene to vitamin A equivalence (1 retinol equivalent = 6 μg of β-carotene) was jettisoned in the US for a new ratio of 12:1, based on new and reproducible stable isotope data. However, there is great variation of the bioconversion equivalence, depending on the food being tested (e.g., for green leafy vegetables >20:1 and for carrots ~15:1). In addition, there is new evidence that foods with a simple, digestible matrix have an equivalence that is much better than 12:1. The tolerable upper level for vitamin A is set at 3,000 μg per day in the US and EU, based upon liver toxicity and teratogenicity among women of reproductive age. In the UK, it is recommended that people not consume more than 1,500 μg per day. The US and EU panels concluded that there was not enough data on which to base a tolerable upper level for β-carotene. However, in the UK an upper level for β-carotene was set at 7 mg per day. In future, the use of systematic reviews will be essential to provide harmonization and transparency in the process of developing intake recommendations.

**Nutritional relevance and challenges**

Keith P West (Johns Hopkins Bloomberg School of Public Health, USA) outlined the nutritional relevance of β-carotene as provitamin A. Vitamin A deficiency can arise when dietary intake is chronically insufficient in meeting needs imposed by life stage, infection and other metabolic stresses. Preventing such deficiency can be achieved through an adequate diet of preformed (e.g., liver, dairy products, egg, etc) and provitamin A carotenoid food sources (e.g., dark green leaves, yellow-orange fruits and vegetables). Dietary β-carotene is the most important precursor of vitamin A and has the potential to fill dietary vitamin A gaps.

The challenge in attaining nutritional adequacy for vitamin A and β-carotene was discussed by Marjorie J Haskell (University of California, USA). The bioavailability and vitamin A equivalency of β-carotene from foods is highly variable and can be affected by food and diet-related factors (such as the food matrix, food processing techniques) and also by characteristics of the target population, such as vitamin A status, other nutrient deficiencies, gut integrity and genetic polymorphisms associated with β-carotene metabolism. Thus, the variability in estimates of vitamin A equivalency is high across studies, as is the variability in vitamin A equivalency ratios between individuals within studies. Hans Konrad Biesalski (University of Hohenheim, Germany) emphasized that consensus among experts in the field of carotenoids holds that β-carotene is a safe source of vitamin A biologic properties, including antioxidant and photo-protective activity. In observational studies, high intake of these has been linked with the reduced risk of a number of chronic diseases.

Focusing on the role of β-carotene as a safe source for vitamin A, Robert M Russell (National Institutes of Health, USA) gave perspectives on vitamin A and carotenes with regard to defining their dietary requirements. In 2001, the old ratio of 6:1 β-carotene to vitamin A equivalence (1 retinol equivalent = 6 μg of β-carotene) was jettisoned in the US for a new ratio of 12:1, based on new and reproducible stable isotope data. However, there is great variation of the bioconversion equivalence, depending on the food being tested (e.g., for green leafy vegetables >20:1 and for carrots ~15:1). In addition, there is new evidence that foods with a simple, digestible matrix have an equivalence that is much better than 12:1. The tolerable upper level for vitamin A is set at 3,000 μg per day in the US and EU, based upon liver toxicity and teratogenicity among women of reproductive age. In the UK, it is recommended that people not consume more than 1,500 μg per day. The US and EU panels concluded that there was not enough data on which to base a tolerable upper level for β-carotene. However, in the UK an upper level for β-carotene was set at 7 mg per day. In future, the use of systematic reviews will be essential to provide harmonization and transparency in the process of developing intake recommendations.

**“Retinoids influence, and in some cases appear to be principal drivers of, immune cell differentiation that, in turn, affects a number of processes”**
**NEW DEVELOPMENTS IN CAROTENOIDs RESEARCH**

**SIGHT AND LIFE | VOL. 25 (3) | 2011**

**EXPERT KEY MESSAGES**

**β-carotene** is a safe source of vitamin A. Its pro-vitamin A function is a crucial contribution to the required total vitamin A intake in both developed and developing countries. Vitamin A is essential for normal growth and development, the immune system, vision and other functions in the human body. The intake of preformed vitamin A from animal products is not sufficient in major parts of the population all over the world, including Europe, the US and Asia. Recent studies suggest that suboptimal levels of vitamin A and β-carotene, even levels well above those causing clinical deficiency syndromes, can be a contributing risk factor in chronic diseases. An appropriate intake of β-carotene in diets, fortified foods and/or dietary supplements could safely compensate for the lack of vitamin A.

**Lutein** is a natural pigment and potent antioxidant present in the macula of the eye and in the skin. It acts as a filter, shielding against the damaging near-to-UV blue light of the sun. Higher dietary intake of foods rich in lutein and zeaxanthin is being discussed for its potentially positive, preventive effects on macular degeneration and cataracts, as well as improved visual performance. Based on a wealth of scientific literature, lutein is considered an eye health nutrient, supporting healthy eyes and vision as people age.

**Zeaxanthin** is, in addition to lutein, the only other major carotenoid specifically located in the macula of the eye. Zeaxanthin, found in the retina, also protects the eye from damage caused by the near-to-UV blue light of the sun. Higher dietary intake of foods rich in lutein and zeaxanthin has been associated with a reduced risk of macular degeneration and cataracts.

**Lycopene** is one of the strongest antioxidants among the carotenoids. Scientific evidence suggests that lycopene helps protect cells against oxidative damage, and it is discussed and researched in the scientific community for its benefits to cardiovascular health.

intake, and that the provitamin A function of β-carotene is essential to achieve vitamin A intake recommendations in both developed and developing countries.

Summarizing the results of epidemiological and human supplementation studies with β-carotene in chronic disease prevention, Susan T Mayne (Yale Schools of Public Health and Medicine, USA) concluded that intervening in populations with low β-carotene status in order to improve it may be a more promising approach than intervening in populations with adequate status in order to raise it to a “supra” adequate status. However, this more personalized approach to nutrient-based intervention is critically dependent on the availability of biological markers of status – in this case, carotenoid status. Recent advances in the development of promising new methods for rapidly and non-invasively assessing carotenoid status suggest that it is increasingly feasible to identify the persons most likely to benefit from carotenoid interventions, allowing for future intervention trials with a greater likelihood of demonstrating beneficial effects than seen to date.

**Landmark findings** Francine Grodstein (Harvard Medical School, USA) reported on clinical studies evaluating the effect of antioxidant β-carotene supplements on cognitive decline in older persons. Most notably, in the Physicians’ Health Study II 6,000 older men were randomized to 50 mg of β-carotene supplementation on alternate days, ranging from one to up to 18 years. For participants with long-term supplementation, cognitive function was significantly better compared to long-term placebo. Other research in this area has been inconsistent with these landmark findings. The explanation for these discrepant findings is not clear, although it is possible that some combination of the appropriate dose and...
duration of β-carotene exposure is necessary for brain health. Future research needs to better consider these questions of dose and duration.

Study results showing β-carotene- and lycopene-rich diet or supplementation to provide protection against skin damage from sunlight were presented by Helmut Sies (Heinrich Heine University, Germany). Although photoprotection through individual carotenoid intake is considerably lower than that achieved using topical sunscreens, optimal supply of antioxidant micronutrients to the skin increases basal dermal defense against UV irradiation, supports longer-term protection and contributes to the maintenance of skin health and appearance.

In a second keynote lecture, A Catharine Ross (Pennsylvania State University, USA) comprehensively outlined the effects of vitamin A and retinoic acid on the immune system. Retinoids influence, and in some cases appear to be principal drivers of, immune cell differentiation that, in turn, affects a number of processes. Vitamin A’s active metabolite all-trans-retinoic acid seems to exert effects on the immune system by heightening antibody responses through promotion of antibody production, regulating T-cell differentiation, and programming precursor T cells for innate immunity. In addition, the retinoic acid inducible gene-1 is a major factor in the response to viral infections and other stimuli.

