<table>
<thead>
<tr>
<th>CONTENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>5</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>6</td>
</tr>
<tr>
<td>Part one:</td>
<td>7</td>
</tr>
<tr>
<td>NUTRITION FROM THE GLOBAL VIEWPOINT</td>
<td></td>
</tr>
<tr>
<td>Part two:</td>
<td>37</td>
</tr>
<tr>
<td>EFFECT OF MALNUTRITION ON BRAIN GROWTH IN EARLY LIFE</td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td>63</td>
</tr>
</tbody>
</table>
INTRODUCTION

The pictures in this booklet were presented as an exhibit at the 13th International Congress of Paediatrics in Vienna, August 29 to September 4, 1971.

The exhibit comprised two parts:

- A general part, pointing out some nutritional problems for human beings on earth — today and tomorrow, and
- A scientific part, showing how malnutrition during the first years of life may influence the brain growth and size.

The exhibit attracted considerable attention. It was felt that its publication in booklet form, primarily for laymen, might serve as a challenge and food for further thought.

In this booklet the exhibit material is supplemented with some additional pictures and brief comments to make the presentation easier for the layman to follow.

The scientific part contains observations from a Brain Growth Study, carried out in co-operation with Dr Gunnar Engsner at the Ethiopian Nutrition Institute, Addis Ababa, Ethiopia. Preliminary results from this study have been published.1 Further results are forthcoming.

It should be noted that the scientific part deals only with the aspect of brain growth. The key problem — will severe malnutrition at an early age cause permanent interference with mental development — is not discussed. This problem is at present the subject of intense research at various centres around the world.

Iréne Sjögren, MD
Assistant Professor
Bo Vahlquist, MD
Professor
Department of Paediatrics, University Hospital
S–750 14 Uppsala, Sweden

October 1971

ACKNOWLEDGEMENTS

The authors want to express their gratitude to others who have made this presentation possible at the Ethiopian Nutrition Institute (ENI), the Ethio-Swedish Pediatric Clinic (ESPC) and the Lidetta MCH Clinic (Lidetta) in Addis Ababa, Ethiopia:

- Dr Bo Åkerrén, Director at ENI
- Dr Mehari Gebre-Medhin, Deputy Director at ENI
- Dr Demissie Habte, Deputy Director at ESPC
- Dr Ulla Larsson, former Head at Lidetta
- Professor Yngve Larsson, former Director at ESPC
- Professor Göran Sterky, Director at ESPC

as well as to the skillful and cooperative staff at the ENI, ESPC and Lidetta.

The exhibition and the research work behind it was made possible thanks to grants from the Margaretha Home Foundation, the Scandinavian Institute of African Studies, the Swedish International Development Authority, the Swedish Medical Research Council and the Wallenberg Foundation at the University of Uppsala, Sweden.
Part one:

NUTRITION FROM THE GLOBAL VIEWPOINT
It is estimated that the population of the world will double within 35 years, from about 3 1/2 to 7 thousand millions between 1965 and the year 2000.

The population of the developing (pre-industrial) countries will increase at a greater rate than in industrial and centrally-planned countries.

In about the year 2000, the number of human beings in pre-industrial countries will amount to 4 thousand millions, a population comparable to that of the whole world today.
<table>
<thead>
<tr>
<th>YEAR</th>
<th>INDUSTRIAL COUNTRIES</th>
<th>CENTRALLY PLANNED COUNTRIES</th>
<th>PRE-INDUSTRIAL COUNTRIES</th>
<th>NO. OF HUMAN BEINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AUSTRALIA, CANADA, EEC—COUNTRIES, ISRAEL, JAPAN,</td>
<td>CENTRALLY PLANNED COUNTRIES IN AFRICA,</td>
<td>AFRICA (EXCEPT SOUTH AFRICA),</td>
<td>7,000 millions</td>
</tr>
<tr>
<td></td>
<td>JUGOSLAVIA, NEW ZEALAND, NORTH AND SOUTH EUROPE,</td>
<td>SOVIET UNION AND EAST EUROPE, CHINA,</td>
<td>COUNTRIES IN ASIA AND FAR EAST (EXCEPT CHINA, NORTH KOREA, NORTH VIETNAM AND JAPAN), NEAR EAST (EXCEPT ISRAEL), CENTRAL AND SOUTH AMERICA.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SOUTH AFRICA, TURKEY, U.S.A.</td>
<td>NORTH KOREA AND NORTH VIETNAM.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>2,479 millions</td>
<td>1,068 millions</td>
<td></td>
<td>4,984 millions</td>
</tr>
<tr>
<td>1965</td>
<td>1,600 millions</td>
<td>928 million</td>
<td></td>
<td>3,355 millions</td>
</tr>
<tr>
<td>1950</td>
<td>1,128 millions</td>
<td>859 million</td>
<td></td>
<td>2,517 millions</td>
</tr>
<tr>
<td>1930</td>
<td>722 million</td>
<td>605 million</td>
<td></td>
<td>2,070 millions</td>
</tr>
<tr>
<td>1900</td>
<td>1,650 millions</td>
<td>1,128 million</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In industrial countries, the total food production has increased at a greater rate than has the population during the last two decades, resulting in successively more and more food per capita, and an increasing number of obese individuals.

