WHITE BLOOD

A HISTORY OF HUMAN MILK

How babies have been fed from antiquity
to modern times and why it matters

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A HISTORY OF HUMAN MILK

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For Marion, Robin and Camilla

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PREFACE

White Blood is a history of human milk. It tells the story of how babies have been fed from antiquity to modern times and why it matters. Feeding infants is a topic of intense concern to mothers and of great interest to public health professionals. 'Breast is Best' had been the consensus view throughout history but, through choice or necessity, other ways of feeding the newborn have been used. In the past, alternatives to mother's milk were a wet nurse or so-called 'dry nursing' or 'hand feeding', often with unsafe and unsuitable substitutes. Milk has been the life and death of babies, and their fortunes have often turned on whether they were fed naturally or artificially.

White Blood explores the ways in which the nature and properties of human milk have been conceived within the fluctuating frames of thought that characterised the historical periods of the past. From shifting scientific and social viewpoints, it charts the impact of changing practices of milk feeding on infant health, growth, welfare and survival. Starting in Ancient Greece and Rome, *White Blood* lets the voices of those concerned with the care of newborn infants, and those who followed them, speak across the centuries of how babies were, and should best be, nourished.

In the ancient world human milk was thought to be blood diverted from the womb to the breast, where it was whitened and vivified. In the Renaissance it was a soft, sweet, subtil (subtle) substance transmutable into flesh; with the Scientific Revolution it became a corpuscular liquid; in the Enlightenment it flowed from 'Nature's bountiful urn'; in the late eighteenth century it was formed of 'combustible, plastic and oily parts'; in the nineteenth century it was a chemical formula made up of carbohydrates, proteins and fats; and in modern times a biological fluid composed of macro- and micro-nutrients, trophic factors, immunoglobulins and living cells.

A vast amount has been written about human milk from multiple perspectives over the centuries, from the ancient works of Aristotle to the modern web pages of Wikipedia. My intention has been to be both selective and personal, as well as lucid and learned, in addressing a rich subject that defies neat and tidy classification. *White Blood* has its origin in my professional, scientific and clinical interests – paediatrics, nutrition and history. It is not a 'how to' book; it does not answer questions such as 'Is baby getting enough milk? When to wean? What to do about colic?', but it does put them in a historical perspective. With a chronological narrative, *White Blood* aims to be reflective and stimulating, written for the curious and thoughtful, whether or not she or he has been a donor or recipient of human milk.

Lawrence Trevelyan Weaver
2020

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Human Milk

MIRACULOUS FLUID

Human milk is the best food for babies and provides all the nutrients needed for about the first six months of life. It contains nutrients that serve the unique needs of the human infant, such as certain polyunsaturated fatty acids, particular milk proteins, and iron in a readily absorbable form. Human milk also contains immunological and bioactive substances, absent from commercial infant formulas, which confer protection from bacterial and viral infections and may aid gut adaptation and development of the newborn.

THUS SPAKE THE World Health Organization (WHO) at the beginning of the twenty-first century, expressing the consensus view that breastfeeding is the best way to feed newborn babies because of the superiority of human milk over all other alternatives. These words were composed by me and three colleagues when we were invited to produce 'guidelines for the WHO European Region on the Feeding and Nutrition of Infants and Young Children' in 2000. There is nothing new about this message, which has been articulated many times before, in different words, by diverse voices, in distant eras, and it is now supported by a massive body of evidence derived from scientific research, clinical trials and population surveys.

Human milk contains all that the baby needs to develop and thrive during early life. Studies of infants that have been exclusively breastfed by healthy mothers show that from whatever country, continent or culture they come from they have the potential to grow at identical rates. It is the sole and sufficient source of nutrition until about six months, when complementary foods are required in addition to mother's milk. The opening statement above represents how we think about human milk now, and is the starting point for an account of how babies have been fed from antiquity to the modern day, and why it matters. Four themes run through this book, as threads binding its chapters together.

The first theme is the *vitality* of human milk, which is the lifeblood of the newborn baby. Just as blood courses through the body carrying everything it needs to flourish, so milk bears from mother to baby all that the infant requires to be nourished and survive. Human milk is a 'vital fluid' in two senses of the word. It bridges the gap between the blood-borne nutrition of the fetus in the womb and the solid diet to which the baby becomes accustomed when weaned. In the absence of safe alternatives, human milk can greatly reduce the risk of premature death in infancy.

The second theme is *transformation* or *transmutation*, the processes by which human milk has its miraculous effects: how it is produced (lactogenesis and lactation) and what happens to it when it reaches the baby (digestion, absorption and metabolism). Mother's breasts and baby's guts, the origin and destination of human milk, the pathway of nutrients from mother to young after birth, operate together in a way akin to the placenta and uterus before birth. The nutrition, metabolism, growth and development of the newborn depend on their coordinated function.

The third theme is *reproduction and nutrition*, which are the essential tasks that all living creatures must accomplish if they are to thrive and perpetuate themselves. For mammals, including humans, milk plays a critical role in both, serving dual purposes. As a unique biological fluid, human milk contains a perfect blend of nutrients and a vast array of other substances that together nourish and protect the newborn. It also helps them to adapt to life outside the womb and to grow, develop and thrive.

The fourth theme is the *morbidity* the baby may suffer from deprivation of human milk or 'improper feeding' with inadequate alternatives to mother's milk. Colic, diarrhoea, malnutrition, rickets and sometimes death are some of the consequences of the 'wrong' sort of milk feeding, often prevented or cured by human milk. Early life is a critical period when the ways in which the newborn is fed may have not just an immediate positive or negative effect on its health but also long-term consequences. Denial of human milk increases the risk to babies of infection, for instance, and may weaken emotional bonding with mother.

While breastfeeding is a biological reality, the ways in which it is conceived and carried out are culturally variable in both time and place. It may be performed by mother or another lactating woman, such as a wet nurse. It may be replaced by what in the past was called 'dry' or 'hand' feeding and nowadays usually termed 'bottle', 'formula' or 'artificial' feeding. The four themes introduced here are developed, chronologically and historically, to tell the story of how, within changing views of nature, culture, philosophy, medicine and science, we have come to think of human milk in the twenty-first century.

This opening chapter outlines the ways in which human milk is now viewed, and is a starting point from which to

explore its history. The seven chapters that follow deal each with a historical period, defined by the dominant framework of thought that then prevailed – Humoralism, Alchemy, Science, Nature, Paediatrics, Puericulture and Technobiology. They are chosen to help the reader enter into the 'zeitgeists', or 'spirits of the time', and thereby understand the care, nutrition and feeding of infants within their contemporary scientific and social contexts. Chapter 8 brings the historical narrative back to Chapter 1.

In the ancient Graeco-Roman world human milk was a humoral and sacred substance – white blood – with material and spiritual qualities. In the Renaissance it was regarded as a soft, sweet, subtil substance with animal and vegetable properties transmutable into flesh by an 'internal alchemist'. In the Scientific Revolution it was viewed as a corpuscular fluid of 'fine particles in organical motion', and in the Enlightenment as the product of 'Nature's bountiful urn'. In the late eighteenth century it was seen as a nutritious liquid formed of 'combustible, plastic and oily parts', by the end of the nineteenth century as a chemical formula made up of carbohydrates, proteins and fats, and in modern times as a biological fluid composed of macro- and micro-nutrients, trophic factors, immunoglobulins and live cells – a living substance, in some ways conceptually akin to that of the ancients.

From domestic, social and medical points of view, infancy has always been recognised as a dangerous time when mortality is highest during the course of life, and has been so throughout much of history. Mother's milk has generally been regarded as the best food for babies, but in many eras, classes and places wet nurses have been employed through choice or necessity – for the children of royalty and nobility, for foundlings and orphans, and for the babies of working mothers. 'Selling

mother's milk' became a commercial business, with the regulation and inspection of wet nurses by municipal authorities. This practice was replaced by postnatal welfare clinics that provided pasteurised mixtures of chemically modified cow's milk for the young of mothers unable to nurse them. The development of the clinical specialty of paediatrics medicalised infant feeding, and the mass production of artificial milks rendered wet nursing obsolete. Public health initiatives for mothers and babies have seen a decline in infant mortality (deaths within the first year of life) in much of Europe from 15 per cent or more in 1900 to well below 1 per cent now. Several generations of children have been successfully reared wholly on the modified milk of another mammal, generally the cow.

Most of our current modern ideas are built upon and incorporate earlier ideas, discoveries, inventions and practices. Some have survived barely changed, such as the critical importance of human milk for babies and simple ways of testing its quality with a drop on the finger nail, for instance, first described in the second century and repeatedly thereafter. Others have been modified, refined or abandoned, such as the belief that human milk transmits the character of the nurse to the baby, or how maldigestion releases 'coarse vapours that encumber the brain'. While each chapter is relatively self-contained, defined by the zeitgeist of its period, together they illustrate sequential, overlapping developments; some ideas growing, transforming or enfolding earlier ideas, others shrinking, metamorphosing or discarding parts or all of them.

These changing ideas can be heard across the centuries in the voices of those who expressed them, and I have let them speak for themselves in the words of their times. Mothers, 'old wives', midwives and matrons; poets, priests, preachers and philosophers; men and women of science, medicine and literature

have framed advice, fashioned recommendations and formulated feeding regimes for babies. These have been based on common sense, trial and error, humoral hypotheses, alchemy and chemistry, the study of nature, the application of technology, nutritional science and medical theories. They have been the subject of treatises, handbooks, guides, lectures, verses and textbooks, and have inspired the creation of foundling homes, wet nursing businesses, child welfare services, commercial milk formulas, crèches and postnatal clinics.

By focusing on the nature and properties of human milk, the chapters that follow shine a light on the health and fortunes, or otherwise, of newborn babies through the ages. We hear words of wonder, warning and woe; instruction, calculation and prediction; kindness, despair and surprise. They trace the ways in which our modern conceptions of the physiology and biology of maternal lactation, fetal development, infant feeding, digestion, growth and development, have been shaped and formed within changing frames of thought and practice, and how babies have been fed, from antiquity to modern times.

So, human milk is a miraculous fluid and breastfeeding is the best way to rear babies because of the superiority of human milk over all alternatives. The description of human milk that follows, as a chemical emulsion of fat and water in which all nutrients and other, living and bioactive substances are distributed, is simplified, but represents a concise summary of our modern notions. It is presented within the context of the themes – vitality and morbidity, reproduction and nutrition, transformation and metabolism – which will be explored in the chapters that follow. If it proves too technical the reader may jump to page 27 and launch straight into the history of how babies have been fed from antiquity to modern times, and return to this chapter when reading Chapter 8.

Human milk is often thought of as simply a food for babies. However, what makes it miraculous and distinguishes it from alternatives, such as artificial baby milk, is not just the perfection of its nutrient composition to meet nutritional requirements, but also the wealth of vital bioactive substances in it. Like cow's milk, human milk is made up of a creamy portion and a watery portion. In the creamy (lipid) portion of human milk are found fats – 98 per cent triacylglycerols – as well as phospholipids, cholesterol and the fat-soluble vitamins A, D, E and K. The watery (aqueous) portion contains the milk sugar, lactose, complex sugars called oligosaccharides, and proteins, principally casein, lactalbumin, lactoferrin and immunoglobulin, as well as vitamins B and C and many essential minerals, including iron and calcium.