The lycopene effect
Xiang-Dong Wang (Tufts University, USA) discussed the importance of lycopene for human health. A high intake of tomatoes and tomato products have been found to reduce the risk of certain chronic diseases in many epidemiological studies, yielding evidence that lycopene (a major carotenoid in tomatoes) is a micronutrient with important health benefits, such as chronic disease prevention (e.g., various types of cancer). Whether the effect of lycopene on various cellular functions and signaling pathways is a result of the direct actions of intact lycopene or its derivatives remains unknown. Steven K Clinton (Ohio State University, USA) noted that epidemiologic studies suggest lycopene as a way to reduce risk or slow the progression of prostate cancer. Human studies focus upon the distribution of lycopene to the human prostate and the potential impact upon biomarkers related to prostate cancer progression.

Paul S Bernstein (University of Utah, USA) elucidated the role of macular pigment carotenoids. Abundant epidemiological evidence suggests that the macular pigment carotenoids lutein and zeaxanthin play key roles in the prevention and treatment of age-related macular degeneration (AMD), a leading cause of irreversible visual loss in the elderly in the developing world. Evidence that lutein and zeaxanthin also seem to improve visual performance in healthy subjects was highlighted by B Randy Hammond (University of Georgia, USA). Finally, Elizabeth J Johnson (Tufts University, USA) reviewed these carotenoids’ effects on cognitive performance in older adults: Cognitive decline in the elderly is a significant public health issue. Oxidative stress and inflammation are believed to be involved in the pathogenesis of cognitive decline. Epidemiological studies suggest that intake of dietary carotenoids may be of benefit in maintaining cognitive health. Given their role as antioxidants and anti-inflammatory agents, lutein and zeaxanthin may play a role in the prevention or delay of cognitive decline. Among all of the carotenoids, only these two cross the blood-retina barrier to form macular pigment in the eye.

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Promoting partnerships and capacity building.
Report from Gogounou

Blessings at the I-Domarou Health Center

Philippe Bani Mora
Domarou Health Centre, Gogounou, Benin

One of the Millennium Development Goals is to reduce the child mortality rate via people’s access to primary healthcare. With this in mind, in April 2010 the I-Domarou health care center was established in Gogounou, thanks to financial support from our faithful partner Sight and Life. The center’s fame quickly spread and it soon set consultation records for the whole community.

I-Domarou, which means blessings in the local language, is competitive in terms of its quality of care, affordability and hospitality. Providing a full range of care, it is run by three people, including a senior public health technician/nutritionist, who also acts as center manager; a social assistant; and a caregiver trained at the center.

Curative work
I-Domarou is an integrated health center and its activities are patient-driven. Cases include childhood illnesses, nutritional diseases, and many others, including skin infections, cuts, injuries and deficiencies in micronutrients. The center initially treated 328 cases in April 2010; however, numbers have risen and a grand total of 2,927 patients were seen over a period of six months. At a community level, the center received 150 patients whose parents did not even have one franc to support their children – most of whom were seriously ill. It also received four orphans and assisted with their medical care. In addition, it has seen 10 cases of night blindness.

Nutritional, preventative and educational work
Nutritional recovery is made on the basis of a “food square” consisting of a source of cereal (starch or tuber); a source of protein (vegetable or animal); a source of mineral complexes and vita-
In future, the center might grow to include a laboratory. However, the need for maternity facilities is also evident and mother and child protection is in great demand. Prenatal consultation and pregnancy monitoring could be carried out in liaison with the area hospital. We need to increase staff with qualified personnel and to obtain a means of transport to enable us to raise awareness in Fula camps and settlements far from the town center and ensure the transportation of medication from the central vendor to our remote workstation 175 km away.

**Progress and prospects**

Since its inception, we have made good progress in a number of areas, ranging from collaboration with the state structure to cooperation with the commune’s elected officials. We have submitted an application to the town hall for more land, to enable the future expansion of the center, including the construction of a clinic.

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“An integrated health center with patient-driven activities”
A Project Report on Training of Adolescent Girls for Prevention and Control of Iron Deficiency Anemia 2009/10

The continuation of a previous project supported by Sight and Life
This is the final report on the training of adolescent girls working in the mining and stone quarrying industries in rural hilly areas of eastern Nepal, in the prevention and control of anemia. This activity was implemented in different locations within Kavrepalanchok district to create awareness among mine and quarry workers. In order to do so and bring taught subjects to life, adolescent girls from different locations were first trained to identify people with iron deficiency anemia (IDA), provide nutrition education, and change behavior in terms of utilizing existing health care service centers early on. After training, during their leisure time these adolescent girls were involved in identifying IDA among pregnant women, nursing mothers and adolescent girls, in order to achieve the stated objectives for the period of 10 months to compare the results of IDA prevalence among these high-risk populations. This project is part of a continuation of a previous project supported by Sight and Life.

Project rationale
IDA is the most common nutritional problem in Nepal and has profound economic and social consequences. Many activities have been implemented by different organizations to combat this. However, some groups or pockets of the population have significant problems and still need to be reached with special packages.

> Although mine and stone quarry workers live in communities that are comparatively similar, it has been found that they are not aware of the problem and do not utilize available health care facilities. More attention needs to be paid to them to reduce the existing burden of IDA.
> As the government does not have a program to reach these groups, there is a strong need for regular outreach health care activities. One-off activities do not help reduce the present problem.
> Mine and quarry owners need to support regular health check-ups, and the provision of nutritious food, especially for pregnant and nursing mothers. Currently, whenever someone wants a check-up, he or she loses pay. Leave facilities should therefore be provided when health check-ups are required.
> Specific target groups require extra efforts and therefore need special attention.
Overall objective
To create awareness of the consequences of micronutrient deficiencies, with a special focus on iron deficiency anemia among pregnant and lactating mothers and adolescent girls of reproductive age working as mine and stone quarry workers.

Specific objectives
> Organize one batch of peer educator training for 25 adolescent girls at different mining and stone quarrying work sites.
> Identify, keep records of and treat pregnant women, lactating mothers, and adolescent girls of reproductive age with IDA.
> Raise awareness of the need for and importance of iron supplementation for pregnant women, lactating mothers, and adolescent girls of reproductive age.
> Raise awareness among pregnant women of the importance of iron supplementation during pregnancy.
> Motivate pregnant women to take iron-coated tablets regularly during pregnancy.
> Create awareness among pregnant women, lactating mothers, and adolescent girls of reproductive age about the importance of daily, sufficient consumption of foods containing vitamin A and iron and the importance of vitamin C rich food to increase dietary iron absorption.

Achievement
Two meetings were conducted with those in charge of health posts, female community health volunteers (FCHVs), social workers, and NGO representatives in program areas.

Two general health check-up camps were held at the beginning and end of the 10-month period for all quarry and mine workers’ family members and people from the community, with a special focus on pregnant women, lactating mothers, and adolescent girls. Health check-up camps to detect IDA among the target groups were organized at the work place at 10 sites to make them accessible and save workers’ time, so that they could return to work quickly.

The heart of the program was to identify and train adolescent girls from among the quarry and mine workers and develop them as motivators to early identify people with IDA and refer them to nearby health care units for treatment, followed by nutritional education. The prevalence of IDA is summarized in Tables 1 and 2.

Nutrition education
After the selection process, three-day nutrition orientation training was organized. It focused on the magnitude of the problem, the target group, nutrition deficiency disorders, early identification of problems, selection and preparation of foods, timely use of available health care units, etc.
Records of existing health care units have shown that those adolescent girls, pregnant women, and nursing mothers referred and detected as having IDA have been found to have visited the health units. Pregnant women and nursing mothers have been found to have adopted preventive measures as suggested, and improved the practice of planning and consuming iron-rich foods. Vitamin A capsules were distributed at all 10 sites, and 100 percent of children aged 6–59 months received vitamin A capsules. This was mainly thanks to the trained adolescent girls, aided by female community health volunteers who visited each house. However, the majority of the target groups did not utilize the health care units as expected, despite regular motivation by trained persons. This was mainly for fear of losing their daily wages. Making the service accessible and providing regular motivation by family members can help reduce the problem of IDA in such target populations.