References:
2. FAO: *The state of Food and Agriculture 1968*, p. 10.
THE DEVELOPMENT OF FOOD PRODUCTION IN INDUSTRIAL COUNTRIES

INDEX (mean for 1952/53 - 1956/57 = 100)

TOTAL FOOD PRODUCTION

POPULATION

FOOD PRODUCTION PER CAPITA

YEAR

1950/51  1955/56  1960/61  1965/66
The total food production in pre-industrial countries has also increased during the last two decades.

But meanwhile, the population in these countries has grown greatly, with the result that the food production per capita has not kept step.

Further, per capita figures do not reflect the very wide variations within a population — even within families — with children and other vulnerable groups being affected more than others.

References:
2. FAO: *The state of Food and Agriculture 1968*, p. 10.
THE DEVELOPMENT OF FOOD PRODUCTION IN PRE-INDUSTRIAL COUNTRIES

INDEX (mean for 1952/53 - 1956/57 = 100)

- TOTAL FOOD PRODUCTION
- POPULATION
- FOOD PRODUCTION PER CAPITA

YEAR

1950/51  1955/56  1960/61  1965/66
Sweden, which is situated in northern Europe, and Ethiopia, situated in East Africa are here taken as examples of an industrial and a pre-industrial country.
Both the total land area of Ethiopia and the total population are about three times larger than in Sweden. Consequently, the population density is roughly the same in the two countries.

Some 50\(^1\) per cent of the population in Ethiopia, but only 21 per cent of that in Sweden, are children below 15 years of age.

The birth rate in Sweden today is very low, 15 per 1000. 200 years ago it was comparable in magnitude (34) with that in Ethiopia today (40).\(^2\)

The mortality rate of children during their first year of life, is 13 per 1000 live births, or 1.3%, in Sweden today. 200 years ago it was, however, 216 per 1000, or around 20% which is a figure slightly higher than that found in Ethiopia today.\(^2\)

References:
1. Estimated figure.
3. *Statistical Abstract of Sweden* (all other figures than those indicated with "1" or "2").
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>SWEDEN</th>
<th>ETHIOPIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>YEAR</td>
<td>1970</td>
<td>1770</td>
</tr>
<tr>
<td>AREA, IN 1000 SQ. KM.</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>POPULATION, MILLIONS</td>
<td>8.1</td>
<td>2.0</td>
</tr>
<tr>
<td>POPULATION, PER SQ. KM.</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td>PER CENT OF TOTAL POPULATION UNDER 15 YEARS OF AGE</td>
<td>21</td>
<td>50(^1)</td>
</tr>
<tr>
<td>LIVE BIRTHS PER 1000 POPULATION</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td>INFANT MORTALITY, PER 1000 LIVE BIRTHS</td>
<td>13</td>
<td>216</td>
</tr>
</tbody>
</table>

References: 1. Estimated figure  
In order to maintain normal growth and development, the young child requires proportionately more nutrition than the adult.

A baby 1/2 — 1 year old needs roughly twice as much energy, protein\(^1\) and Vitamin A, per kilogram of body weight, as does an adult male, and 6 times as much calcium and vitamin D, and more than 10 times as much iron.

Human milk contains all the nutrients needed for normal growth and development during the first 6 months of life.

Reference:


Only the values for kcal and protein are in the reference given per kilogram of body weight, other values presented in the figure are calculated from "recommended dietary allowance" by the authors.