Human milk is the entire source of energy for the newborn baby, and fat accounts for approximately half of the calories in mature human milk, and lactose for the rest. It also supplies the baby with long-chain polyunsaturated fats (PUFAS) out of which the brain and nervous system are made. The proteins in human milk provide the building materials (amino acids) for flesh and bone (muscles, skeleton, skin) and carry other vital substances, such as calcium and iron, around the body in the blood. The nutrients in human milk vary in major and minor ways from those that are found in cow's milk, but what may look like small differences in the amounts of each conceal significant differences in their compositions. Human milk is whey-predominant (60 per cent), containing mainly β-lactalbumin, whereas cow's milk is casein-predominant (80 per cent), with α-casein and the bovine protein β-lactoglobulin. Compared with cow's milk, human milk has more unsaturated

fatty acids and less protein. Its curd is soft and flocculent, while that of cow's milk is tough and rubbery, diminishing its digestibility. These chemical and physical differences make human milk nutritionally preferable to cow's milk for human babies.

The vital non-nutritional bioactive substances in human milk help the newborn to adapt to life after birth, during a time when the infant's body is vulnerable, immature, rapidly developing and utterly dependent on mother. Antibodies (immunoglobulins) and other protective factors defend against many infections which baby and its mother may encounter. Human milk oligosaccharides entrap harmful bacteria which would otherwise cause damage to the lining of the gut, and prevent them from gaining a foothold on its surface. Trophic factors promote the development and function of tissues and organs of the baby's body, and regulate their growth. Digestive enzymes compensate for the poorly developed activity of the baby's gut at birth, such as lipase which breaks down fat, so that the nutrients in mother's milk can be rapidly digested, absorbed and made use of during the early weeks and months of life. These are just some of the many antimicrobial and anti-inflammatory agents, trophic factors and growth modulators, hormones and transport proteins, digestive enzymes and cytokines, and living cells found in human milk.

Antimicrobial and anti-inflammatory agents: secretory IgA, immunoglobulins M and G, lactoferrin, lysozyme, complement, lactoperoxidase, oligosaccharides, bifidus factor, prostaglandin E & F, alpha-1 antitrypsin and chymotrypsin, cobalamin and folate binding proteins, anti-Staphylococcus factor, anti-Giardia factor. *Trophic factors* and growth modulators: epidermal growth factor, nerve growth factor, transforming growth factor, insulin-like growth factors, somatomedin-C, spermines, nucleotides, taurine, polyamines. *Hormones and transport proteins*: thyroxine, thyroid-stimulating hormone, thyrotrophin-releasing hormone, corticosteroids and adrenocorticotropic hormone, insulin, somatostatin, luteinizing hormone-releasing factor, gonadotropin-releasing factor, oxytocin, prolactin, erythropoietin, parathyroid hormone, calcitonin. *Digestive enzymes and cytokines*: amylase, bile salt-dependent lipase and esterase, tumour necrosis factor, interleukin 1 and 6, interferon. *Living cells*: leucocytes, macrophages, lymphocytes, bifidobacteria, lactobacilli, and many more ...

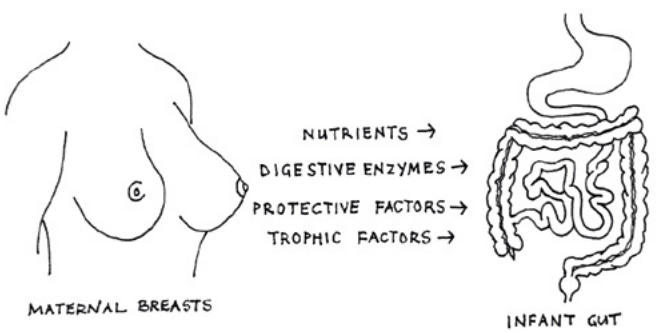
Birth represents a huge challenge to the unborn baby. It marks an end to its nourishment in the womb. In the place of a continuous flow of blood carrying everything the fetus needs via the placenta and umbilical cord, the baby suddenly relies on an intermittent, punctuated supply of mother's milk from her breasts. This abrupt switch from intrauterine parenteral nutrition of the fetus to extrauterine enteral nutrition of the newborn requires mother's breasts to produce milk and baby's digestive system to make immediate and efficient use of this novel substance for all its nutritional and other needs. The sudden changes involved in 'turning on' the neonatal digestive system occur in concert with the lungs independently supporting respiration, by breathing in and out, the heart pumping oxygenated blood around the whole body and the liver taking on full responsibility for nutrient storage, metabolism and detoxification.



Wax model of fetus *in utero*, c. 1830

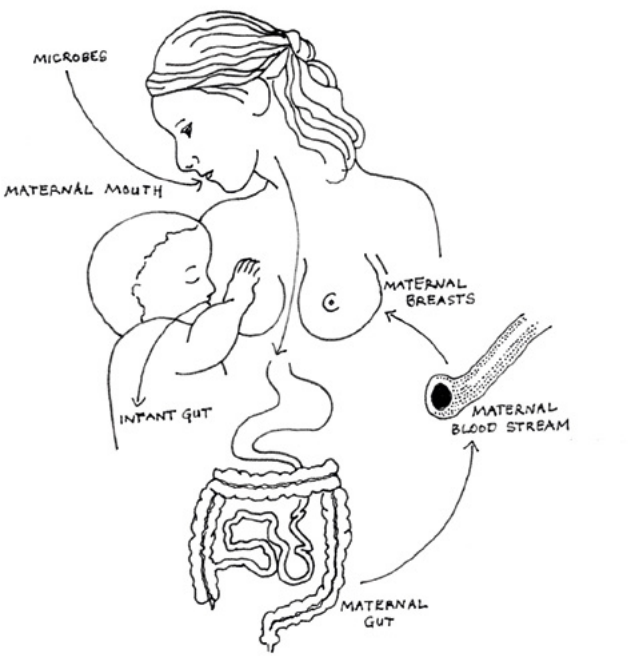
Mother's breasts and her baby's gut operate in unison and the unique composition and properties of human milk ensure that this dynamic collaboration proceeds smoothly and efficiently. A full understanding of the nature and properties of human milk therefore demands an understanding of how it is produced in mother's breasts (lactogenesis and lactation) and how it is made use of in the baby's digestive system (digestion, absorption and metabolism).

The human breast is primarily an organ of milk production (lactation). While it may be regarded, both figuratively and literally, as a prominent female secondary sexual characteristic, its biological purpose is also to provide milk for babies. The mammary gland is composed of glandular tissue in which special cells manufacture and then secrete fat droplets, proteins and lactose and other substances into a nutritious mineral-rich emulsion, which passed down ducts that swell into sacs during lactation, holding milk in readiness for suckling, whence it flows via mother's nipple into the mouth of the baby.



Breast and gut

The ingredients for making human milk are derived from what mother eats and her body reserves of nutrients. Some components of human milk are pre-formed by mother and accumulate in her stores ready for delivery into milk, while others come directly from her diet. They are small compared to her overall nutritional needs, and during the first two trimesters of pregnancy mother accrues growing reserves of energy and nutrients in readiness for the synthesis and delivery of milk at birth. Lactation is driven largely by the demands of the sucking infant, and milk volume and composition are remarkably resistant to variations and insufficiencies in maternal diet. The milk first produced (colostrum) appears thin and watery but is rich



Entero-mammary immune system

in immunoglobulin A (IgA) and lactoferrin, which help to protect the newborn against infections. IgA defends the baby from the same infections to which mother is exposed, through the 'entero-mammary immune system'. Special M cells lining her gut and bronchial tubes detect the pathogenic microbes she swallows or inhales and make white blood cells which migrate to her breast, where they stimulate the production of specific IgA that is carried in her milk to form an antiseptic protective coating to the gut-lining of the baby, thereby protecting it against the harmful bugs to which both mother and child are exposed.

The composition of human milk changes rapidly during the first few days of lactation, and its volume increases as the milk 'comes in'. Milk intake by the baby on the breast rises to around 750-800 ml (about a pint and a half) per day by six weeks, but a healthy well-nourished mother is capable of producing double that volume, to feed twins, for instance. During the first half year of lactation, mother may produce more than 22 gallons (180 pints or 100 litres) of human milk. Milk composition varies between mothers, and within the same mother, during lactation, during the course of the day and through a single feed. A five-fold rise in the amount of fat in 'hind milk' acts as a 'satiety signal' to the suckling infant to come off the breast. This elegant feed-back mechanism that curtails sucking when nutritional requirements are met ('demand feeding') is easily overridden by bottle-feeding in which the volume and composition of milk the baby receives is unvaryingly uniform, includes many ingredients that are biologically more appropriate for calves, lacks bioactive and living substances and is under the control of mother alone. The intimate interrelation between mother and baby via the 'breast-gut' axis serves to balance supply and demand, so that lactation meets the baby's nutritional

needs and digestive capacity. Human milk supplies the newborn with everything he or she needs to grow, develop and thrive, but in order to do these things it must be effectively digested and its constituents absorbed and metabolised by the baby.

The gut of the newborn is far more than simply an inert tube running from mouth to anus. It is primed for the reception of mother's milk by the passage of amniotic fluid through it in the womb, and is ready at birth to take on, in place of the placenta, the full task of supporting the nutrition of the baby. When human milk enters the stomach it is partially digested by gastric acid, as well as digestive enzymes from the baby's salivary glands and mother's milk. The jejunum (upper small intestine) is especially permeable to the uptake of many bioactive substances in colostrum, and is uniquely adapted for the digestion of lactose, the principal source of energy in human milk, by virtue of the presence of the enzyme lactase on its surface (mucosal) cells. Other mucosal enzymes, along with those present in human milk, help to digest milk-borne fats needed for insulation, adipose storage and development of the brain and nerves.

The liver and pancreas are the source of bile, bicarbonate, trypsin, lipase and amylase, which are secreted as a juice into the duodenum to digest proteins into peptides and amino acids, lipids into fatty acids and complex carbohydrates into simple sugars called monosaccharides. The products of digestion are absorbed and pass to the liver via the portal vein where they are reconstituted, such as amino acids into proteins to build bone and muscle or used to carry specific nutrients in the blood to nourish, defend and repair the body, metabolised or stored, such as glycogen and fat for energy.

The gut is also a part of the immune system, and when exposed to so-called 'foreign' food proteins, such as antigenic

β-lactoglobulin, it will treat it as a nutrient and digest it into polypeptides, or it may react inappropriately to cow's milk protein causing damage to the lining of the gut. Too early introduction of non-human milk proteins can make allergy to cow's milk more likely. The neonatal gut is also an endocrine organ which secretes locally acting gut hormones that help to regulate intestinal and metabolic adaptation to extrauterine life. The digestive system plays a part in water conservation and electrolyte homoeostasis, helping to maintain normal blood pressure and hydration of the body.