Each trainee was provided with a kit bag containing a record book to record details of people with nutritional anemia and vitamin deficiency disorders, nutrition posters, iron tablets, and referral slips. As a preventive measure for the whole target population, nutrition education was delivered with the help of pictorial printed materials.

Trained adolescent girls took responsibility in their respective workplaces and health educators delivered nutrition education to a group every two months. Due consideration was given to the importance of micronutrient supplements for safe delivery, safe motherhood, prevention and control of childhood blindness, and mortality. Nursing mothers were encouraged to breastfeed their children up to at least two years of age, and to feed children food rich in iron and vitamin A from six months.

"IDA is the most common nutritional problem in Nepal"

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The Centre de Lutte Contre la Malnutrition de Lemba (Center for the Fight Against Malnutrition in Lemba) is located on avenue Mambu N°20, in the settlement of Kinsundi-Lemba, Bas-Congo province. It is 40 km from the port town of Boma in the south west of the Democratic Republic of Congo and 540 km from Kinshasa. The settlement of Kinsundi-Lemba is home to 21,935 inhabitants including 3,729 children aged up to 59 months. The majority of the population farms, while the remainder is made up of traders, teachers, craftsmen and the unemployed.

The creation of the center began on September 11, 2009 on the initiative of Georges Nicks Tsimba, senior ophthalmologist and nutritionist at the NGO Foyer d’Encadrement pour le Développement FED-ASBL. He had the excellent idea to set up a health facility to combat malnutrition and its effects on vulnerable people (children and others).

A year of action
From September 11, 2009 to September 11, 2010 there was an extensive program of activities.

The training of community liaison staff was the first task to be carried out, since it enabled us to gain the facilities to raise people’s awareness about malnutrition, micronutrients and nutritional anemia. We trained five community liaison staff: three men and two women.

Taking into account the difficult access to the most remote villages, we then created three diagnostic sites. Each of these has a representative to deal with cases of malnutrition.

A need to raise awareness followed and was addressed by making use of the community liaison staff as well as posters, radio and word of mouth.

Dietary treatment: First, we needed food. Since our center is located in a farming area, we carried out a survey to find out which foodstuffs are most commonly consumed and how, as well as the methods of producing them. From the results, we determined the best foodstuffs to be consumed. A parallel study was conducted to identify the components and nutritional values of each foodstuff, with most having been processed into flour, juice or pulp. These were mixed to increase the nutritional strength, then packaged and stored. Treatment depended on the degree of malnutrition.

Medical treatment: Consisting of vitamin A, folic acid, Vermox, Amoxicillin, and eye and dental products.

Preventative treatment: Including nutritional education about exclusive breastfeeding, feeding a sick child, food hygiene, culinary principles and personal hygiene, and teaching mothers about vegetable growing.

The challenges
Numerous problems were encountered, including difficulties in accessing people, solid meals given to parents of sick children being consumed by the whole family, seasonal food out of stock, untimely power cuts, lack of transport, rental difficulties and insufficient funds.

Despite this, the center achieved most of its goals, with five staff trained, four sites created, 36 visits undertaken and 342 children diagnosed and treated. All this was assisted in part by the US $6,600 that was received from Sight and Life.

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Anne-Catherine Frey Sight and Life, Basel, Switzerland E-mail: Anne-Cath.Frey@sightandlife.org
Report from Ratanakkiri
School Health Watch

Janie Rose Ilustre,
Pen Sarouen and Kim Chhay Sotheavy
Voluntary Service Overseas,
Cambodia

The School Health Watch government-initiated project provides health and nutrition guardianship in schools, and aims to target the prevention, treatment and control of health and nutrition problems among school children.

The province of Ratanakkiri, in northeast Cambodia, clearly illustrates a higher prevalence in malnutrition, in comparison with the data of malnutrition for the entire country (see Table 1). It is for this reason that the School Health Watch project was initiated.

Ground-breaking changes
After the implementation of the project, a Health and Nutrition Manual was developed to serve as reference material and national trainers from the School Health Department were identified as core trainers for possible expansion in future.

A total of 70 primary school teachers from five different schools were trained in health and nutrition skills and the knowledge to implement the project effectively. In addition, each school received water filters, first aid kits, hygiene sets, weighing scales, and height boards.

Anthropometric data on 1,572 primary school children were recorded. The results revealed that 23.2% were severely underweight; 62.8% were moderately underweight; and 14% were mildly underweight. Two hundred and fifty malnourished children were therefore identified to receive 15-day supplemental feeding, and among them 176 showed significant improvement (70.4%). Furthermore, the parents of these children attended a nutrition orientation workshop to ensure continued rehabilitation at home. The Ministry of Education, Youth and Sport rectified the School Health Policy Guidelines that were developed to ensure the sustainability and adaptability of the project among interested partners and stakeholders. To date, the project has become a successful benchmark for other partners. Belgium’s Handicapped International supported a rolling-out of the project in two of their targeted provinces in Takeo and Battambang, Cambodia, and the World Food Programme has shown an interest, with initial discussions taking place.

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**TABLE 1:** Cambodian Demographic and Health Survey (CDHS) (children 6–59 months old)

<table>
<thead>
<tr>
<th>Anthropometrics</th>
<th>Cambodia</th>
<th>Ratanakkiri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stunted</td>
<td>37%</td>
<td>54%</td>
</tr>
<tr>
<td>Underweight</td>
<td>36%</td>
<td>52%</td>
</tr>
<tr>
<td>Wasting</td>
<td>7%</td>
<td>8%</td>
</tr>
</tbody>
</table>

Cambodia is engaged in mobilizing resources to strengthen and rebuild its society, including the health and nutritional status of its schoolchildren.

“The project has become a successful benchmark for other partners”
Sight and Life Special Research Grant 2010 Awarded and Call For 2011 Grant

The theme for the 2010 Sight and Life Special Research Grant was "Assessing vitamin A dietary intake and status in developing countries where fortified foods are commercially available." Seventeen applications were received and two groups of researchers were selected. The first grant was awarded to the South African Medical Research Council (MRC), under the aegis of lead researcher Dr Mieke Faber. The research will determine the vitamin A intake and status of a representative sample of randomly selected South African children aged two to five years and their caregivers in each of five diverse geographical sites. The second grant was awarded to the University of California, Davis, and Helen Keller International, Cameroon, with the lead researcher being Dr Kenneth Brown. The theme of the research is "Vitamin A fortification of refined cooking oil in Cameroon: Optimization of fortification levels using dietary intake data and use of biological indicators of vitamin A status for program impact evaluation.” We look forward to sharing the results from both research programs.

The 2011 Special Grant theme will be “Examining the optimal formulation of micronutrient powders and the effect of their use on anemia, micronutrient status, and physical growth in malaria endemic settings.”

For details on the theme and how to apply, visit www.sightandlife.org

The SUN Keeps on Rising

The nutrition world is abuzz with activity as, now that both the Framework and the Road Map have been developed, the Scaling Up Nutrition (SUN) process moves from its talk phase to its action phase. The SUN concept has been reinforced by political interest in nutrition among leaders of national governments and development partners alike – some 14 countries have already been enlisted as “Early Risers”. However, there is still much work to be done. In 2011, the focus will be on translating the Road Map into actions with a view to helping countries affected by malnutrition to achieve long-term reduction in undernutrition, realize the first Millennium Development Goal, and start demonstrating this impact within three years.

The ongoing development of SUN is being led by a Transition Team and six inter-linked Task Forces, while the overall...
The three principles guiding the SUN movement are:

1. Efforts are led from countries and external support processes must add value to this country-led action and must be demand-driven;
2. Ongoing initiatives to improve nutrition should be linked together for greater coherence, efficiency, and impact wherever possible; and
3. A combination of networks and movements are needed to enable a range of stakeholders to work together and contribute to lasting results.