\(^1\)Protein equivalent to human milk.
THE YOUNG CHILD HAS A MUCH HIGHER NEED OF NUTRIENTS, CALCULATED PER KILOGRAM OF BODY WEIGHT, THAN THE ADULT. Need per kilogram of body weight in an adult male (18–22 years, weight 67 kg) and a young child (½ – 1 year, weight 9 kg) of

| ENERGY, kcal | 42 | 100 |
| PROTEIN, gram | 0.9 | 1.8 |
| CALCIUM, mg | 12 | 70 |
| IRON, mg | 0.15 | 1.7 |
| VITAMIN A, I.U. | 75 | 170 |
| VITAMIN D, I.U. | 6 | 45 |
Thus the baby will follow "the road of healthy growth" during the first 6 months of life when reared on breast milk alone, in satisfactory quantity.

Later on, during the weaning period, continued progress on "the road of healthy growth" is possible only by supplementing breast milk with other suitable food of animal and vegetable origin providing additional sources of protein, minerals and vitamins.

If the baby in weaning is not adequately supplied with additional nutrients, it will not gain in weight and height as it should, and will be forced to take "the road of PCM", "PCM" being the abbreviation of "Protein and Calorie Malnutrition".

A malnourished child is much more sensitive to infections than a normal child, and its growth will be retarded even more by infections.

In this way a "vicious circle" is formed which eventually may lead to serious illness and death.

Reference:
INADEQUATE FOOD AND FREQUENT INFECTIONS ARE THE IMMEDIATE REASONS WHY SO MANY CHILDREN DEVIATE TO "THE ROAD OF PCM" (PROTEIN AND CALORIE MALNUTRITION).

Normal progress with breast feeding up to 6 months

ROAD OF HEALTHY GROWTH
80% of standard

ROAD OF PCM
Inadequate protein in supplement and weaning food

The weaning period

AGE in years
There are two different types of protein-calorie malnutrition: marasmus and kwashiorkor.

There also exist intermediary forms of the two: marasmic kwashiorkor.

MARASMUS

Age predilection: 0–2 years

Signs always present:
• Extreme growth failure — weight and height

Signs occasionally present:
• Various signs of vitamin and/or mineral deficiency
• Infections — especially gastroenteritis

Causation:
• Starvation — infections
KWASHIORKOR

Age predilection: 1–3 years

Signs always present:
- oedema
- growth failure (weight more than height)
- psychological disorder (apathy, anorexia)
- weak, wasted muscles

Signs usually present:
- hair changes – dyspigmented, thin, easily plucked hair
- skin changes – dyspigmentation, flaky paint rash
- anaemia
- loose stools

Signs occasionally present:
- enlarged liver
- various signs of vitamin and/or mineral deficiency
- infections

Causation:
- unbalanced diet, low in protein, high in carbohydrates
- infections
- maternal deprivation
Ethio - Swedish cooperation in the field of health

Ethiopia and Sweden cooperate in many different activities in the field of health. With respect to Swedish governmental support in the field of child health, the following activities deserve special mention:

- the Ethio-Swedish Pediatric Clinic (ESPC)
- the Ethiopian Nutrition Institute (ENI)
- health programmes in different, mainly rural areas
I. ETHIO-SWEDISH PEDIATRIC CLINIC (ESPC)

Founded in 1957, extended in 1967/1968, located at the Princess Tsahai Hospital, under the administration of the Ministry of Public Health.

Functions as the Pediatric Department (70 beds) of the Haile Selassie I Faculty of Medicine.

Hospital and allied activities:
- inpatients: 1,700 (1969)
- outpatients: 102,000 (1969)
- rehabilitation clinic
- mobile immunization team

Educational activities:
- twenty undergraduate students per year
- postgraduate training

Director: Professor Göran Sterky
Deputy Director: Dr Demissie Habte

Finances: mainly contributed by the Ethiopian Government
II. ETHIOPIAN NUTRITION INSTITUTE (ENI)

This institute was formed under the name of Children's Nutrition Unit (CNU) in 1962, located at the Princess Tsahai Hospital, side by side with ESPC, under the administration of the Ministry of Public Health.