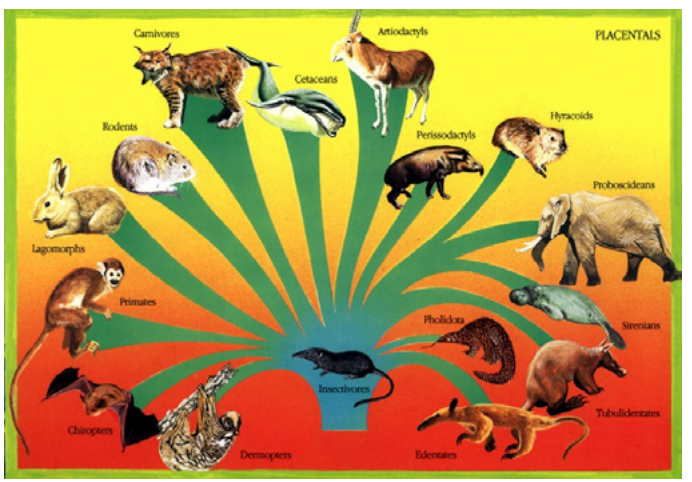
The baby's large bowel (colon) becomes the home of a microbial flora, which conclude the digestion of complex carbohydrates that are not broken down in the small intestine, and salvages and recycles other substances, such as essential amino acids, vitamins and antimicrobial compounds. It is colonised within a few hours of birth by mother's gut bacteria which the baby acquires during vaginal delivery. As it travels through the birth canal, the baby's face passes over mother's anus and is exposed to her colonic microbes. They play an important part in the fermentation of complex carbohydrates to short-chain fatty acids which are fuel for the cells lining the large bowel and for its friendly microbial inhabitants. Babies born by Caesarean section are not immediately colonised with mother's gut flora.

REPRODUCTION AND NUTRITION: NATURAL HISTORY OF MAMMALS AND MILKS

Nourishment of the young after birth on milk is a defining feature of all mammals, of which woman and man (*homo sapiens*) are – hence the name of this class of vertebrate animals. The co-evolution of the maternal mammary gland (breast) and

the neonatal digestive system (gut), with complementary structures and functions dedicated to producing and making use of human milk, reflects the long and intimate interrelations of these two organs throughout mammalian evolution.

Mammals share a common ancestry with dinosaurs and birds, whose young grow and mature in eggs which also contain the nutrients needed to do so. Evolving from tiny four-legged creatures called therapsids during the Triassic period more than 60 million years ago, the first primitive mammals probably lived off insects and laid eggs. Mammary glands are thought to have evolved from sebaceous or sweat glands on the chest and abdomen that may have secreted antimicrobial factors which protected the young by anointing the egg or the hatchling at birth. In the course of mammalian evolution the egg lost its shell and became retained in the maternal reproductive tract. This was followed, in the place of nutrients packed in an egg, by the evolution of placentation (in all mammals but



Origin and radiation of placental mammals

marsupials and monotremes) as a secure and direct route for the blood-borne transfer of nutrients from mother to young while the baby is in the uterus, and of lactation to supply them in milk after birth.

Lactation provides a regulated liquid food supply to the young, which is readily available, ingestible without teeth and perfectly composed for the nutritional and other needs of the newborn. It has permitted the geographical mobility of species unconstrained by the immediate task by mothers of seeking food for their infants. Mammals have exploited most terrestrial habitats, as well as the skies, seas and inland waters, with their diverse food resources, while providing a constant and uniform source of food to their young. It is no surprise, therefore, that the composition of the milks of all mammals, terrestrial, aerial and aquatic, varies and reflects the nutritional and developmental needs of their offspring. The milk of the seal, for instance, whose young are born in the freezing Arctic seas, has ten times more fat (calories) than that of human milk. The newborn tree shrew, which doubles its weight every twenty-four hours, consumes milk with eight times more protein than that of humans. For the baby kangaroo (joey), which spends many weeks in mother's pouch with its mouth fused to one of her teats, breast and gut are akin to the umbilical cord, through which flows milk of a changing composition to meet the changing needs of the growing joey.

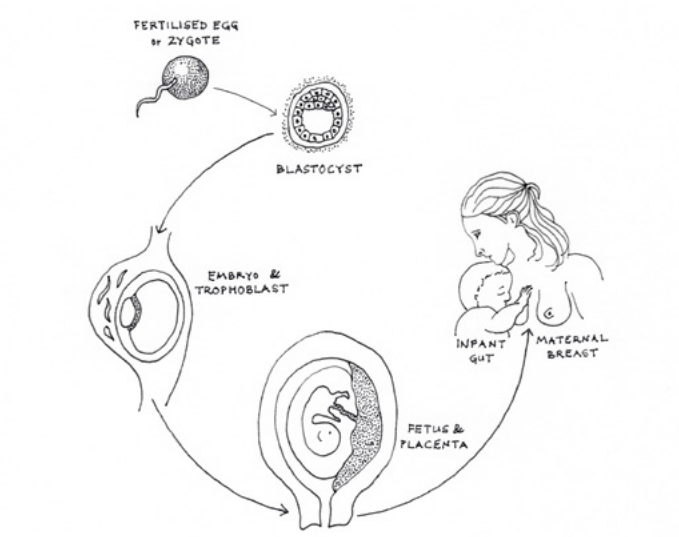
Baby mammals range from those born very immature, helpless and dependent on maternal care (altricial), such as mice and rats, to those that are very mature and independent at birth (precocial), such as guinea-pigs and foals. After a short gestation, altricial young make use of milk for all the nutrients they need and many non-nutritional bioactive substances via the gut. Precocial young are born later in the course of gut development, are weaned earlier and have relatively smaller dependence on milk. There is an inverse relation between the contributions of placentation and lactation to the transfer of nutrients and non-nutritional substances from mother to young during early life: those factors that are not transferred prenatally via the placenta are obtained postnatally from milk, and *vice versa*. The human newborn baby (usually a singleton) is more altricial than precocial. After a relatively long gestation of nine months, it is born without teeth and may be reared exclusively on mother's milk for six months, when weaning or complementary feeds are gradually added. It is helpless and utterly dependent on mother during this early feeding period, fully formed but growing slowly and requiring constant care, regular nourishment, warmth and attention, well into childhood.

MORBIDITY: WHY EARLY NUTRITION MATTERS

How babies are fed can have immediate and lasting effects on their growth development and future health. Because human milk is tailored to the needs of the newborn in so many vital ways, and provides exactly the right nutrients and other substances at the right time to build its growing tissues and organs and protect it from many infections, lack of human milk, unless it is replaced by a suitable alternative, can lead to many problems, from under-nutrition and allergies to a greater risk of infection, and even to death.

Early nutrition matters, not just because of what all the good things in human milk do, but also because of the bad things that not having it can lead to. The advantages to the baby of human milk include a lower risk of diarrhoeal diseases, chest and ear infections, sudden infant death syndrome,

cow's milk protein allergy and obesity. In addition to its nutritional and protective effects, specific fats in human milk may be responsible for superior brain development and function, and therefore higher psychomotor function, visual acuity and cognitive abilities. Feeding babies on raw or modified cow's milk denies them the fatty acids that are constituents of its brain, as well as 'living' bioactive substances that confer protection against infections during the development of its immune system. There are advantages to mother of breastfeeding her baby: it promotes recovery from childbirth, extends postpartum infertility, mediates child-spacing, speeds up return to pre-pregnancy body weight and uterine size, and may lessen the risk of breast and ovarian cancer, as well as osteoporosis. It may strengthen the emotional bond between mother and baby, with long-term advantages to both.

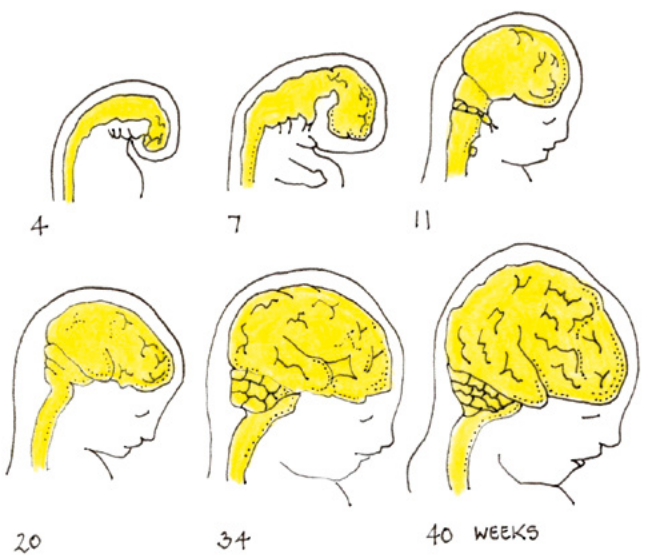


Development of fertilised egg into embryo, fetus and baby

The embryo, fetus and infant are composed of tissues and organs made of the nutrients that mother supplies to her developing offspring. Starting off as a small bundle of cells derived from the fertilised egg, the blastocyst divides, differentiates and embeds in the wall of the womb, where it is nourished by maternal secretions, sometimes called uterine milk. Growing in size, taking shape and provided with nutrients via trophoblastic cells which become the placenta, the human embryo assumes the essential form of the newborn baby by ten weeks of gestation. Thereafter its tissues and organs expand in volume and complexity.

During the last trimester of pregnancy there is a big increase in maternal and fetal adipose (fatty) tissue as energy stores are laid down in anticipation of postnatal needs. Most of the weight that mothers put on in pregnancy is fat, and she shifts much of it to her fetus to produce a chubby, rounded newborn baby. Consequently, the growth of the baby's body is most rapid during the last three months of gestation and the first four months after birth. After losing and gaining about 10 per cent of its body weight during the first ten days outside the womb, the human baby doubles its weight within the first six months and triples it by a year. The organs of the body grow at different rates relative to each other – skeletal muscle increases as a percentage of body weight, whereas fat rises and falls in concert with energy needs. The amount of energy (from lactose and fats) the baby requires doubles at birth. This fat is needed for energy (to be physically active), for insulation (to keep warm), for its own stores (to be metabolically independent) and to build its brain (to cerebrate optimally). Taking, say, 500 ml of breastmilk a day containing 20 g of fat (4 per cent milk fat), a baby consumes almost 3.6 kg (8 lb) of fat during its first half year. In the first year its body fat increases from 16 per cent to 25 per cent.

The brain is a lump of fat (60 per cent lipid). Detectable in the embryo as a blob at the top of the spinal cord within three weeks of conception, it grows rapidly so that by birth it comprises 10 per cent of the weight of the newborn. Maximal brain growth occurs in late fetal and early neonatal life, and it triples its weight, to a kilogram, during the first year. The fats out of which the brain is made are not like those in foods, such as lard, or even of *Flora*, but are PUFAs with unpronounceable names such as docosahexaenoic (DHA) and eicosapentaenoic acid (EPA). The brain and nervous system are made up of millions of nerve cells, or neurones, which stretch from head to toe, each with numerous tendrils, called dendrites, that interface with other cells. The brain grows in size through multiplication of these neurones, creating a dense web that accounts for

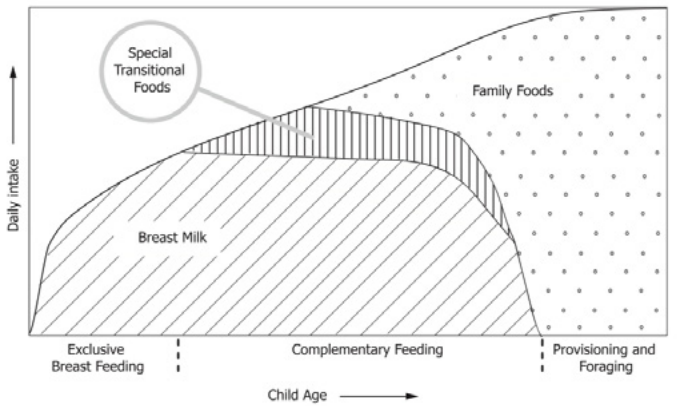


Growth of the fetal brain

its extraordinary complexity and remarkable function. Each and every one of these spidery cells is enclosed in a membrane made up of PUFAs. Neither the fetus nor the baby has the capacity to make these lipids and they have to be delivered by mother, preformed, at the right time, in the right amounts, during brain growth.