The Transition Team is made up of and working closely with individuals from the UN’s Standing Committee on Nutrition (SCN) and a wide range of organizations that includes the FAO, UNICEF, WHO, WFP and the World Bank, the REACH initiative, the African and European Unions, other regional bodies, civil society, farmers’ organizations, the research community, private companies, development partners and philanthropic foundations. The Transition Team is focusing on arrangements through which national authorities can request, and then access, support for actions to Scale Up Nutrition. The team has begun to consider how best to ensure that support is responsive to country needs and requests, coordinated, of high technical quality and effective.

Four outcomes are being pursued by the Transition Team:

1. Rapid increase in support for “Early Riser” countries that seek immediate help with their efforts to Scale Up Nutrition through encouraging links between the national authorities that want to get going now and those development partners that are ready to help them. This support will take stock of existing efforts and implementation gaps and will facilitate the development (or strengthening) of national multi-stakeholder nutrition platforms.
2. Ensure the development of long-term systems that provide support to Scaling Up Nutrition in all countries affected by undernutrition. These systems will enable national authorities to better connect and engage with key nutrition stakeholders from both civil society and the private sector, in ways that are effective, credible and accountable.
3. Foster the SUN Movement with effective advocacy and leadership. A durable multi-audience advocacy campaign will be built that encourages the emergence of effective and self-sustaining nutrition leadership at community, national, regional and global levels. The accomplishments of the SUN movement throughout its first three years and beyond will be documented and communicated, in close coordination with the 1,000 Days movement.
4. Agreement on transparent and accountable institutional arrangements for the SUN effort, once the Transition Team has completed its work. This will require analysis of needed features, organizational arrangements, and available options. It is intended that countries will be engaged as full partners and that key stakeholders wishing to contribute to country-led SUN actions will be able to do so. This work is being taken forward in conjunction with efforts to reform the SCN.

Each of the six Task Forces is responsible for the development of more detailed aspects of giving SUN life and cover:

- **Task Force A**: Country capability development. This focuses on developing and strengthening country capabilities for Scaling Up Nutrition. It includes the provision of support to multi-stakeholder platforms, the development of management systems and increased access to knowledge, standards and harmonized policies.
- **Task Force B**: Communication for Scaling Up Nutrition. This is responsible for communications and advocacy for Scaling Up Nutrition, with the 1,000 Days movement at its core. The Task Force also encourages the emergence of “Nutrition Leaders” at community, national, regional and global levels.
- **Task Force C**: Civil society participation. The focus is on ways to ensure inclusive civil society participation in the SUN process, at local, country, regional and global levels, ensuring the rights and well-being of those at risk of malnutrition and promoting the accountability of decision makers.
- **Task Force D**: Engagement of development partners. Developing ways in which development partners, including bilateral agencies, development banks and philanthropic organizations, can be fully engaged in a coordinated response and the effort to Scale Up Nutrition and can take a leading role in work with national governments.
- **Task Force E**: Engagement of the business community. Working on ways in which the business community can be better engaged in the effort to Scale Up Nutrition at all levels in ways that have the potential to be sustainable, and explore market-based responses at a national level.
- **Task Force F**: Monitoring and reporting on in-country progress. This focuses on multi-country and multi-stakeholder action to monitor and report on progress on Scaling Up Nutrition at country level; working with authorities and with the other Task Forces identifying the need for more effective approaches that could be the subject of in-depth analysis.
Each Task Force is finalizing its specific terms of reference as well as an action plan and many are doing this at the same time as beginning to deliver on specific projects. *Sight and Life* is represented on Task Force B by Jane Badham. We will ensure that we give regular updates on the various SUN activities, as its aim is to be transparent and include as many stakeholders as possible.

SUN is currently consolidating and building stakeholder alliances and aligning donor commitments with country-led plans for improving nutrition. In a recent article by David Pelletier et al, published in *Health Policy and Planning* (2011;1–13) and entitled “Nutrition agenda setting, policy formulation and implementation: lessons from the Mainstreaming Nutrition Initiative”, the authors highlight the reality that we face. While undernutrition is the single largest contributor to the global burden of disease and can be addressed through a number of highly efficacious interventions, in general it has not received commensurate interventions in policy agendas at global and national levels. Implementing these efficacious interventions at a national scale has also proven difficult. This is an important fact that has to be considered and overcome as SUN rolls out at a country level.

**Key messages include:**

› Strengthening the full spectrum of policy activities is necessary if large-scale and sustained reductions in undernutrition are to be achieved.

› Within this policy spectrum, high priority should be given to strengthening strategic capacities because these are fundamental to advancing commitment building, agenda setting, policy formulation, capacity building for operations, and all other aspects of a long-term nutrition agenda at country level.

› These conclusions are especially relevant for major global initiatives currently under development that seek to address nutrition through country-led processes and convergence between multiple organizations.

› The extensive investments in documenting the efficacy of nutrition interventions are unlikely to produce sustainable reductions in undernutrition unless or until these weaknesses in the policy spectrum are better understood and addressed.

SUN and the 1,000 Days movement are the start of a larger movement that hopes to address these real global nutrition issues by focusing attention, aligning and increasing resources, and building partnerships. The SUN must shine if nutrition is to take its rightful place and deliver to alleviate the suffering caused by undernutrition among millions of people around the world – especially pregnant women and children under two years of age.

**Coming soon will be a SUN website**
watch for the link from www.sightandlife.org

*Sight and Life* and Vitamin Angels – Together Improving Lives in India

*Sight and Life* and the non-profit organization Vitamin Angels, whose mission is to mobilize and deploy private sector resources to advance availability, access and use of vitamin A by newborns, infants and children most in need, have recently signed a Memorandum of Understanding. The partnership will work together to build on their individual strengths to foster local ownership of the problem of vitamin A deficiency in India, and catalyze a locally sustainable supply and distribution system in India.

Fifty-one percent of the 190 million children under five who suffer from moderate and severe vitamin A deficiency live in India, making addressing vitamin A deficiency in India a critical component of the global challenge to eliminate micronutrient deficiencies. While the Government of India fully supports initiatives for vitamin A supplementation and a large proportion of infants, children and lactating women receive supplementation, there remains a significant portion of the population that has yet to be reached.

“Through this partnership, *Sight and Life’s* advocacy and technical expertise and Vitamin Angels’ successful implementation of universal vitamin A supplementation projects aim to reach millions of those in India who have to date not
had access to life-saving vitamin A,” says Dr Klaus Kraemer, Director of *Sight and Life*.

In signing this Memorandum of Understanding, both partners hope to engage other international and Indian for-profit, not-for-profit and government entities. The aim is to mobilize support and participate in this initiative, in order to harness innovative public-private partnerships to sustainably tackle the vitamin A deficiency epidemic in India and improve the lives of millions of infants, children and women.

For more information on Vitamin Angels go to www.vitaminangels.org

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**UNICEF Workshop on Scaling Up the Use of Micronutrient Powders to Improve the Quality of Complementary Foods for Young Children in Latin America and the Caribbean**

In June 2011, UNICEF and the US Centers for Disease Control and Prevention (CDC) co-hosted a four-day workshop in Mexico to discuss the role of micronutrient powders (MNPs) in improving the quality of complementary feeding in Latin America and the Caribbean and to support countries in their plans to introduce and scale up MNP programs. Extensive research shows that MNPs are safe, efficacious, acceptable, easy to use and do not alter the taste or appearance of food. MNPs are particularly useful to improve the quality of complementary foods prepared at home. Based on current evidence, MNPs can easily and cost-effectively be administered under programmatic conditions and implemented at scale. Successful public health scale-up of MNPs does require that they are integrated within Infant and Young Child Nutrition (IYCN) and Early Child Development (ECD) programs. Under these conditions, MNPs have the potential not only to improve the micronutrient content of complementary food and decrease the burden of anemia, but also to improve complementary feeding and care practices of young children that will, in turn, lead to better growth and development outcomes for young children.