Functions:
- public health activities in the field of nutrition
- educational programmes
- production of a protein rich weaning food, Faffa
- research in nutrition

Director: Dr Bo Åkerrén
Deputy Director: Dr Mehari Gebre-Medhin
4 non-Ethiopian experts, 10 Ethiopian graduates, skilled and non-skilled staff

Finances:
Routine administrative and hospital care expenses paid by the Ethiopian Government.
Research supported by the Swedish International Development Authority (SIDA) and special funds.
III. COOPERATION IN THE IMPLEMENTATION
OF HEALTH PROGRAMMES IN DIFFERENT PROVINCES

Support to provincial medical officer organization and basic health services in the provinces of Wollega and Illubabor.

IV. VARIOUS OTHER ACTIVITIES

Cooperation — directly or indirectly — in preventive and curative health programmes in Addis Ababa and other parts of Ethiopia.
A protein-rich weaning food named FAFFA is produced at the Ethiopian Nutrition Institute (see page 28-29).

In 1970, 350,000 kilograms were produced and distributed within Addis Ababa and the provinces of Kefa, Arussi, Harar, and Eritrea.
4.4: FAFFA IS AN AMHARIC WORD WHICH MEANS "TO GROW STRONG AND HEALTHY"
Base components of Fatta (Sm 20)

Wheat 57%  Sugar + iod. salt 10%
Chick peas 10%  Vitamins – Rec. allow.
Soy flour (defatted) 18%  Minerals – Ca and Fe added
Dried skim milk 5%

FAFFA POWDER: Chemical Composition per 100 grams*

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>340</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>64.5 g</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.84 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.61 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>9.8 mg</td>
</tr>
<tr>
<td>Ash</td>
<td>4.1 g</td>
</tr>
<tr>
<td>Fat</td>
<td>2.2 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>300 mg</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.84 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.61 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>9.8 mg</td>
</tr>
<tr>
<td>Ash</td>
<td>4.1 g</td>
</tr>
<tr>
<td>Fat</td>
<td>2.2 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>300 mg</td>
</tr>
</tbody>
</table>

FAFFA PORRIDGE: Calculated Chemical Composition per 100 grams

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>68</td>
</tr>
<tr>
<td>Fat</td>
<td>0.44 g</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>12.9 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>60 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>3 mg</td>
</tr>
</tbody>
</table>

FAFFA POWDER: Amino Acid Composition*

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>mg/g total nitrogen</th>
<th>g/100 g FAFFA powder</th>
<th>mg/g total nitrogen</th>
<th>g/100 g FAFFA powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>257</td>
<td>0.89</td>
<td>Arginine</td>
<td>439</td>
</tr>
<tr>
<td>Leucine</td>
<td>565</td>
<td>1.93</td>
<td>Histidine</td>
<td>157</td>
</tr>
<tr>
<td>Lysine</td>
<td>319</td>
<td>1.11</td>
<td>Alanine</td>
<td>233</td>
</tr>
<tr>
<td>Methionine</td>
<td>100</td>
<td>0.35</td>
<td>Aspartic acid</td>
<td>531</td>
</tr>
<tr>
<td>Cystine</td>
<td>142</td>
<td>0.48</td>
<td>Glutamic acid</td>
<td>1391</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>305</td>
<td>1.06</td>
<td>Glycine</td>
<td>243</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>217</td>
<td>0.75</td>
<td>Proline</td>
<td>429</td>
</tr>
<tr>
<td>Threonine</td>
<td>233</td>
<td>0.80</td>
<td>Serine</td>
<td>368</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>50</td>
<td>0.18</td>
<td>Amid-NH₂</td>
<td>136</td>
</tr>
<tr>
<td>Valine</td>
<td>281</td>
<td>0.98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average values of two analyses on moisture-free materials with total amounts of amino acids in milligrams being 6750 and 6148 respectively, due mainly to a difference in sums of essential amino acids. Amino acid content per 100 g FAFFA calculated on a powder containing 8% moisture.

Chemical Score calculated on basis of A/T (Mitchell) = 50 (tryptophan). Second limiting amino acids are valine and isoleucine with a score of 62. For methionine + cystine the score is 70.

Chemical Score calculated on the basis of A/E (FAO/WHO Expert group) = 65 (tryptophan). Second limiting amino acids are isoleucine and valine with scores of 81. As reference whole dried hen’s egg protein was used.