The early years of life are an intense period of learning, which explains why the maximal rate of brain growth is around birth, in anticipation of the development of the helpless infant on the breast into a studious child. Because PUFAs are found in abundance in human milk, but not in cow's milk, how babies are fed has implications for their brain development, eyesight and intelligence.

There has long been a view that early health and nutrition may affect later health. Small babies, like the runt of a litter, are more fragile and susceptible to disease. Early life is a critical period for growth and development, and how the baby is fed can influence both. It may even influence health in adulthood. During periods of rapid developmental and organisational change, as occurs in fetal and neonatal life, growing tissues and organs are susceptible to positive and negative influences, which can affect the structure or function of the body. Intrauterine growth restriction (IUGR), for instance, due to poor placental function or maternal undernutrition, can lead to small babies which grow up with a higher risk of cardiovascular and metabolic disease, obesity, diabetes and premature death. It is possible that rapid catch-up growth after birth can amplify this. On the other hand, overweight babies, often reared on artificial milk formulas, are more likely than breastfed babies to become obese adults, and suffer the associated problems of diabetes and cardiovascular disease.



Complementary feeding, from Dan Sellen, 2007

WEANING AND COMPLEMENTARY FEEDING

The full capacity of the digestive system of the baby to assimilate non-milk carbohydrates, such as starches and other polysaccharides in complementary foods, is not reached until around the time when the first milk teeth erupt and its immune function is sufficiently mature to do without the protective factors in human milk for defence against infections. Because human milk is one of the chief determinants of infant health and development, breastfeeding should continue as long as possible, exclusively until about six months, and then in concert with complementary foods into the second year of life or longer. Six months is judged to be the age when, in the words of the WHO, 'the process starting when breastmilk alone is no longer sufficient to meet the nutritional requirements of infant and therefore other foods or liquids are needed, along with breastmilk'. The period of milk feeding from birth to the start of weaning, and the natural termination of breastfeeding, should be a gradual process involving the timely introduction of non-milk (transitional) foods by spoon, cup, fingers or bottle.

Complementary feeding is a unique cultural feature of human reproduction that reduces the maternal nutritional costs of lactation and diminishes the time interval between births without increasing maternal or infant mortality. There is a trade-off between the maternal costs of lactation and risks of poor infant outcomes. However the proportion of newborns, globally, who are breastfed exclusively for six months, receive timely and appropriate complementary foods and continue to be breastfed into their second year or beyond, is small. All too often, in many parts of the developing world, babies receive unsafe and inadequate transitional foods that are nutritionally deficient and polluted, compounded by the premature cessation of breastfeeding, without supplementation with formula or other appropriate milk substitutes.

The flexibility of time of weaning and duration of breastfeeding presents many mothers and babies in parts of the world where clean water and nutritionally suitable weaning foods are not available or hygienically prepared with an impossible choice, sometimes termed 'the weanling's dilemma'. Too early introduction of weaning foods, which are infected or nutritionally inadequate, can increase the risk of diarrhoeal disease and malnutrition, and prematurely terminate breastfeeding, while too late introduction of weaning foods can cause undernutrition because of the inability of human milk alone to meet nutritional needs, and a lack of safe, clean, nutritionally adequate complementary foods. This combination of nutritional inadequacy and bacterial contamination of weaning foods is responsible for much diarrhoea, growth faltering and malnutrition worldwide. Prolonged breastfeeding, into the second

year of life, ensures greater survival of children, even if they are undernourished. This may not be critical for babies reared on clean, chemically-constituted breastmilk substitutes, but it can be fatal to those born where such feeds are unavailable, adulterated, nutritionally imbalanced or deficient. Worldwide, over half a million children under five die each year of diarrhoea and malnutrition. Seventy-five per cent are infants; that is 1,000 babies each day.

One way of recognising whether babies are getting enough milk, or not thriving for other reasons, is by weighing them. The body weight and length of babies are useful measures of the development of infants, and growth charts are widely used to monitor their health. Modern WHO growth standards have been compiled from the sequential measurements of 6,000 fully breastfed babies born and reared in five different countries around the world. They suggest that cultural and environmental factors, such as quality of feeding, hygiene and the prevalence of infection, rather than genetic endowment and ethnicity, are the principal determinants of rate of growth in infancy.

HOW WERE BABIES FED FROM ANTIQUITY TO MODERN TIMES AND WHY DOES IT MATTER?

Human milk is much more than simply food for babies. It plays a vital role in reproduction and nutrition, supplying the baby and all its tissues and organs with everything it needs to grow and develop normally. It is also the foundation of health in childhood and later life. The miraculous and vital qualities of human milk are most fully understood within the context of mammalian biology and evolution, where milk defines reproductive strategies. This is how we see human milk now, but how

was it regarded, and what part did it play culturally, domestically, socially and medically in the lives of mothers and babies of the past?

Pre-industrial societies were probably small rural communities made up of large families. As Derrick and Patrice Jelliffe suggested in *Human Milk in the Modern World* (1978):

> Women were direct and indirect contributors in their own right to agricultural activities, in the storage and preparation of food, and in the bearing and rearing of children needed for the families' workforce. Breastfeeding was not only a normal unquestioned and irreplaceable female function, but an economic essential for the prosperity and survival of the family.

Surrounded by domestic animals and occupied with their husbandry, breeding, rearing and care, in which calving, lambing, farrowing, suckling, milking and dairying were all intimate and ever-present activities, nursing mothers were at home. Breastfeeding was not only a normal, familiar and unquestionably female function, but also vital to the welfare of the whole family.

The anthropologist Dan Sellen has explored the pre-history of infant feeding, and argued that flexibility in the duration of breastfeeding and the timing of first weaning foods imply that human milk feeding habits not only varied during the evolution of hominids, but also included cultural practices, such as mothers pre-chewing into semi-liquid form weaning foods for their babies and offering them other non-milk complementary foods, practices which brought about biological changes in early child rearing.



Venus of Willendorf, c. 25,000 BC

The demographic historian Valerie Fildes, surveying infant feeding practices of pre-industrial societies in *Breasts, Bottles and Babies* (1988), suggests that a 'high regard for lactating women is implied in the wealth of images of mother goddesses, usually holding or suckling an infant'. Before the existence of written sources from early Graeco-Roman civilisation, clues to how human milk was thought about may be gleaned from archaeological artefacts such as figurines fashioned in bone, stone and clay, for example the *Venus of Willendorf*. With prominent breasts, abdomen and thighs, she clearly represents fecundity and fertility, procreation and lactation.

The cultural historian George Sussman reminds us that 'although the biology of infancy is universal in historical time, human perceptions of infancy and what it requires are socially conditioned and subject to historical change'. Or as the novelist Leslie Hartley famously said: 'The past is a foreign country; they do things differently there.' To understand the past is not just to rediscover what happened then, but to do so within the context of, and through the eyes of, those who lived before us.

While babies have been reared on human milk from time immemorial, the ways in which this has been done at home, in families, in hospitals and other institutions, and how human milk has been regarded popularly by mothers and carers, and professionally by midwives, physicians and scientists, for instance, have varied greatly. The options faced by mothers of how to feed their young are essentially choices between maternal nursing (breastfeeding), wet nursing (the milk of another mother), the milk of another mammal (most often the cow), or artificial alternatives composed of mixtures of milk, water, cereals, sugar, salts, honey, meat, vegetables, fruit juices (and a host of other things, including wine and beer), as paps, broths and gruels delivered by spoon, hand, horn or bottle, in sequence or combination. Breast has been regarded as best throughout history but the twentieth century saw a revolution in infant feeding practices, with an unprecedented break with the past, rendering human milk apparently no longer vital, and by the 1970s the Jelliffes noted that:

> Bottle-feeding with cow's-milk formulas has become the usual way of feeding babies in recent decades. Under the economic, hygienic, and social conditions found in the majority of families in resource-rich countries this practice is now considered to be as safe and effective as breastfeeding as regards the growth, nutrition, and health of such infants, and, indeed, as most appropriate economically and culturally for modern urban life-styles.

With the application of the sciences of chemistry, microbiology, immunology and physiology, human milk is now regarded as much more than simply a chemical fluid and source of food, but as a biological substance with many other vital and life-giving and protective properties. At the same time it has come to be seen as a reference against which to measure and model synthetic artificial alternatives which are now widely available and used. This dual biological and technological concept of human milk epitomises our modern, twenty-first-century zeitgeist, with all its tensions between natural and artificial, and breast versus bottle. We view the human body as a multicellular organism composed of tissues, organs, fluids and other extracellular substances, in which chemical processes mediate molecular transformations to build, nourish, defend, repair and power it. Such a model of the human body, including its reproductive and nutritional capacities, is very different from that conceived in the past. This opening chapter is designed to set the scene for an exploration of how babies have been fed through history and why it matters, starting in the ancient Graeco-Roman world of Hippocrates, Aristotle and Galen.

2

Humours

WHITE BLOOD

Blood is the moister part of flesh, being a kind of liquid flesh; and milk is the sweeter and finer part of blood. For whether it be the blood supplied to the fetus and sent through the navel of the mother, or whether it be the menses, shut out of proper passage and by natural diffusion bidden by the all-nourishing and creating God that proceed to the already swelling breasts and are transmuted by the heat of the spirits, blood is formed into food desirable for the babe.

NEARLY 2,000 YEARS ago the theologian, Clement of Alexandria (c. AD 200), combined his knowledge of the philosophy of Aristotle, the teachings of Christ, the writings of the physician Galen and the art of dairying to describe the origins and role of human milk in pregnancy, lactation and infant feeding. For the 'ancients' of the Graeco-Roman world human milk was transmuted blood. It was a humoral fluid and a sacred substance, and the baby in the womb or on the breast was nourished by mother, whose blood was diverted to the fetus *in utero*, and to her breasts after birth where it was transformed into milk.

The womb and the breast, the seats of generation and lactation, received both nourishing and vitalised blood, which fed

and animated the fetus and baby. After birth 'women continue to have milk until their next conception, and then the milk stops coming and goes dry. So long as there is flow of milk the menstrual purgations do not take place,' wrote Aristotle (384–322 BC). Clement describes the special affinity between the breasts and the womb in his Pedagogus (c. AD 198):

> For of all the members, the breasts have the most sympathy with the womb. When there is parturition, the vessel by which the blood was conveyed to the fetus is cut off: there is an obstruction of the flow, and the blood receives an impulse towards the breasts; and on a considerable rush taking place, they are distended and change the blood to milk.

The fluids of the humoral body were transmutable, one into another. Milk was white blood.

> The blood from the veins in the vicinity of the breasts, which have been opened in pregnancy, is poured into the natural hollows of the breasts; and the spirit discharged from the neighbouring arteries being mixed with it, the substance of the blood, still remaining pure, it becomes white by being agitated like a wave. Yet still the essence is supplied by the blood.

Blood, the foremost of the four humours, was a 'vital fluid' that carried throughout the body all it needed to thrive, and endowed it with the spirit of life. Blood could be changed into other fluids, including saliva, urine and tears, and into semen and milk, by the power of pneuma, spirit from the air, which

'spits forth briny foam', transforming it into a sweet, white, nourishing, life-bearing substance.