Many countries in Latin America and the Caribbean (LAC) are poised to scale up the use of MNPs as part of integrated IYCN and ECD strategies. Furthermore, a unique aspect of the Latin American experience is the use of MNPs as part of an integrated package of services included under social protection schemes such as Conditional Cash Transfer (CCT) programs to reduce social inequities.

The comprehensive workshop covered relevant topics, including the current status of MNP interventions in Latin America and the Caribbean; the evidence base for MNPs; relevant recommendations regarding MNPs; MNPs in national policies; MNPs integrated in nutrition strategies; the design of MNP interventions; MNPs and other interventions to improve micro-nutrient intake; choice of MNP formulation; target
In an excellent on-line article (www.slate.com/id/2281097/) originally from Project Syndicate, Copenhagen Consensus Centre Director Bjørn Lomborg writes: “Micronutrient deficiency is known as ‘hidden hunger’. This is a fitting description, because it is one of the global challenges that we hear relatively little about in the developed world. It draws scant media attention or celebrity firepower, which are often crucial to attracting charitable donations to a cause. But there is a larger point here: Billions of dollars are given and spent on aid and development by individuals and companies each year. Despite this generosity, we simply do not allocate enough resources to solve all of the world’s biggest problems. In a world fraught with competing claims on human solidarity, we have a moral obligation to direct additional resources to where they can achieve the most good. And that is as true of our own small-scale charitable donations as it is of governments’ or philanthropists’ aid budgets. In 2008, the Copenhagen Consensus Center asked a group of the world’s top economists to identify the ‘investments’ that could best help the planet. The experts – including five Nobel laureates – compared ways to spend US$75 billion on more than 30 interventions aimed at reducing malnutrition, broadening educational opportunity, slowing global warming, cutting air pollution, preventing conflict, fighting disease, improving access to water and sanitation, lowering trade and immigration barriers, thwarting terrorism, and promoting gender equality. Guided by their consideration of each option’s costs and benefits, and setting aside matters such as media attention, the experts identified the best investments: those for which relatively tiny amounts of money could generate significant returns in terms of health, prosperity, and community advantages. These included: increased immunization coverage, initiatives to reduce school dropout rates, community-based nutrition promotion, and micronutrient supplementation.”

The article goes on to ask: “How could US$ 10 best be spent? Should we, say, buy carbon offsets, or donate to a charity providing micronutrient supplements? By putting all benefits to individuals, communities, and countries in monetary terms, we can compare the two options. Expert researchers for the Copenhagen Consensus found that carbon offsets are a relatively ineffective way of reining in global warming and reducing its effects – US$10 would avoid about US$ 3 of damage from climate change. By contrast, US$10 spent on vitamin A supplements would achieve more than US$170 of benefits in health and long-term prosperity. One lesson we can draw is that while global warming may exacerbate problems like malnutrition, communities bolstered by adequate nutrition will generally be less vulnerable to climate-based threats. Overall, we can typically best help through direct interventions, including micronutrient supplements, fortification, biofortification, and nutritional promotion.”

The workshop was attended by participants representing 15 countries in LAC, who had the opportunity to engage in and discuss the current status of MNP activities in their respective countries and improve the design of these interventions. Countries exchanged experiences in a way that contributed to strengthening their program design, which in turn had the potential to substantially contribute to the body of evidence on the effectiveness of MNPs in programmatic settings.
“Food and nutrition security and HIV: how to ensure food and nutrition security are integral parts of HIV programming” was the theme of the 27th meeting of the UNAIDS Programme Coordinating Board meeting held in Geneva in December 2010. The day was organized by representatives of the three UNAIDS constituencies and included a range of expert speakers, as well as speakers with experience of working in countries and programs. It aimed to provide a stimulating opportunity for dialog, exchange, and learning, in order to identify pragmatic policy and programmatic strategies to ensure that food and nutrition become integral parts of HIV programming – supporting prevention, treatment care and support measures.

Experience and evidence are mounting that an effective response to the HIV/AIDS epidemic, including the achievement of universal access to prevention, treatment, care and support, requires issues of food and nutrition security to be addressed. Adequate nutrition is crucial for good health outcomes in general and a strong immune system in particular. For HIV and frequent co-infection tuberculosis (TB), as with any other infection, good nutrition is critical to keeping the immune system strong. Good nutrition can impact the pace of either disease, but will not eliminate the infection. Good nutrition is not only a critical adjunct of any treatment regimen, but is also important at all stages of the disease.

Before the initiation of treatment, good nutrition is critical in order to maximize the chances of slowing down disease progression. At around the start of antiretroviral therapy (ART), nutritional support is necessary to minimize side effects and metabolic challenges, thereby improving adherence. In low resource settings, HIV and frequent co-infection TB often strike where malnutrition is already prevalent and compound it. Additionally, malnutrition is associated with high mortality in the early months of treatment. The faster the achievement of nutritional recovery through a combination of ART or TB treatment and nutritional support, the better the chances of reducing early mortality.

People living with HIV (PLHIV) are at high risk of weight loss and wasting, which may compound existing malnutrition. Symptomatic HIV-positive children, for example, have calorie needs that are 50–100% greater than those of HIV-negative children. However, young children often struggle to consume the amount of calories required, especially when they do not have access to energy dense foods.

Although advances in ART have enabled many people to lead relatively normal lives and have significantly reduced HIV-related mortality and morbidity, fewer than half of the people living with HIV had access to treatment in 2010. While supply-side issues are part of the reason for this, many fail to seek treatment or show poor adherence. The reasons behind the lack of uptake and adherence are not always well understood, but evidence suggests that food insecurity and the cost of transport may be partially responsible. For those who have access to treatment, weight loss or malnutrition may affect the efficacy of ART.
Food and nutrition security is also an essential element of effective care and support in HIV-affected households and communities. In low-income countries, HIV contributes to food insecurity and malnutrition and has consequences for entire communities and societies, with the potential to significantly slow down economic development. Livelihoods are disrupted as PLHIV lose the ability to work, which exacerbates food insecurity, and they and their families are often excluded from informal safety nets because of the stigma associated with the disease.

Food insecurity frequently places people, especially women and girls, in situations that make them more vulnerable to transmission. It can lead to behaviors that have negative consequences, such as selling assets, removing children from school, migrating and engaging in transactional sex. These behaviors exact a substantial price in the long term, including increased exposure to HIV. Mitigating food insecurity can, therefore, contribute to a reduction in the risk of transmission.

All these elements highlight the importance of appropriate policy and programs to ensure the integration of food and nutrition in HIV and co-infection program design and implementation, with reference to the related reality that effective food and nutrition security programming must also be HIV-sensitive.

All aspects of UNAIDS work are directed by the following guiding principles:

- aligned to national stakeholders’ priorities;
- based on the meaningful and measurable involvement of civil society, especially people living with HIV and populations most at risk of HIV infection;
- based on human rights and gender equality;
- based on the best available scientific evidence and technical knowledge;
- promoting comprehensive responses to AIDS that integrate prevention, treatment, care and support; and
- based on the principle of non-discrimination.

To access the UNAIDS Strategy 2011-2015, go to www.unaids.org/en/strategygoalsby2015/

International Food Policy Research Institute (IFPRI) – Making the Link between Agriculture and Nutrition

Economic growth, which many assume has a natural positive impact on nutritional status through increased incomes and food expenditures, has not translated into improved nutrition in a number of developing countries. Considering this disconnect, IFPRI has released an important paper entitled “The nexus between agriculture and nutrition – Do growth patterns and conditional factors matter?” This seeks to provide an overview of the complex and dynamic relationship between nutrition and growth, examine how different growth patterns lead to different nutritional outcomes, and identify the factors that influence the magnitude of this relationship. It aims to offer researchers insights on areas for future research and analysis and to provide policymakers with knowledge regarding potential development strategies and investment policies that will increase the likelihood of positive nutritional outcomes.