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PER*</td>
<td></td>
</tr>
<tr>
<td>FAFFA</td>
<td>2.83</td>
</tr>
<tr>
<td>Casein</td>
<td>3.34</td>
</tr>
<tr>
<td>Casein + methionine</td>
<td>4.20</td>
</tr>
<tr>
<td>FAFFA</td>
<td>50.6</td>
</tr>
<tr>
<td>Casein</td>
<td>57.4</td>
</tr>
<tr>
<td>Casein + methionine</td>
<td>77.2</td>
</tr>
</tbody>
</table>

Average values of three analyses. Experimental time three weeks.

* Analyses performed at the Institute of Medical Chemistry, University of Uppsala, Sweden.

34
CONCLUSIONS  PART ONE

- The population of the world will double within 35 years.

- This will mean a rapidly increasing demand for more food.

- In order to maintain normal growth and development, the young child requires proportionately more nutrition than the adult.

- Health (nutrition) education programmes and the launching of low cost protein rich food are essential for normal development of the young generation.
Resumé

As the result of the population explosion, the population of the world will double in 35 years.

The explosion will be felt most in the developing countries, and considerably worsen the grave problems they now already have.

This will mean a rapidly increasing demand for more food.

Unless extraordinary measures are taken to correct the present trends, already existing serious problems of unequal distribution within societies, within communities and within families will become even more accentuated.

The special needs of the vulnerable groups — children, pregnant and lactating women — must be met. Health (nutrition) education programmes and the launching of low cost protein rich food are essential for this purpose.

The SIDA supported Ethiopian Nutrition Institute has carried out programmes of this nature.
Part two:

EFFECT OF MALNUTRITION ON BRAIN GROWTH IN EARLY LIFE
It is now realized that early malnutrition may have an irreversibly detrimental effect on the child.

Recent observations, furthermore, have established that the development of the brain may also suffer. To what extent early malnutrition influences the intellectual functions is still unknown.
BACKGROUND

"It is unfortunate that we are restricted in the field of human nutrition to indirect measurements of the brain size"

GROSS ANATOMY

BRAIN WEIGHT: Reduced
HEAD CIRCUMFERENCE: Reduced
TRANSILLUMINATION: Increased
Measurements of the brain size through:

- HEAD CIRCUMFERENCE
- TRANSILLUMINATION
- ECHOENCEPHALOGRAPHY

MICROANATOMY AND BIOCHEMISTRY

CELL CONTENT: Reduced (DNA Analysis)
LIPID CONTENT: Selective reduction

PSYCHOLOGY:

Intellectual development Retarded

References:

Dobbing, J., in Malnutrition, Learning and Behaviour, 1968. Ed. by Scrimshaw, N.S. and Gordon, J.E.


Present Study.


The brain lies protected in a cavity formed by the skull. Between the skull and the surface of the brain is a thin layer of fluid. In the center of the brain are small fluid-filled cavities ("ventricles"). Normally the width of the two large ("lateral") ventricles should not exceed one third¹ of the diameter of the skull.

Reference:

SCHEMATIC FIGURE OF A CHILD'S HEAD

THE BRAIN (BLACK)

AND FLUID-FILLED SPACES (WHITE)

IN THE CENTRE OF THE BRAIN ("VENTRICLES")

AND BETWEEN THE BRAIN

AND THE SKULL (DOTTED)
Method

In the study we made, the children were carefully examined with respect to their neuro-physiological development, height, weight and head circumference. The size of the fluid filled cavities (ventricles) in the brain was measured using ultra sonic echo, a type of radar technique called echoencephalography, a harmless and quickly performed method of examination.¹

The thickness of the layer of fluid between the skull and the brain was measured by a transillumination method² using a small 25 watt flash-light in a completely darkened room.

References:

   Part one: Some physical aspects of ultrasound.
   Part two: Method and methodological difficulties.
SCHEMATIC FIGURE OF THE INSTRUMENTS FOR MEASURING THE SIZE OF

- A CHILD’S HEAD
- THE LATERAL VENTRICLES
- THE LAYER OF FLUID BETWEEN THE SKULL AND THE BRAIN

<table>
<thead>
<tr>
<th>INSTRUMENT</th>
<th>MEASUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEASURING-TAPE</td>
<td>HEAD CIRCUMFERENCE</td>
</tr>
<tr>
<td>ECHO-ENCEPHALOGRAPH</td>
<td>FLUID-FILLED CAVITIES (VENTRICLES)</td>
</tr>
<tr>
<td>OSCILLOSCOPE</td>
<td>IN THE BRAIN</td>
</tr>
<tr>
<td>TRANSILLUMINATION LAMP</td>
<td>LAYER OF FLUID BETWEEN THE BRAIN AND SKULL</td>
</tr>
</tbody>
</table>
Echoencephalography

APPARATUS

For the echoencephalographic examinations, a Siemens echoencephalograph (Kraut-Krämer System), modified by Elema-Schönander, Solna, Sweden, was used.