> In this way also the rivers, borne on with rushing motion, and fretted by contact with the surrounding air, murmur forth foam. The moisture in our mouth, too, is whitened by the breath ... The blood is converted into that very bright and white substance by the breath. The change it suffers is in quality, not in essence. You will certainly find nothing else more nourishing, or sweeter, or whiter than milk. In every respect, accordingly, it is like spiritual nourishment, which is sweet through grace, nourishing as life, bright as the day of Christ.

Blood was also the substance out of which the fetus was formed, as Clement described:

> The process of formation of the seed [semen] in conception ensues when it [blood] has mingled with the pure residue of the menses which remains. For the force that is in the seed coagulating the substances of the blood, as the rennet curdles milk, effects the essential part of the formative process.

The fetus was formed from mother's blood and father's seed, which coagulated it in the womb. Paraphrasing Aristotle, Clement wrote that 'rennet is milk that contains vital heat, as semen does, and this integrates the homogenous substance and makes it "set". Thus, when the bulky portion sets the fluid portion comes off; and as the earthy portion solidifies membranes form all around its outer surface.'

Generation (reproduction or gestation) was a kind of incubation comparable to making a milk pudding. 'Rennet is thus milk that contains fire, which comes first from the heat of the animal while the milk is undergoing concoction,' wrote Aristotle. Concoction, 'which ensues whenever the matter, the moisture is mastered by the formal heat in the object', is akin to cooking. 'The reason is similar to that of the growth of yeast, for yeast also grows great from a small beginning as the more solid part liquefies and the liquid is aerated. This is effected in animals by the heat of the juice contained in them.' The same sort of thing that happens on the kitchen table, in the oven and in the womb, also happens in the stomach, where food is turned into a milky fluid called chyle.

> The contents of the stomach are at first milky, a coagulation of fluid [chyle]; then the same coagulated substance is changed into blood; but when it is formed into a compact consistency in the womb, by the natural and warm spirit by which the embryo is fashioned, it becomes a living creature. Further also, the child after birth is nourished by the same blood; for the flow of milk is the product of the blood and the source of nourishment is the milk.

Aristotle classified animals into those which bore their young in eggs (oviparous) and those that were born live from mother's womb (viviparous) and then nourished on milk. Both mammals and birds are what we now call 'warm-blooded'. The incubation of an egg and the development of the embryo into a chick within it were another example of how heating and drying concocted the young.

> Nature not only places the material of the creature in the egg but also the nourishment sufficient for its growth, for since the mother bird cannot protect the young within herself, she produces the nourishment in the egg along with it ... Whereas the nourishment which is called milk is produced for the young of vivipara in another part, in the breasts, Nature does this for birds in the egg.

The womb acted as the liver and heart of the fetus, as a source of nourishment and life before birth. 'Just as the liver continuously furnishes and supplies blood to the animal through the veins, and the heart pours out heat through the arteries to strengthen and perfect all natural processes, so too the uterus of the pregnant woman, as if it were the liver and the heart, supplies and transports all these elements into the entire fetus through the veins and arteries.' The blood is supplied by mother, whose 'vessels join into the uterus like the roots of plants and through them the embryo receives its nourishment. This is why the embryo remains within the uterus.'

Aristotle considered that the young of viviparous animals were warm and moist and he regarded them as highest in the *scala naturae*, topped by man. As a vital fluid made of blood, milk was channelled to the breast of women where it was warmed by the heat of the heart nearby. For Clement:

> Meat [flesh] is not as something different from milk, but the same in substance. For the very same Word is fluid and mild as milk, or solid and compact as meat. And entertaining this view we may regard the proclamation of the Gospel, which is universally diffused, as milk.

Blood, milk and flesh were transmutable, just as bread and wine were transubstantiated into the flesh and blood of Christ, as St John said in the words of Jesus, 'Eat ye my flesh and drink ye my blood,' or as Clement said, 'The blood of the Word is manifested as Milk.'

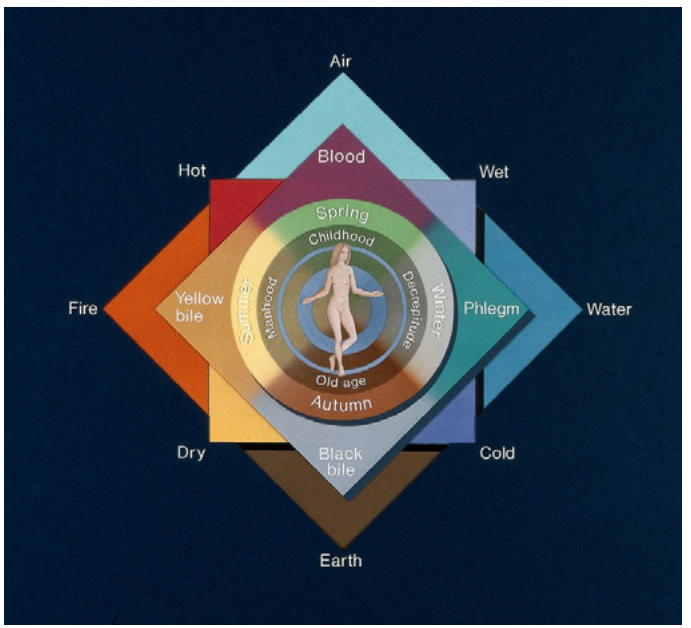
> The flesh figuratively represents to us the Holy Spirit; for the flesh was created by Him. The blood points out to us the Word, for as rich blood the Word has been infused into life; and the union of both is the Lord, the food of the babes – the Lord who is Spirit and Word. The food – that is, the Lord Jesus – that is, the Word of God, the Spirit made flesh, the heavenly flesh sanctified.

Whilst Clement's chief intention was to reconcile Christian theology with Greek philosophy, his writings about human milk, infant care and feeding draw upon the works of Aristotle, Galen, Soranus and Hippocrates to synthesise a naturalistic explanation of how the miraculous fluid is formed within a physical body governed by the four humours. Healthy living, which was the basis of a healthy life and body, included generation, with healthy sex, reproduction, childbirth, lactation and infant feeding, all of which depended on maintaining a healthy humoral balance.

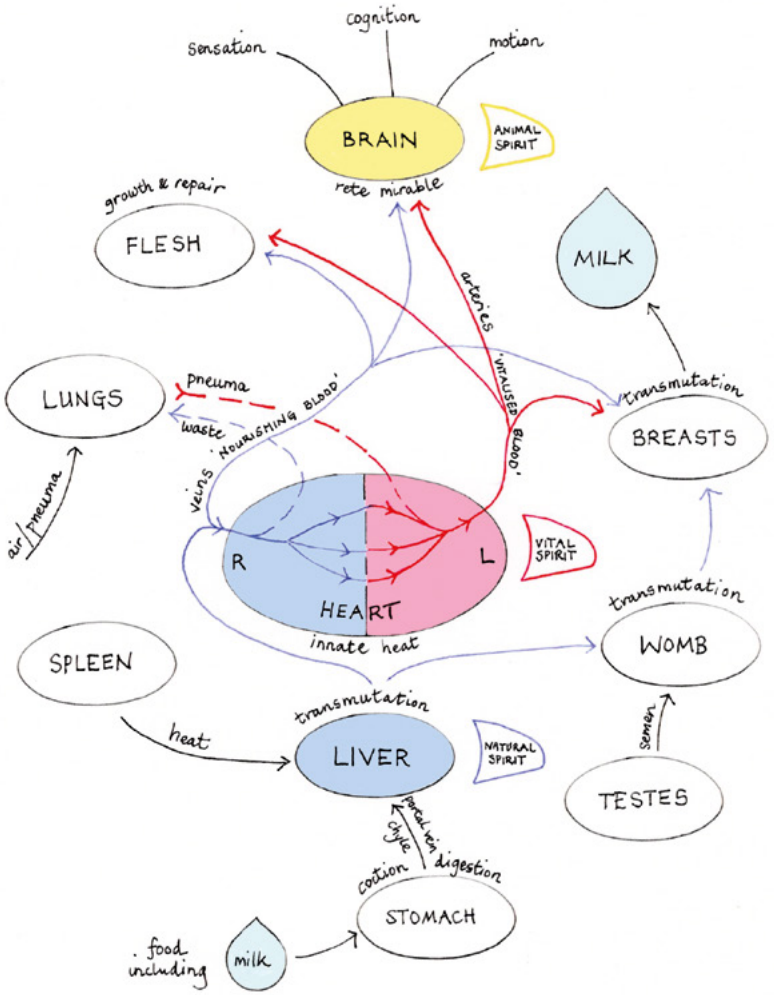
THE HUMORAL BODY AND PHYSIOLOGY OF THE ANCIENTS

All things were composed of four elements – fire, water, earth and air – which were blended to form the four humours whose balance of properties – hot, wet, cold and dry – determined health, temperament, chance of illness, and the nature and assimilation of foods. Hippocrates, *On the Nature of Man* (c. 400 BC), describes the theory as follows:

> The Human body contains blood, phlegm, yellow bile and black bile. These are the things that make up its constitution and cause its pains and health. Health is primarily that state in which these constituent substances are in the correct proportion to each other, both in strength and quantity, and are well mixed. Pain occurs when one of the substances presents either a deficiency or an excess, or is separated in the body and not mixed with others.



The four elements and the four humours



Galenic physiology of digestion, nutrition, transmutation and generation

The humoral body of the ancients was formed of solid and fluid parts: organs (stomach, liver, heart, brain, urinary and generative organs) linked by tubes (gut, veins, arteries, nerves, urinary tract) through which fluids flowed under the influence of heat, moisture, pneuma and spirits.

The principal organs (solid parts) were the seats of four 'faculties' – the liver of nutrition and growth, the heart of vitality and the passions, the brain of sensation, movement and cognition, and the genitalia of generation or formation – operated by changes in the relative balance of the humours: attraction (e.g. appetite) by heat and dryness; mutation (e.g. digestion) by heat and moisture; retention (e.g. growth) by coldness and dryness; and expulsion (e.g. excretion) by coldness and moisture. The function of the body was regulated by these faculties, whereby genesis and flux of the humours within and between its solid parts permitted the transmutation of blood into milk (in mother's breasts) and milk into flesh (in baby's body). The digestion of milk began in the stomach, where it was 'cooked' (concocted) by the natural heat of the body 'as the flame of a torch consumes oil, wax, tallow, so doth it alter and digest the nutritive matter' into chyle. An anonymous fourteenth-century scribe illustrates overleaf the circular stomach in which the four humours that mediate coction are represented as red protrusions on the inner walls.

Chyle passed to the liver through pores in the wall of the gut and via the portal vein, where it was turned into nourishing blood endowed with *natural spirit*, then transformed in the heart by heat and pneuma from the lungs, to bear *vital spirit*, and thence carried by the arteries to nourish and repair flesh, and to the brain, the seat of the soul, where *animal spirit* mediated sensation, cognition and motion. The arterial and venous blood systems were separate.



Circular stomach, from Manuscript Ashmole, thirteenth century AD

The liver continuously produced dark red blood (blue in the Galenic physiological system) which was distributed about the body for nutriment by the veins. A portion of this blood was drawn into the heart where it passed through the pores in the septum separating the right from the left ventricle, and air (pneuma) from the lungs via the pulmonary artery converted it into bright red arterial blood (red in figure on page 39), which suffused vital spirit to brain and body. No blood returned to the heart.