As globally we try to break down the individual silos that nutrition and agriculture have built and functioned within, and in light of the growth of the Scaling Up Nutrition (SUN) movement, this paper is important. It will hopefully lead to many meaningful discussions and, more importantly, agricultural growth that leads not only to increased production and reduced poverty, but also to improved nutrition.

The paper can be accessed at www.ifpri.org/publication/nexus-between-agriculture-and-nutrition-0
The UK Government Office for Science recently published the Foresight Project Global Food and Farming Futures report, which provides an overview of the evidence and discusses the challenges and choices for policy makers pertaining to all aspects of the global food system. The impetus for the development of the document was the question of how to balance the competing pressures and demands on the global food system. The project brought together evidence and expertise from a wide range of disciplines across the natural and social sciences to assess what might enable or inhibit future change.

The report is comprehensive and covers five specific challenges:

1. Balancing future demand and supply sustainably, and ensuring that food is affordable;
2. Ensuring adequate stability in food supplies, and protecting the most vulnerable from any volatility that does occur;
3. Achieving global access to food, and an end to hunger;
4. Managing the contribution of the food system to the mitigation of climate change; and
5. Maintaining biodiversity and ecosystem services while feeding the world. The report emphasizes the need to build in greater resilience to future food price shocks, highlights the vulnerability of the global food system and is a must-read for anyone interested in the food system.

Global food prices rose to a fresh high in February 2011 – the eighth consecutive month of rising prices. Averaging 236 points, prices were up 2.2% from January and were the highest since January 1990, the inception date of the index. With the exception of sugar, the prices of all other commodity groups monitored registered gains in February, with dairy products and cereals climbing the most. The Food and Agriculture Organization of the United Nations (FAO) index measures monthly price changes for a food basket composed of dairy, meat and sugar, cereals and oilseeds. With the current global unrest and recent natural disasters, it is unclear where prices will go in 2011. This is cause for real concern, especially given that the last crisis pushed 100 million additional people into hunger and, in addition, that rising food prices have the greatest impact on poor countries, where food and energy are people’s major spending focus.

To monitor the index, visit www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/

The Hungrier the Louder

Source: Challenges, March 3, 2011
With nutrition gaining more visibility at all levels internationally, regionally and nationally, the USAID Nutrition Update 2010 is an important resource. The 36-page document provides information on nutritional status, anemia status, breastfeeding, the introduction of solid, semi-solid or soft foods, minimum dietary diversity, minimum meal frequency, minimum acceptable diet, women’s dietary diversity, and micronutrient supplementation among pregnant and postpartum women and infant and young children (less than five years).

With the exception of reported data on Guatemala (which comes from the 2008-09 Encuesta Nacional de Salud Materno Infantil (ENSMI), a Regional Health Survey), the study summarizes data from the results of Demographic and Health Surveys (DHS) providing population level estimates of key nutrition indicators and carried out between 2003 and 2009 in 35 countries in Sub-Saharan Africa, South/Southeast Asia, Latin America, and the Caribbean. The majority of these countries are among those identified in the 2008 Lancet Series on Maternal and Child Nutrition as having the greatest burden of undernutrition. All the data presented in this document were re-run for comparative purposes and thus some numbers in the report might not be an exact match with the DHS final country reports.

A2Z: The USAID Micronutrient and Child Blindness Project Releases Five New Publications Designed to Support Food Fortification Efforts in the West Bank

**A2Z:** The USAID Micronutrient and Child Blindness Project consolidates, builds, and expands on USAID’s long-term investment in micronutrients, child survival, and nutrition. Food fortification is viewed by A2Z as an important strategy in achieving its goal and focus countries have included Bangladesh, Cambodia, the ECSA region, India, Nepal, Philippines, Tanzania, Uganda and the West Bank. A2Z have provided technical assistance to the Palestinian Authority in order to increase the provision of essential micronutrients in the Palestinian diet, thereby reducing the risk of micronutrient deficiencies in the West Bank.

In line with this, it recently released five publications focused on the West Bank:

- Determining the Dietary Patterns and Biochemical Markers among Women and Children in Hebron and Gaza City
- The Demand for Locally Manufactured Complementary Food Products among Palestinian Caregivers
- Manual of Methods for Determining Micronutrients in Fortified Foods
- Inspection Manual for Monitoring Salt and Flour Fortification
- Analysis of Inspection Results from Salt and Wheat Flour Samples

All five publications are available at [http://a2zproject.org/node/89](http://a2zproject.org/node/89)

WHO Launch a Set of Recommendations on the Marketing of Food and Non-Alcoholic Beverages to Children

According to the WHO, non-communicable diseases (NCDs) represent a leading threat to human health and socioeconomic development. Eighty percent of NCD deaths occur in low- and middle income countries. And, while deaths from NCDs primarily occur in adulthood, the risks associated with an unhealthy diet begin in childhood and build up throughout life.

“The already heavy burden caused by NCDs, along with the fact that the majority of these deaths are premature and could be averted, provide a strong public health and policy imperative to act,” states Dr Ala Alwan, the Assistant Director-General Non-communicable Diseases and Mental Health of the WHO, in the foreword to a new WHO publication entitled “Set of recommendations on the marketing of food and non-alcoholic beverages to children.”
This review by Aamer Imdat and coworkers includes 43 randomized trials representing 215,633 children and shows that giving vitamin A capsules to children aged six months to five years can reduce death and some diseases. The results of 17 of the studies have been summarized and indicate that vitamin A reduces the overall risk of death by 24%. Death due to measles, respiratory infections or meningitis was not specifically reduced, but vitamin A could reduce new occurrences of diarrhea and measles. When people took very large doses of vitamin A, they were more likely to vomit within two days.

In the author’s opinion, given the evidence that vitamin A supplementation (VAS) causes a considerable reduction in child mortality, further placebo-controlled trials of VAS in children between six months and five years of age are not required. There is, however, a need for further studies that compare different doses and delivery mechanisms (for example, fortification). In addition, as the effects of VAS on relevant pathogens and disease pathways are not well understood, these could be further researched, together with the elucidation of the relationship (if any) between vitamin A and growth.

The reviewers also give implications for practice, given that national and regional programs of VAS are in place in over 70 countries worldwide and may be among the most cost-effective public health interventions. As more than 190 million children are vitamin A deficient around the globe, a reduction in their risk of mortality by 24% could save almost 1 million lives a year. These interventions respond to an immediate need for adequate nutrition; however, they are not ideal long-term solutions to the underlying problem. Fortification, food distribution programs and horticultural developments may provide more permanent relief.

Furthermore, if vitamin A reduces mortality by preventing measles, widespread vaccination will reduce the relative contribution of vitamin A supplementation. Until such long-term solutions are in place, supplementation should continue. The researchers also recommend that, as access to vitamin A increases, it will be important to continue to identify at-risk groups and deliver supplements to them. They strongly recommend vitamin A supplementation to children under five in areas at risk of VAD. The exact nature of how these programs should be structured and administered – the dose, frequency, and duration of intervention – is less certain. The researchers also suggest that VAS for pregnant and lactating mothers and other efforts to promote the delivery of vitamin A (such as increased rates and duration of breastfeeding) may require further attention.

Finally, it is worth noting that two additional Cochrane reviews recently investigated the effects of vitamin A during the neonatal period (infants aged one to six months) and will be available shortly.

For the full review, go to http://onlinelibrary.wiley.com/o/cochrane/clsysrev/articles CD008524/frame.html

The recommendations can be accessed in a number of languages from www.who.int/dietphysicalactivity/publications/recsmarketing/en/
Cochrane Collaboration Joins the World Health Assembly

The Cochrane Collaboration was recently accepted as a Non-Governmental Organization in Official Relations with the World Health Organization (WHO). In formalizing the relationship with the WHO, the Collaboration has been awarded a seat as an observer at the World Health Assembly, allowing the Cochrane Collaboration to provide input on WHO health resolutions and formalizing the communications between the two bodies.