For the examination of infants, probes of 4 mc/sec and 10 mm diameter were used, and for older children those of 2 mc/sec and 24 mm diameter. Liquid paraffin was used as a contact medium between the probe and the head.

MIDLINE CONTROL (MC)

The geometrical midline of the baby's head was defined ultrasonically by the transmission method, whereby ultrasound was transmitted by one probe and detected by another placed symmetrically on the opposite side of the head; the surfaces of the two probes were held parallel. The oscillogram at the midline control examination was photographed.

The midline control distance (D/2) multiplied by two corresponds to the diameter (D) of the baby's head.

ECHOENCEPHALOGRAPHIC EXAMINATIONS (DX AND SIN)

For the examination, the baby lay on its back with its nose pointing straight up towards the ceiling.

For recording the midline echo and the lateral ventricle echoes, the probe was held against the head about 2–4 cm above and slightly in front of the external auditory meatus. The echoencephalographic examination (Dx and Sin) was performed from two symmetrical points in the temporal region.

For recording echoes from the third ventricle, the probe was held slightly below and in front of the point from where the midline echo was recorded.

References:


Schematic pneumogram compared with enlarged patterns of a midline control (Mc), and echoencephalogram from the right (Dx) side of the head and an inverted echoencephalogram from the left (Sin) side.
A diagram was constructed in which two parallel vertical lines were drawn at a distance of the diameter (D), these lines symbolizing the right (1) and left (3) external contours of the baby’s head. Line 2 represents the geometrical midline of the head.

From the echoencephalograms (Dx and Sin) the distances from the initial complex to the midline echo, the distal lateral ventricle echo and the bottom echo were measured and marked in the diagram. The measurements from the right-sided echoencephalogram (Sin) were marked in from line 3 (symbolizing the left side of the head).

INDEX CALCULATION
After marking these in the diagram, a schematic picture of a tomogram (in the antero-posterior projection of the temporal region of the head) was seen where the marks for the echoes mentioned above indicated the position of the cerebral midline structures, the lateral wall of the lateral ventricles and the superficial structures (skin, skull etc.), respectively.

The distance (T) between the two marks for the distal lateral ventricle echoes in the two echoencephalograms respectively was measured and expressed in relation to the diameter (D) as an index (I = T/D). This index multiplied by 100 gave the added widths of the ventricles as a percentage of the diameter of the head. The more dilated the lateral ventricles, the higher the values of the index.

Normally, the lateral ventricle index (II) should not exceed 0.33 or 33% of the diameter of the head in newborn babies.

References:
See page 40 and 44.
Figure illustrating an echoventriculogram (EVG) within the gray field — including a midline control (Mc) and echoencephalograms from the right (Dx) and left (Sin) side of the head, as well as the principles for diagram construction and index calculations.
Transillumination

APPARATUS

The transillumination lamp used was of the oculus type, with a small 25 watt lamp. Fixed to the rim held against the baby’s head was a black rubber adapter, to which was attached a circular scale plate of plexi-glass, 10 cm in diameter, in the centre of which was a hole, 3 cm in diameter. Outside the hole there were equidistant concentric circles 0.5 cm apart. The plate was divided into four quadrants, marked with a diminishing number of points from the periphery towards the centre: 5 points in the periphery, followed by 4, 3 and 2 points and 1 point close to the rim of the rubber adapter.

PROCEDURE

The examinations were performed in a totally darkened room where the examiner had adapted his eyes to the darkness for 3–5 minutes. As a routine, all babies were examined over the frontotemporal and parieto-occipital region on the right as well as the left side of the head. When the light halo was not circular, the findings were expressed as the mean value of the transillumination findings within the most and the least illuminated quadrant of the point scale.