Aristotle taught that the nature and property of all things, animate and inanimate, might be explained according to four 'causes': formal (structure), material (composition), efficient (function) and final (purpose). Thus human milk was a soft, sweet fluid produced by the breast to satisfy the appetite of babies and nourish them. Clement, following Aristotle on this point, believed that all living things combined material substance with spiritual form, which together determined their physical appearance and essential properties, as in the

nourishing matter and vitalising spirit of blood and milk, and the corporeal body and incorporeal soul; a co-existence of the human and the divine.

For Clement these miraculous processes of generation and nutrition (gestation and lactation) were the work of God:

> Milk being thus provided in parturition is supplied to the infant, and the breasts, which till then looked straight towards the husband, now bend down towards the child, being taught to furnish the substance elaborated by nature in a way easily received for salutary nourishment. For the breasts are not like fountains of milk, flowing in ready prepared, but, by effecting a change in the nutriment, form the milk in themselves, and discharge it. And the nutriment suitable and wholesome for the new-formed and newborn babe is elaborated by God, the nourisher and the Father of all that are generated and regenerated.

Clement's account of the humoral body, with its focus on the processes of generation and nutrition, was shared by many other ancient authors who wrote about how babies should be fed, reared and cared for. Such a synthesis of the form and function of the human body informed their advice about hygiene and healthy living, as well as choice of wet nurse and treatment of disease. Pregnancy, childbirth, infant care and feeding were the provinces of women – mothers, midwives and wet nurses – whose practical skills included assessing the quality of milks, caring for babies and dealing with the processes and problems of feeding them. Clement's contemporary, the physician, Soranus of Ephesus (*c.* AD 200), was one of many who taught that:

All things being equal it is better to feed the child with maternal milk, for this is more suited to it, and the mothers become more sympathetic towards the offspring, and it is more natural to be fed from the mother after parturition just as before parturition. But if anything prevents it one must choose the best wet nurse.



Roman mother suckling her infant, third century BC

Maternal breastfeeding was the general rule, for good practical and theoretical reasons. The physician, Galen (AD 130–200), had argued that 'Children fed on mother's milk are not only having the customary food but also the most proper, and nature seems not only to have prepared such nourishment for infants, but at the same time endowed them from the beginning with an inborn faculty enabling them to use it.' Moreover, he regarded human milk as the proper food for infants 'since they have a moister constitution than those of other ages', echoing the Hippocratic corpus (460–370 BC), which taught that 'the growing organism has the most innate heat and therefore requires more nourishment'. The moist warm body of the baby was best nourished with food that conformed to these humoral qualities.



Roman infant feeding vessel with spout, first century AD

Hippocrates offered practical guidance on infant feeding and the management of snags associated with it, in the form of aphorisms such as 'Children at the breast that take milk are generally drowsy', and 'children with voracious appetites and who suck much milk do not put on flesh in proportion', and 'infants that have the belly much moved and good digestions are the healthier; they that have scant movement, and being gross feeders are not nourished in proportion, are sickly'. These simple rules offered guidance about weaning, such as 'those that eat solid food while being suckled bear weaning more easily'.

Judging from the large numbers of feeding vessels with spouts found in the graves of children in the Ancient Greek and Roman worlds, weaning from mother's breast usually involved the milks of other animals, including sheep, asses and goats. Mural paintings, decorated vases, carved figurines and minted images of Romulus and Remus suggest that the milks of wild animals, which clearly felt tenderness towards their offspring, were also suitable nourishment for children. Or perhaps the mythical founders of Rome were imbibing the martial qualities of wolves.



Romulus and Remus on Roman coin from reign of Constantine, fourth century AD

Wet nurses in Ancient Greece were often domestic slaves responsible for the care of infants well into childhood. Galen recorded that they might be hired at the *Colonna Lactaria* in the Roman Forum. Contracts were drawn up between wet nurse and family, such as with Didyna who 'agrees to nurse and suckle outside at her own home in the city, with her own milk pure and untainted, for a period of sixteen months the foundling Marcus for wages for milk and nursing of ten silver drachmas and two cotyla [pints] of oil every month'. Her own sexual activity was to be curtailed, with penalties if she became pregnant.

Wet nurses were favoured by royalty and the wealthy, as well as for the care of orphans. Choice of wet nurse was all important, not just concerning her capacity to deliver abundant and nutritious milk, but also because she was liable to pass on to the baby in her milk both desirable and undesirable aspects of her character.



Memorial to a Roman wet nurse, 'Severina Nutrix', third century AD

> One should choose a wet nurse not younger than twenty nor older than forty years, who has already given birth twice or thrice, who is healthy, of good constitution, of large frame, and of a good colour. Her breasts should be of medium size, lax, soft and unwrinkled, the nipples neither big nor too small and neither too compact nor too porous and discharging milk overabundantly.

Soranus emphasised that 'she should be of good constitution, that is, fleshy and strong' because 'nourishing milk comes from a healthy body, unwholesome and worthless milk from a sickly one'. The physical quality of human milk could be judged by its 'colour, smell, composition, consistency, and with regards to its taste, whether it changes with time'.

> It should be moderately thick, for fluid, thin and watery milk is not nutritious and may disturb the bowels; while thick and cheesy milk is hard to digest and, in the same way as food that has been partially chewed, it blocks up the pores and, as it occupies the main passages of the body, it is a danger to life. Cheesy breastmilk is unhealthy for the woman and a sign that she is sick.

Soranus recommended two ways to judge the quality of human milk: first, to put a drop on to the fingernail and if it 'congeals like honey and remains motionless then it is thick'. Secondly to drop it into water and if 'the milk does not disperse and sinks down after a while, so that when the water is poured out, one finds around the bottom [of the jar] a substance that is cheesy, thick and hard to digest'. His successor, Oribasius (325–403),

applied culinary craft to testing human milk: 'Pour an eighth part of the milk into a glass vessel, add rennet in proportion and stir with the fingers, then leave it to set and see whether the curd is less than the whey, for such milk is no good, and the reverse is indigestible. The best is that which contains both in equal proportion.' Paul of Aegina (625–90) suggested remedies for milk that was too thick, too acrid, too thin or too plentiful:

> If it be too thick, the phlegm ought to be evacuated by vomits ... if it should be too acrid and thinner than natural the nurse ought to be fed on strong soups and the flesh of swine ... if it be too small a quantity she ought to get soups and a generous diet with sweet wine to drink, and her breasts and nipples should be rubbed ... When the milk is bad, whether it be thick, acrid or of a strong smell, it is first to be sucked out and then the child applied.

Paul proposed 'Medicines for the formation of milk [which] are the root and fruit of fennel boiled in ptisan [barley water] the leaves of cytisus [broom] in dark-coloured wine or ptisan, dill and the root and fruit of the carrot.' While it was important to make sure the milk of the wet nurse was good, Soranus stressed that 'she should be self-controlled, sympathetic and not ill-tempered, a Greek, and tidy'. Her character and behaviour could affect not just the quality of her milk, but also the character and temperament of her ward:

> The wet nurse should abstain from coitus, drinking, lewdness, and any other such pleasure and incontinence. For coitus cools the affection towards the nursling by the diversion of sexual pleasure and

> moreover spoils and diminishes the milk or suppresses it entirely by stimulating menstrual catharsis through the uterus or by bringing about conception.

The baby might imbibe from the milk the bad as well as the good qualities of its nurse, 'since by nature the nursling becomes similar to the nurse and accordingly grows sullen if the nurse is ill-tempered, but of mild disposition if she is even-tempered ... And she should be a Greek so that the infant nursed by her may become accustomed to the best speech.' There were abundant reasons why drinking alcohol should be avoided:

> First the wet nurse is harmed in soul as well as in body and for this reason the milk also is spoiled. Secondly, seized by a sleep from which she is hard to awaken, she leaves the newborn untended or even falls down upon it in a dangerous way. Thirdly, too much wine passes its quality to the milk and therefore the nursling becomes sluggish and comatose and sometimes even afflicted with tremor, apoplexy, and convulsions, just as suckling pigs become comatose and stupefied when the sow has eaten drugs.

The nurse and quality of her milk were vital to the good health and development of the baby. Soranus recommended that infants should be fed on human milk alone until about six months old, but confessed that this was not always general practice, as 'those women are too hasty who after only forty days try to give cereal food'. Like Galen, he regarded the cutting of the first teeth as a signal to introduce weaning foods, first as 'crumbs of bread softened with hydromel [fermented honey] or milk, sweet wine or honey wine [mead]. Later one should give soup made of spelt, a very moist porridge, and an egg that can be sipped.' The child should be fully weaned when it had teeth to chew foods more solid than cereals.

Teething was a dangerous time, associated with numerous complaints. Hippocrates devoted a whole book to 'On Dentition' which he defined as the time in early childhood when the milk teeth erupt. Coinciding with the weaning period, teething was when many infantile illnesses, especially soreness and bleeding of the gums, fever, gripes, convulsions and diarrhoea occurred. The correspondence of teething with weaning focused attention on the transition from human milk to that of other animals, and non-milk foods. Weaning was best done gradually, rather than quickly, 'for it is harmful to anoint the nipple with some bitter and evil smelling things and thus wean the infant suddenly, because the abrupt change has an injurious effect, and sometimes because the infant becomes ill when the stomach is damaged by drugs or new foods'.

FROM THE CLASSICAL AND MEDIEVAL WORLDS TO THE RENAISSANCE

With the decline of the Ancient Greek and Roman civilisations and the rise of Christianity, and then Islam during the first millennium, many classical writings were lost or they were preserved in Arabic translations and infused with the works of Islamic scholars and physicians. Thinking and practice about child care and feeding changed little over this time, judging from the writings of the Persian polymath, Rhazes (*c.* 865-930), and the physician, Avicenna (980–1037), for instance. They reproduced and elaborated the works of Hippocrates, Aristotle, Galen and Soranus, focusing on the practical concerns of

choice of wet nurse, her diet and regime, the nature and quality of milks, how to stimulate lactation and deal with medical problems surrounding teething and weaning. Rhazes reiterated the importance of teething, as both a period of infancy that marked the transition from breastfeeding to semi-solid foods and also a time of many childhood complaints:

> Concerning the ailments which happen to children about the appearing of the teeth, Galen said, when the teeth are coming, often their coming is easy and of little distress, but then the teeth will be weaker; when their coming is slower the distress will be more severe, but the teeth will be stronger and hard; and if teething begins in the spring they come at once without distress, and the reverse if it is in winter, but then the gums will not swell: and if it happens in summer, they have little distress, and there happens to them at this time often swelling in the jaws and gums and glands, and pricking in the ears and discharge of blood and poisonous material, and there happens to some, perhaps, fever and flux of the belly or constipation.

Rhazes was succeeded by Avicenna, and both shared the view that teething and weaning were closely related during the transition from breastfeeding to paps, gruels, broths and other semi-solid vegetable and animal-based foods. These foods were the cause of a constellation of infantile disorders, including diarrhoea, convulsions and bleeding gums, particularly in the summer months. The absence of human milk, from mother or wet nurse, was also blamed for the incomplete digestion that ensued.

> There happens also to infants a flux of the belly, especially at the time of the eruption of teeth, which some affirm happens because the infant swallows with the milk in sucking, a salt and sanious humour excreted from the gums. But it may come from another source; nature being occupied in the manufacture and formation of the part does not complete digestions, for pain more than anything prevents digestions in feeble bodies.