The partnership will allow the Cochrane Collaboration to significantly influence the way research evidence is created and used by the WHO, by improving the collection of reliable health information and promoting intersectoral collaboration and high-quality research to produce the necessary evidence to ensure policies in all sectors contribute to improving health and health equity.

Current plans for continued partnership between the Cochrane Collaboration and the World Health Organization include the development of the WHO e-Library of Evidence for Nutrition Actions (eLENA). Cochrane contributors have identified relevant Cochrane Reviews and are updating or conducting new Cochrane Reviews in response to the WHO’s priorities. This process will facilitate the development of sound, evidence-informed guidelines on nutrition issues relevant to WHO Member States and other partners.

For more information on the Cochrane Collaboration, visit www.cochrane.org

DSM Joins New York Academy of Sciences’ Nutrition Council

DSM, of which Sight and Life is the humanitarian initiative, officially joined the Leadership Council of the New York Academy of Sciences’ Global Nutrition Science Research Initiative during the Academy’s gala dinner. DSM is the only food ingredient company to be among the more than 20 organizations coming from government, academia and the non-profit and private sectors that comprise the Council.

This landmark move will bring together the best scientific research and development competences available on nutrition to address global hidden hunger in rich and poor countries alike. In collaboration with the World Health Organization, this initiative will shape the global nutrition science research agenda and facilitate a multi-sector action plan. The objective is for this body of research to be used to help donor countries, development organizations, and governments to design and implement more effective nutrition programs.

“I am excited and honored to be part of such an ambitious and one-of-a-kind initiative and [to have] the opportunity to work with such a prestigious group of experts,” commented
CeSSIAM began in Guatemala as a non-profit organization dedicated to nutrition research and education and has as its mission the improvement of human health and well-being in underprivileged societies through better nutrition. It works in partnership with the Hildegard-Grunow-Foundation for Nutrition Research (HGF) and the Nevin Scrimshaw International Nutrition Foundation (INF). The current Executive and Scientific Director is Dr Noel Solomons, who was awarded the National Science and Technology Medal for 2010 in recognition of his scientific research in the area of nutrition, and its significant contribution to health in Guatemala. His research has also had a significant impact on child nutrition policies at both national and international levels. *Sight and Life* has had a long relationship with CeSSIAM and presented Dr Solomons with a certificate to mark its 25th Anniversary at a celebration at the World Public Health Nutrition Congress in Porto in October 2010.

To find out more about CeSSIAM, visit www.hgrunowfoundation.org/cessiam
Guatemala’s Medal of Science and Technology is awarded to CeSSIAM’s Dr Noel Solomons

At their fourth regular meeting in 2010, the National Council of Science and Technology of Guatemala (CONCYT) reviewed the proposals for the 2010 competition for the award of the Medal of Science and Technology, or “Medalla de la Ciencia y Tecnología.” The medal is the highest annual recognition at a national level for a scientist who has made a transcending social impact.

The Guatemalan Academy of Medical, Physical and Natural Sciences submitted a proposal for the award to go to Dr Noel W Solomons of the Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM). As a result, CONCYT decided to name Dr Solomons as the winner of this award, on the basis of his contribution to nutrition research in Guatemala.

The medal was presented at a ceremony held in conjunction with the Congress by Dr Rafael Espada, Vice President of the Republic of Guatemala.

International Year of Chemistry: Vitamin C Molecule on Swiss Stamp

2011 having been declared by the United Nations to be “International Year of Chemistry”, the Swiss Post has released a special issue stamp that features a vitamin C molecule. Synthetic vitamin C was first developed by Tadeus Reichstein in 1933 at the Swiss Federal Institute of Technology (ETH) Zurich.
Advocating better nutrition for brighter futures.
Comments on the Comparison of the Effects of Organic and Conventional Food on Health in *Sight And Life* 2/2010

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We read the article on Organic vs Conventional Food in *Sight And Life Magazine* 2/2010 with interest. It states that the nutritional quality of organic food is not different from conventional food, and that there is no evidence of any difference that might have an impact on health. At a certain point, the argument veers to the subject of epidemiological studies that show that a diet high in fruit and vegetables reduces mortality from cardiovascular diseases, but there is scant evidence on the effects of cancer. We have no reservations about the health advantages of recommended levels of fruits and vegetables. However, the comparison of conventional and organic food impact on health appears to require further revision.

**What is conventional food?**

We understand the term “conventional food” to mean the foodstuffs that are produced by intensive agricultural systems where considerably improved technology, particularly in the form of agrochemicals, is applied to enhance productivity. However, a marked level of uncertainty about health risk still attaches to this sort of conventional food.

When conventional food is compared with organic food, nutrient composition is not a major concern with regard to health risks. Indeed, varying foodstuffs are different in terms of their composition, which is why diverse sources of nutrients are used to balance a healthy diet. No foodstuff is complete on its own, and diversity and complementarities are the order of nutrition.

The major health concern about conventional food is its contamination with agrochemicals, particularly those related to pesticides, hormones and antibiotics. A large number of studies reveal that people consuming a conventional diet are more exposed to pesticide residues than those who consume an organic diet; some examples are cited below.

Recent studies in the US show that children fed organic diets had significantly lower exposure to organophosphorus pesticide than children with primarily conventional diets. The median total methyl metabolite concentration in their urine was about six times higher for those children on a conventional diet than it was for children on organic diets (0.7 vs 0.03 μmol/L; P=0.003), and mean concentration differed by a factor of nine (0.34 vs 0.04 μmol/L). At present, the pesticides that are most commonly and widely used are organophosphate pesticides. They are normally eliminated from the body after three to six days, and the detection of this compound indicates continuing exposure.

Assessments conducted on more than 90,000 samples of 20 major crops, grown organically or conventionally, indicated that the frequencies of residue detection and residue levels were considerably higher in conventional than in organic foods. Conventional food contained pesticide residues in more than 75% of the cases. Not all of the organic foods were, however, totally free from pesticide residue. They were also adulterated, but to a markedly lesser extent and frequency than conventional food. Most of the residues in organic foods are explained as the unavoidable results of environmental contamination by post-pesticide use, or drift (sprays blown in from adjacent, non-organic farms).
Pesticide exposure around the world

Human beings can be exposed to pesticides in a variety of ways, at different dose levels, and for varying periods of time. In the developed world, the problem of acute pesticide poisoning has largely been controlled; major health problems arise from exposure to low levels of pesticide residues in food over a long period of time. In developing countries, however, the main health problem arising from pesticides is that due to acute poisoning. A minimum of 25 million agricultural workers in developing countries suffer an episode of pesticide poisoning each year. It has become evident in the last few years that acute pesticide poisoning is mainly the concern of the developing world, which lacks appropriate protection and management mechanisms due to low levels of awareness and inadequate infrastructures.

Exposure to pesticides can potentially affect human health. Controlled studies on animals indicate substantial toxicological evidence showing that repeated low-level exposure to organophosphate pesticides affects neural development and growth in developing animals. Some of these studies indicate the impairment of maze performance, locomotion and balance in neonates exposed in the uterus and early in postnatal life. Possible mechanisms leading to these effects include inhibition of brain acetylcholinesterase, down-regulation of muscarinic receptors, decreased brain DNA synthesis, and reduced brain weight. It is also possible that exposure to organophosphate pesticides relates to respiratory diseases in children through improper regulation of the autonomic nervous system.

Studies of the effects of pesticide exposure on children's health have been limited to birth defects. Several case-control studies have associated parental exposure to pesticides or pesticide use in the home with childhood brain tumors, leukemia, lymphomas, and testicular cancer.

A small number of ecological studies have examined whether the low-level chronic exposure of children to pesticides can lead to adverse health consequences. A study in Mexico found that children of four to five years of age living in an agricultural valley with presumably higher pesticide exposure had deficits when tested for stamina, coordination, and recall, as compared to children living in the foothills where there was mainly ranching.