Normal newborn babies transilluminate frontally up to scale point two or less, parieto-occipitally up to scale point one or less.

Transillumination lamp (type oculus, A) fixed to the black rubber rim (B) held against the baby’s head, with a circular scale plate (C) attached to the rim.

References:
Material

Three groups of Ethiopian infants and children, at ages between 2 weeks and 2 1/2 years old, were examined at the Ethio-Swedish Pediatric Clinic (ESPC), the Ethiopian Nutrition Institute (ENI) and/or at other preventive and curative health institutions within the Ethio-Swedish cooperation in the field of child health (see pages 26–31).

Of 75 children examined, 38 were “controls” i.e. healthy children from privileged families, 28 were marasmic patients (see pages 22–23) and 19 kwashiorkor patients (see pages 24–25), examined before any treatment was given.¹

The patients were examined several times after being treated with the protein rich weaning food Faffa (see pages 32–35), amongst other foods, and results from those studies² will be presented later.

References:
2. Engsner, G., Habte, D. and Sjögren, I.: To be published.
MATERIAL

A total of 75 Ethiopian infants and children aged 2 weeks to 29 months were examined:

Controls (38 children) apparently healthy and no history of malnutrition or severe disease; 19 were residents at an orphanage attached to the Ethiopian Nutrition Institute, and 19 were from privileged Ethiopian Families.

Marasmus (28 patients) attending either a special nutrition rehabilitation clinic run at the Lidetta MCH Centre or the Nutrition Rehabilitation Clinic run by the Ethio-Swedish Pediatric Clinic.

Kwashiorkor (19 patients) admitted to the Ethio-Swedish Pediatric Clinic, where the diagnosis of kwashiorkor was confirmed.

Transillumination examinations were performed on 20 normal newborn babies and 13 normal infants and children as well as on 10 marasmic and 10 kwashiorkor patients.

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>MATERIAL</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROLS</td>
<td></td>
<td>38</td>
</tr>
<tr>
<td>MARASMUS</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>KWASHIORKOR</td>
<td></td>
<td>19</td>
</tr>
</tbody>
</table>

Age in months

| 6 | 12 | 18 | 24 | 75 |
Results

WEIGHT

All the controls of less than 9 months of age showed normal weight progress similar to normal Swedish infants. Most of the controls of older ages weighed slightly less than normal Swedish infants and children.

Most of the marasmic and kwashiorkor patients weighed much below the normal weight for their age.
RESULTS

WEIGHT

CONTROLS:

In 17 out of 38 cases 2 sigma below normal for Swedish children.

MARASMUS:

In 27 out of 28 cases 2 sigma below normal.

KWASHIORKOR:

In 19 out of 19 cases 2 sigma below normal.
HEAD CIRCUMFERENCE
The head circumference in relation to age was quite normal in 35 out of 38 controls.

In 15 of the 28 marasmic patients and in 13 of the 19 kwashiorkor patients, the head circumference was too small in relation to other children of similar ages.
RESULTS

HEAD CIRCUMFERENCE

CONTROLs:
In 2 out of 38 cases more than 2 sigma below normal for age

MARASMUS:
In 15 out of 28 cases more than 2 sigma below normal for age

KWASHIORKOR:
In 13 out of 19 cases more than 2 sigma below normal for age

### HEAD CIRCUMFERENCE IN RELATION TO AGE

<table>
<thead>
<tr>
<th>Head circumference in cm</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in months</td>
<td>6</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Symbols**

- ○ NORMAL HEAD CIRCUMFERENCE according to O'Neill (1961) and Westropp-Barber (1956)
- □ ETHIOPIAN
- ○ CONTROLS
- ▲ MARASMUS
- □ KWASHIORKOR
FLUID FILLED CAVITIES WITHIN THE BRAIN

The fluid filled cavities (ventricles) within the brain, measured by echoencephalography, were of normal size in all the controls, and most of the marasmic patients.