Infancy was a dangerous time and milk could be harmful as well as life-giving. Avicenna's account of the management of breastfeeding, drawing much from Hippocrates, Galen and Soranus, includes a long list of galactogogues (herbal preparations to promote the flow of milk) and stresses that the 'most important and chief principle in the treatment of infants is to have care of the wet nurse'. Whatever the disease of the infant – constipation, pustules, cough, catarrh or flux of the belly – the wet nurse was to be treated by cupping, bleeding, dieting or herbal medicines.

The teachings of both Islam and Christianity influenced child care. The prophet Muhammad, (570–632), was an orphan whose life was preserved by a wet nurse, and he taught that mothers should suckle their children for two full years, and if unable to do so, to employ a wet nurse. She came to share kinship with the biological mother of the baby she suckled, as a 'milk parent'. The Koran laid down rules about health and remedies for diseases, which worked only with Allah's will. The cities Bagdad and Cairo were the sites of medical teaching and the promotion of public health and welfare, which included maternity and infant care, and during the Islamic Caliphates of the seventh to tenth centuries charitable hospitals, pharmacies



Ambrogio Lorenzetti, *Madonna del Latte*, 1330

and public welfare services provided for children. Christianity, on the other hand, proclaimed the healing power of God, whilst acknowledging that health was the highest good of Hippocratic teachings. Religious and secular medicine coexisted, combining prayer, charms, incantations and contact with saints' relics, with diets, herbal remedies, bleeding and simple surgical operations.

Holy mother and child were recurring subjects of early Christian iconography and Byzantine art, and images of the

Madonna in the acts of nursing, bathing and swaddling the baby glorified the holy child and sanctified his mother. The sight of a plump Jesus on the breast was comforting at times when poverty, malnutrition and anxiety about food supply were prevalent. The milk of the virgin Mary was sacred and nourishing, and representation of the *Madonna Lactans* in churches reminded the congregation that God was not just feeding his only begotten son, but all of his children. Milk represented the love of God, just like the blood of Christ was symbolically transmuted and transferred to the faithful at the eucharist. Breastfeeding was a sacred occupation and milk bore goodness and love as well as nourishment. Next to the blood of Christ, Mary's milk was regarded by some as the most miraculous and incorruptible of fluids, with curative properties, secreted in glass vials and treasured with holy relics in churches and shrines.

It is hardly a surprise that most children in Ancient Greece and the Roman world were reared on human milk, either from their mother's breasts or from those of a wet nurse, and then on the milk of another mammal or some sort of non-milk weaning food. However, some babies will have been deprived of proper feeding during infancy. The historian, John Boswell (1947–94), says in *The Kindness of Strangers* (1988) that many children were abandoned throughout Europe from Hellenistic antiquity to the end of the Middle Ages in great numbers by parents of every social standing, for many reasons:

> In desperation when they were unable to support them, due to poverty or disaster; in shame when they were unwilling to keep them because of their physical condition or ancestry (e.g. illegitimate or incestuous); in self-interest or the interest of another child, when inheritance or domestic reasons would

be compromised by another mouth; in hope, when they believed that someone of greater means of higher standing, might find them and bring them up in better circumstances; in resignation, when a child was of unwelcome gender or ominous auspices; or in callousness, if they simply could not be bothered with parenthood.

An early death, often recorded on tablets and gravestones, was the fate of many children. Babies will have died for many reasons, such as infections, congenital abnormalities and birth injuries, but lack of human milk in the early months of life was almost always a sentence of death. Christianity denounced infanticide and abortion (with edicts) and preached love and the care of the young. Nevertheless, Christianity may have increased the rate of infant abandonment by stressing the necessity of procreation in all human sexual acts, and by providing, through churches and monasteries, accommodation for orphans. From sometime in the thirteenth century foundling homes run by holy orders appeared and within a century or two nearly all major European cities had such hospices which took in abandoned children.

While hospices, hospitals and monasteries with their infirmaries offered comfort, nursing and charity, there is little evidence that practitioners with an exclusive or dedicated interest in the medical treatment of sick children, or institutions devoted solely to their care, were common in European countries before the first printed books of the Renaissance. In medical manuscripts children's ills were usually scattered within chapters on gynaecological and obstetric matters, which together with pregnancy, labour and childbirth addressed infant feeding, rearing and the medical problems of early life.

Avicenna, for instance, dealt with the care of infants in three sections of his *Canticum de Medicina* (1025), under the headings 'The Regimen of the Infant First in his Mother's Womb', 'The Choice of the Wet Nurse' and thirdly, 'The Regimen of the Infant in what Concerns Himself' (broadly pregnancy, infant feeding and infant care). 'Let care be taken of the infant in his mother's womb, that no harm happen to his body ... let the mother's blood be kept in good order and let the excess of it, out of which the infant is formed, be kept pure.' Simple rules for the treatment and prevention of children's ailments, such as vomiting, diarrhoea, constipation, fever, dry skin, weakness, worms, teething, epilepsy, ulceration of the mouth and sleeplessness, were based on rules expressed as aphorisms, just like those of the Hippocratic corpus.

With the foundation of the first universities and medical schools from the twelfth century, such as at Salerno, Bologna and Oxford, medical texts (mostly translations of Greek and Arabic manuscripts) formed the basis of a bedside medicine, taught from books that dealt with diseases from head to foot (*a capitem ad calcem*), often seeking to encompass all that was known and written about them. Medicine, alongside Theology and Law, was one of the three faculties of the medieval university, and the teaching of 'physic' was rooted in the teachings of Hippocrates, Galen and Avicenna. It was bookish and scholastic rather than empirical or practical.

The doctrine of humoralism was combined with the practice of astrology, so that each organ of the body and its humour corresponded with a sign of the zodiac – water with *Pisces* for instance – and susceptible to planetary influences corresponding with its qualities – for example, phlegm with the lungs and blood with the liver. Knowledge of one's own constitution (melancholic, bilious, sanguine or phlegmatic), which reflected the



Galen, Avicenna and Hippocrates

relative proportion of the four humours in the body, augured risk of illness, guided treatment and predicted outcome, as well as shaping many features of daily life, including social relations and household management.

General guides to healthy living, or *Regimen Sanitates*, such as the *Tacuinum Sanitatis* (*c.* 1400), combined illustrations with commentaries and summarised the 'six things that are necessary for everyman in the daily preservation of his health, about their exact use and their effects'.

> The first is the treatment of air, which every day concerns the heart. The second is the just use of foods and drinks. The third is the correct use of movement and rest. The fourth is the problem of prohibition of the body from sleep and excessive wakefulness. The fifth is the correct use of the elimination and retention of the humours. The sixth is the regulation of the person by moderating joy, anger, fear and distress.

These, the six Hippocratic non-naturals – air, exercise and rest, sleep and waking, food and drink, excretions, passions and emotions – were the keys to healthy living, and were implicit in the cataloguing, presentation and explanation of the nature, properties, uses and effects of everything from seasons to emotions, foods and drinks to indoor and outdoor activities.

> The secret of the preservation of health will be the proper balance of all these elements, since disturbing the balance causes illnesses which are permitted by the glorious and most exalted God. We shall speak of the choices suitable to each person as dictated by his constitution and age, and will include all these elements in simple tables [illustrations] because the discussion of the Ancients and the discordances among so many diverse books may bore the reader. From science men desire only the benefits, not the arguments but the definitions. Accordingly our intention is to shorten long-winded discourses and synthesise the various ideas. Our intention is also that of not neglecting the advice of the Ancients.

Such health handbooks summarised all that was needed to know how to live well, covering everything from partridges to pine cones, from cabbages to chestnuts. Lac Dulce, or Sweet Milk, came from sheep, and underneath an illustration of a ewe being milked is a commentary listing its nature and properties: 'Nature: Of moderate warmth or sweetly warm. Optimum:



Lac Dulce (Sweet Milk), from the *Tacuinum Sanitatis*, c. 1400

That which comes from young sheep. Usefulness: For the chest and lungs. Dangers: For fevers. Neutralisation of Dangers: With seedless raisins.'

Fennel, a galactagogue to stimulate human milk, is characterised as: 'Nature: Warm in the third degree dry in the second. Optimum: Domestic variety, fresh and strong taste. Usefulness: Stimulates milk and urine flow, diminishes flatulence. Dangers: It is digested slowly. Neutralisation of Dangers: By chewing it well.' The milk of sheep might not be as sweet and warm as human milk, but sometimes the milks of other animals – sheep, goats or asses – were used to suckle infants, directly (on the breast) or indirectly (with bottle or horn), in spite of the anxiety that 'the child nourished on animal milk does not have perfect wits like one fed on mother's milk'. The same concern was attached to the milk of a wet nurse.

FROM HUMORALISM TO ALCHEMY

Works such as the *Tacuinum Sanitatis* embody humoral and Hippocratic ideas, and the account in this chapter of how human milk and infant feeding were conceived and practised scientifically and socially in the classical Graeco-Roman and medieval worlds prefigure and anticipate new conceptions of the nature and properties of human milk, reinterpreted and articulated in the Renaissance in alchemical terms and vernacular languages.

The humoral body, powered by innate heat, animated by pneuma, governed by spirits and ordained by God, presents a physiology of lactation, digestion and metabolism based on the belief that human milk was 'white blood', a vital fluid with all the life-bearing properties of the hot wet red humour. When mother suckled her baby, her milk was transmuted into flesh by coction in its stomach, where the nutritious and spiritual parts were separated from the dross. The ideas and practices of ancient, Islamic and early Christian patristic and medieval authors are the starting point for the development of explanations of the workings of the body inspired by pyrotechnic experimentation in the laboratory.

3
Alchemy

SOFT SWEET SUBTIL SUBSTANCE

> *I intend to write something of the nurse and of the milk, with the qualities and complexions of the same, for in it consists of the chief point and sum, not only of the maintenance of health, but also of the forming or infecting either of the wit or manners. If the lambs be nourished with the milk of goats they shall have coarse wool, like the hair of goats, and if kids in like manner suck upon sheep, the hair of them shall be soft like wool. Whereby it does appear that the milk and nourishing have a marvelous effect in changing the complexion.*

THESE ARE THE words of Thomas Phayre (1510–60), author of the *Boke of Chyldren* (1545), the first printed work in English about the medical care of children. As expressed in many Renaissance treatises and echoing the works of the ancients, Phayre points out that human milk transfers to the suckling baby more than just nourishment, but also the qualities of its nurse. It has miraculous effects. First he puts the nurse and her milk in the context of reproduction:

> To begin a treatise of the cure of children it should seem expedient that we should declare somewhat of the principles, as of the generation, the being

> in the womb, the time of proceeding, the manner of the birth, the binding of the navel, setting of the members, lavatories, unctions, swathings and entreatments ... some only pertaining to the office of the midwife, others to the reverence of the matter not meet to be disclosed to every vile person.

The subject matter and format of most treatises on the health and treatment of children dealt first with pregnancy and child birth, secondly the care, feeding and rearing of infants, and thirdly with their diseases. Phayre declares:

> My purpose is here to do them good that have most need, that is to say, children: and to shew the remedies that God hath created for the use of Man, to distribute in English to them that are unlearned, part of the treasure that is in other languages, to provoke them that are of better learning to utter their knowledge in such like attempts.