Advantages of organic food over conventional food

In general it can be said that, despite the paucity of information concerning the potential health effects in children of chronic, low-level exposure to pesticides, substantial evidence from rodents and limited information from adult humans shows that chronic, low-level exposure to pesticides may affect neurological functions, neurodevelopment, and growth. The preference for organic food over conventional food appears advantageous in view of the lower exposure to insecticide residues and minimizing health risks.

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References


“Chronic, low-level exposure to pesticides may affect neurological functions, neurodevelopment, and growth”
More than a decade has passed since the first edition of Folate in Health and Disease was published. During this time, there have been thousands of new research studies related to folate and its link to disease and birth defect risk, thus providing the impetus for an updated interpretation of this large body of scientific evidence. The public health implications of these new findings are enormous; therefore, the second edition bridges basic science with clinical medicine and public health.

The first chapters provide background knowledge related to folate chemistry, metabolism, bioavailability, and the influence of genetic polymorphisms. Folate’s role in reproduction and birth defect prevention is then reviewed, followed by a separate chapter in which epidemiological evidence linking specific birth defects and folate status is evaluated. Chronic disease is covered in a similar manner to that of birth defects. The interrelationships between folate and other nutrients required for normal one-carbon metabolism are then covered in several chapters, and the biochemical and clinical ramifications of alterations in status are highlighted. The interaction between folate and vitamin B₁₂ is addressed from a biochemical and public health perspective. The complexities of diagnosis and treatment of a clinical folate deficiency are discussed, followed by a related chapter on the effect of alcohol on folate and methionine metabolism. Choline is covered in a separate chapter.

Dietary intake recommendations for select countries worldwide are compared with an overview of the approaches used by the Institute of Medicine’s committee to estimate the Dietary Reference Intakes. Changes in folate status over time within the US population are a focus of this chapter, with attention given to the influence of folic acid fortification and supplement use on folate status. Estimated dietary folate intakes for the US population and specific population subgroups are presented.

For more information, please visit http://www.routledge.com/books/details/9781420071245/
Carotenoids
A Colorful and Timely Research Field

Because carotenoids are widely consumed and their consumption is a modifiable health behavior (via diets or supplements), health benefits for chronic disease prevention, if real, could be very significant for public health.

This book spans the breadth of ongoing work by researchers around the world, ranging from basic studies to advanced applied biomedical research. As in many fields of research, new tools and techniques for measuring carotenoids in various systems are critical to support research progress. Several chapters discuss new methodologies to measure carotenoids, carotenoid metabolites/radicals, or carotenoids in vivo in complex biological systems, especially in the human eye. Other chapters describe the oxygenase enzymes that are essential components of carotenoid metabolism to active metabolites.

**How carotenoids behave**
Carotenoids are highly lipophilic: an active area of research concerns how carotenoids interact with and affect membrane systems. Also, the lipid solubility of these compounds has important implications for carotenoid intestinal absorption: models such as the Caco-2 cell model are being used to conduct detailed studies of carotenoid absorption/competition for absorption. The lipid solubility of these carotenoids also leads to the aggregation of carotenoids. Carotenoids aggregate both in natural and artificial systems, with implications for carotenoid excited states. This in turn has implications for a new indication for carotenoids, namely, serving as potential materials for harnessing solar energy.

In summary, the amazing breadth and depth of research in carotenoids are reasons why it draws investigators to this fascinating field of research. The research spans the continuum from detailed studies of the roles of photoprotective carotenoids in plants to the potential application in the prevention of disease in humans. This is translational research at its best and I commend the editor, Dr John Landrum, for assembling such an interesting and informative collection of current research.

Reviewed by
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Yale University School of Medicine

For more information, please visit  
http://www.routledge.com/books/details/9781420052305/
The physical and chemical properties of the omega-3 fatty acid DHA (docosahexaenoic acid) enable it to facilitate biochemical processes in the membrane. This effect has numerous benefits, including those involved in the growth of bacteria, rapid energy generation, human vision, brain impulse, and photosynthesis, to name but a few. However, DHA also carries risks that can lead to cellular death and disease. Omega-3 Fatty Acids and the DHA Principle explores the roles of omega-3 fatty acids in cellular membranes, ranging from human neurons and swimming sperm to deep sea bacteria, and develops a principle by which to assess their benefits and risks.

The DHA Principle states that the blending of lipids to form cellular membranes is evolutionarily honed to maximize benefit while minimizing risk, and that a complex blending code involving conformational dynamics, energy stress, energy yield, and chemical stability underlies all cellular membranes.

Understanding the code
This book lays the groundwork to understanding this code. It examines the evolution of DHA and the membrane, and explores the general properties of omega-3s and other membrane lipids. It then focuses on cellular biology before shifting to a practical discussion on applications. The authors discuss the DHA Principle as applied to petroleum degradation, winemaking, global warming, molecular farming, aging, neuro-degenerative diseases, and the prevention of colon cancer.

A reflection on the increased public interest to have emerged over the years, this volume uses an integrative approach to explain the complex roles of omega-3s in the membrane. Incorporating principles from chemistry, cellular biology, evolution, and ecology, this work gives researchers in a variety of fields the building blocks to stimulate further study.

For more information, please visit http://www.routledge.com/books/details/9781439812990/
Nutrition Books Available from TALC Valuable for Nutrition Practitioners and Trainers

TALC (Teaching Aids at Low Cost) is a unique charity providing and developing educational material which promotes the health of children and advanced medical knowledge and teaching in the UK and throughout the world.

The organization was founded in 1965 by David Morley when he was lecturer at the Institute of Child Health, in response to many requests from overseas students for teaching equipment to use in their own countries.

TALC believes good health provision should be available to all – especially those in the poorest communities in Africa, Asia, and Latin America – and has been working for over 40 years to achieve this. They currently supply over 10,000 health workers with health materials, ranging from text books and videos to CDs and weight charts.

Below is a list of nutrition books, CD-ROMs and accessories available from TALC, as recommended by Ann Burgess and Marko Kerac (* indicates the book is available in other languages besides English).

- Community Nutrition: a handbook for health and development workers; 2009 Burgess, Bijlsma & Ismael; £5.50.
- Infant and Young Child Feeding – model chapter for textbooks for medical students and allied health professionals; 2009 WHO; £1.30.
- Caring for Severely Malnourished Children; 2003 Ashworth & Burgess; £4.10 (also available at the same price as a PDF download).
- Sight And Life Manual on Vitamin A Deficiency Disorders (VADD); (2nd ed 2001) Sight And Life; £1 (*French, Spanish).
- The Politics of Breastfeeding (3rd edition); 2009 Palmer; £7.70.
- Protein-Energy Malnutrition; 2006 Waterlow; £7.50.
- Nutrition for Developing Countries (2nd edition); 1993 Savage King & Burgess; £12.00.
- Community Nutrition CD-ROM; TALC 2006. Free to health professionals who have limited access to the internet, Community Nutrition is a new CD-ROM containing hundreds of nutrition resources including manuals, training courses, academic papers, briefs, practical guidelines, pictures, presentations, and a video.
- Topics in International Health – Nutrition CD-ROM; 2000 Wellcome Trust; £5.00. Twelve interactive tutorials that provide an illustrated introduction to the causes, epidemiology, treatment, and prevention of malnutrition in developing countries.
- e-TALC Health Development CD-ROMs. The e-TALC project provides a reliable and regular source of free health information, aimed at healthcare workers in developing countries who have no or limited access to the internet. Small colored insertion tape (MUAC); 115mm; £0.25.
- Hemoglobin color scale; £24.00. A simple device for estimating hemoglobin, for use when laboratory hemoglobinometry is not available.

TALC is based in the UK. To order any of these items, visit http://www.talcuk.org/index.htm or e-mail info@talcuk.org or call +44 (0)1727 853869. Prices do not include postage.

If you know of any other recent, good value nutrition-related books that TALC might add to its catalogue, please let them know.
Sharing knowledge for improved nutrition.
Sight and Life Magazine
Incorporating the Xerophthalmia Club Bulletin

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