There was a ventricular dilatation, however, in 17 out of 19 kwashiorkor patients.
RESULTS

ECHOENCEPHALOGRAPHY

○ CONTROLS:

The 38 controls showed no ventricular dilatation

▲ MARASMUS:

3 out of 28 patients showed slight increase in the lateral ventricle index

☐ KWASHIORKOR:

17 out of 19 patients showed an increased lateral ventricle index

<table>
<thead>
<tr>
<th>Lateral ventricle index</th>
<th>WIDTH OF LATERAL VENTRICLES IN RELATION TO AGE</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td><img src="image" alt="Graph showing width of lateral ventricles in relation to age" /></td>
<td>ETHIOPIAN ○ CONTROLS ▲ MARASMUS ■ KWASHIORKOR</td>
</tr>
</tbody>
</table>

NORMAL WIDTH OF LATERAL VENTRICLES IN SWEDISH CHILDREN measured by echoventriculography according to Sjögren (1968, 1970)
FLUID BETWEEN THE SKULL AND BRAIN

The thickness of the layer of fluid between the skull and the brain, measured by transillumination was quite normal in all but one of the 38 controls.

In 5 out of 10 marasmic patients examined, the thickness of the layer of fluid was somewhat greater than normal.

In all the 10 kwashiorkor patients examined, there was, however, an abnormally thick layer of fluid between the skull and brain.
RESULTS

TRANSILLUMINATION

CONTROLS:
In 1 out of 33 controls slightly increased fronto-temporally

MARASMUS:
In 5 out of 10 patients

KWASHIORKOR:
In 10 out of 10 patients moderately increased fronto-temporally parieto-occipitally (may partly be explained by decreased bone thickness)

TRANSILLUMINATION FINDINGS IN RELATION TO AGE

<table>
<thead>
<tr>
<th>SCALE POINT</th>
<th>NO.</th>
<th>FRONTO - TEMPORALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AGE IN MONTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCALE POINT</th>
<th>NO.</th>
<th>PARIETO OCCIPITALLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

59
Discussion

The results of the study presented in part two make it obvious that many babies who obtain an insufficient quantity of food or the wrong sort of food during early life (see pages 18–21), will not only show all the well-known signs of marasmus and kwashiorkor (see pages 22–25) but will also manifest various signs of retardation of brain growth. Further studies will elucidate to what extent the abnormalities observed are reversible or not. Obviously the observations made by other investigators and by us relative to nutritional brain damage make the prevention of widespread malnutrition among children in developing countries more urgent than ever.
CONCLUSIONS PART TWO

SEVERE PROTEIN — CALORIE MALNUTRITION IN EARLY LIFE AFFECTS THE BRAIN IN VARIOUS WAYS.

IN THIS STUDY IT HAS BEEN SHOWN THAT

- THE GROWTH OF HEAD CIRCUMFERENCE IS OFTEN RETARDED

- FLUID-FILLED SPACE ON THE SURFACE OF THE BRAIN IS OFTEN SLIGHTLY — MODERATELY INCREASED

- FLUID-FILLED CAVITIES OF THE BRAIN ARE OFTEN INCREASED IN KWASHIORKOR.
Resumé

The results of the study presented in part two make it obvious that babies suffering from severe protein-calorie malnutrition are retarded in brain growth.

It seems likely that retarded growth of this kind at an age when the child should normally be lively and exploring its body and surroundings may have lasting ill effects.

Whether or not mild-moderate protein-calorie malnutrition, which is much more common, has a similar though milder effect, is not yet known.
THE POPULATION EXPLOSION IS, IN MOST DEVELOPING COUNTRIES, A SINISTER REALITY.

THE POPULATION EXPLOSION INCURS A DEFINITE RISK THAT THE AVERAGE PER CAPITA INTAKE OF NUTRIENTS WILL LAG SUCCESSIVELY MORE AND MORE BEHIND MINIMAL NEEDS.

IT IS ALREADY A PRECARIOUS SITUATION FOR LARGE VULNERABLE GROUPS (CHILDREN, PREGNANT MOTHERS, DISURBANIZED FAMILIES). MANY CHILDREN DIE OF MALNUTRITION. AMONG THE SURVIVORS MANY WILL SUFFER FROM PERMANENT SEQUELAE.

THIS STUDY HAS SHOWN THAT IN MARASMUS, AND MORE ESPECIALLY IN KWASHIORKOR THE BRAIN MASS IS REDUCED TO AN EVEN GREATER EXTENT THAN IS INDICATED BY DIMINISHED HEAD CIRCUMFERENCE ALONE.

FURTHER STUDIES ARE NEEDED TO CLARIFY TO WHAT EXTENT THE DEFORMITIES ARE OR ARE NOT REVERSIBLE.