God was the source of health. As a Renaissance physician, sharing the humanistic ideals of his time, Phayre's intention was to make this treasure trove of ancient knowledge widely accessible, at least to the literate, by writing in the vernacular. He deals with practical aspects of infant feeding:

> Moreover it is good to look upon the milk, and to see if it be thick and gross or too much thin and watery, blackish or blue, or inclined to redness or yellow, for all such are unnatural and evil. Likewise when you taste it in your mouth, if it be either bitter, salt or sour, you may well perceive it is unwholesome.

> That milk is good that is white and sweet, and when you drop it on your nail and do move your finger, neither fleeteth abroad at every stering, nor will hang fast upon your nail when you turn it downward, but which is between both is best.

Phayre was familiar with the writings of Soranus, and of other ancient authors whose works had been first written in their native languages and later translated into Latin via Arabic versions of their original texts.

> For if Galen, the prince of this art [physic], being a Grecian, wrote in the Greek, king Avicenna of Arabia in the speech of the Arabians; if Pliny, Celsus, Soranus and other of the Latins wrote to the people in the Latin tongue ... what reason is it that we should hugger mugger [conceal] among a few the thing that was made to be common unto all?

We should share this ancient knowledge among us for the common good. This was the knowledge upon which the new thinking about the nursing and care of babies was based in the Renaissance, on 'not only the famous and excellent authors of antiquity, but also the men of higher learning now of our days, as Manardus, Fuchsius, Ruellius, Musa, Campegius, Sebastian of Austrike, Otho Brunfelsius, Leonellus etc.'. With their latinised names, in deference to their ancient predecessors, these learned European physicians, herbalists and botanists embraced the *studia humanitatis* and sought to combine the reading of classical texts with the cultivation of 'good and sure experiments that are found profitable by daily practice'. Phayre saw nature as the guide to feeding babies, whether by mother or wet nurse:

> Wherefore as it is agreeing to Nature so it is also necessary and comely for the own mother to nurse her own child. Which if it may be done it shall be more commendable and wholesome, if not you must be well advised in taking of a [wet] nurse, not of ill complexion and of worse manners; but such as will be sober, honest and chaste, well formed, amiable and cheerful, so she may accustom the infant into mirth; not drunkard, vicious nor sluttish, for such corrupts the nature of the child.

Nature's secrets, or laws, laid down by God, were responsible for the temperament and complexion of the baby, not just through the balance of humours that governed its conception and generation in the womb, but also through the origin and composition of the milk it received after birth. Even the divine poet Virgil, 'thoroughly expert in the privities [secrets] of nature, understood right well how great an alteration everything taketh of the humours, by which it has his aliment and nourishing in the youth; which thing also was considered by many wise philosophers: Plato, Theophrastus, Xenophon, Aristotle and Pliny, who did all ascribe unto the nourishment as much effects or more, as to the generation'.

When Phayre came to address the diseases of children, in the third part of his *Boke of Chyldren*, he revealed his familiarity with the latest alchemical ideas about how human milk is turned into flesh, and how its corruption leads to 'distemper and weakness' of the baby:

> Sleep is the nourishment and food of a suckling child, and as much requisite as the very teat, wherefore when it is deprived of the natural rest, all the whole body falleth in distemper: crudity and weakness it procedeth commonly by corruption of the milk, or too much abundance, which overladeth the stomach, and for the lack of good digestions, vapours and fumes arise into the head, and infect the brain, by reason whereof the child cannot sleep, but turneth and vexeth itself with crying.

Sleep and good food were the two most vital of the six Hippocratic 'non-naturals' to the newborn. The stomach was the home of an 'internal alchemist', which separated the 'pure' from the 'impure' in food. The pure contained the spirit, which was freed from the impure poisonous, thick parts which were expelled in the faeces. If the internal alchemist failed, then corruption of the milk ensued, leading to defective separation, thick chyle, clogging of the blood vessels with unrefined matter and coarse vapours rising up to encumber the brain.

Thomas Phayre, who had been solicitor to Mary Tudor (1516–58), Queen of England, was one of the few of his time who addressed children's care and diseases, and his *Boke of Chyldren* was first published as the fourth part of a compendium, including his translation of the *Regimen Sanitatis Salerni*, another early Renaissance text akin to the *Tacuinum Sanitatis* dealing with domestic medical practice such as daily hygiene and diet. He also wrote *A Goodly Bryefe Treatise of the Pestilence* (Plague), followed by *A Declaration of the Veynes of Man's Body, and to what Dyseases and Infirmities the Opening of Every One of Them Does Serve*, both works indicating that Phayre was thoroughly conversant with the humoral practice of blood-letting, and with the writing of his European contemporaries.

Phayre was a man of learning and a man of letters, and his *Boke of Chyldren* stands at a transition from a medieval to

an early modern conception of nature and the world. Tudor England shared this changing European outlook, mediated by voyages of geographical exploration that opened up new trade routes, advances in navigation and cartography that expanded the map of the world, and discoveries of novel spices, herbs and minerals that enriched the medicine cabinet and kitchen cupboard. Together they stimulated new ways of thinking and living, with man and his endeavours at the centre of the universe.

The artist, Hans Holbein (1497–1543), captures the spirit of the European Renaissance in his portrait of Jean de Dinteville (ambassador of Francis I of France) and Georges de Selve (Bishop of Lavour) visiting the English court. They



Hans Holbein, *The Ambassadors*, 1533

display the instruments of exploration, invention, music and commerce. On the upper shelf, representing the heavens, can be seen a celestial globe, sundial, quadrant and torquetum. On the lower shelf, representing Earth, a terrestrial globe, set square, dividers, lute and flutes, hymn and account books.

Veneration of ancient authority and obedience to the Scriptures was accommodating religious tolerance, observation and experiment, with a shift from a theocentric cosmology to an earthly secularism in many branches of learning. Nicolaus Copernicus (1473–1543) proposed the revolutionary theory of a heliocentric universe in his *De Revolutionibus Orbium Coelestium* (1543) and Andreas Vesalius (1514–64) described the anatomy of the human body from dissected corpses in his *De Humanis Corporis Fabrica* (1543). Both works, published within a year or two of Phayre's *Boke of Chyldren*, challenged ancient Ptolemaic and Galenic frames of thought.

Those who wrote about the care of infants, like Thomas Phayre, were well-connected; court physicians with responsibility for the care of the families of royalty and nobility, or men of education and learning in public offices or universities. Yet, while owing their social and professional positions to the European aristocracy, many wrote in their native tongues and were concerned with the health and welfare of the 'common people'.

The Paduan physician Paolo Bagellardo (d. 1494), for instance, advised that a wet nurse should be procured for feeding the newborn, but 'if the infant is a child of the poorer class let it be fed on its mother's milk'. His Bavarian contemporary, Bartholomew Metlinger (d. 1492), in his German *Ein Regiment der Jungen Kinder* (1473), directed his medical advice exclusively on children, warning that all too often 'our common people give infants a little of the stuff called "quietness", a decoction

or boiled down extract of black poppies or poppy seeds'. His simple handbook brought advice and remedies within reach of the unlearned. Lobera de Ávila (1480–1551), physician to the Holy Roman Emperor, Charles V, produced a *Regimen for the Health and Hygiene of Men and Women and the Diseases of their Children* (1551) in Spanish, and Simon de Vallambert (fl. 1555–65), physician to the Duchess of Savoy and Berry, and 'for a short time' to the Duke of Orleans, 'writing in a tongue understanded by the people' published *The Feeding and Management of Children from their Birth* (1565) 'because the majority of midwives and nurses are ignorant, I have undertaken the writing of this instruction to teach them'.

The authors of these works were practical men of letters linked together not just by their common concern for the care of children and wish to disseminate their knowledge in the vernacular, but also by a shared world-view of the cosmos, God and nature. The cosmos (macrocosm) was divinely ordered, with the sun, moon, planets and stars orbiting in fixed spheres within the heavens, and the human body (microcosm), made of the same elements, mirrored its form and substance: 'The human body is vapor materialized by sunshine mixed with the life of the stars.' The order of this theocentric cosmology was ordained and maintained by God's laws of nature, which ensured harmony of all bodies within and between the celestial and sublunary worlds. Nature was the Art of God, who worked through nature. To understand nature was to understand God.

MEDIEVAL AND ALCHEMICAL PHYSIOLOGY

The humoral physiology of the ancients (Chapter 2) was being reinterpreted within alchemical conceptions of how the body worked. The pioneer of this new theory of transmutation was Theophrastus von Hohenheim (1493–1541), who took not only his Christian name but also his pen-name of Paracelsus from the ancients. However, his mission was to repudiate Aristotle and Galen. He viewed the human body as a chemical laboratory, rejecting humoral theory and its four elements (earth, air, fire and water), instead seeing all things as composed of salt (body – earth), mercury (soul – fluid) and sulphur (spirit – flame), reflecting his trinitarian Christian beliefs. All bodies, whether animal, vegetable or mineral, were made of these three 'principles' and conceived to be alive.

Paracelsus used alchemy to discover the nature and properties of all things. Fire was the chief way to reduce all substances, or 'natural bodies', to their principal parts. Pyrotechnia employed the furnace to heat 'mixed bodies' in alembics and crucibles, with distillation, evaporation and sublimation, to



Alchemical apparatus,
from Steven Blanckaert, 1693

bring about calcination, crystallisation, conjugation and congelation; to separate the pure essence from the impure dross.

In a hermetically sealed flask, base matter might be heated until its contents became coal black, indicating the first step in its transformation. Then the proto-stone displayed myriad colours – the 'peacock's tail' – before turning pure white, and with further heating to dark yellow and into a dense brittle deep red stone, capable of transmuting base metals into gold. The pursuit of the philosopher's stone in the laboratory was a metaphor for the search for the elixir of life, the quest for the 'materia prima' in the form of pure oils, spirits and white precipitates, containing the essences of mixed bodies. Alchemy was a mystical and practical means of understanding and imitating nature.

'This is alchemy, and this is the office of Vulcan; he is the apothecary and chemist of the medicine,' wrote Paracelsus, who saw himself as 'a physician of man and nature' dedicated to unlocking her secrets, and thereby understanding all of God's creation. God was the 'master chemist' and 'man is a microcosm, or a little world, because he is an extract from all the stars and planets of the whole firmament, from the earth and the elements; and so he is their quintessence'.

Just as grains were harvested in the fields, so were minerals mined from the ground. Their 'semina' grew and were delivered from the fertilised and pregnant earth in the same way as plants and animals come into being. Impregnation of the earth by astral seeds and the growth of metals in the earth's veins, the eruption of minerals from volcanoes, the flowering of plants from seeds, the germination of oak trees from acorns, the hatching of chicks from eggs, were all one and the same thing. The internal heat of the earth and the innate heat within the organs of the body was transformative, and the essence of



Jan van der Straet, *Alchemist's Laboratory*, c. 1600

things, vitalised by the *spiritus mundi*, was sought and to be found in minerals, in seeds, in blood and in milk.

Alchemical discoveries confirmed scriptural truths and reaffirmed the cosmic order, even though the conduct of experiments and interpretation of their outcomes might be subject to magical spells and the conjunction of astrological bodies. Paracelsus challenged the authority of the ancients, encasing his alchemical theories within a Christian framework, in which God represented the ultimate cause of all things. However, the Scriptures were not alone of sufficient authority to explain God's work. God made nature and within it living spirits directed all things, and the practice of the alchemical arts was a means of revealing them and thereby the work of God.

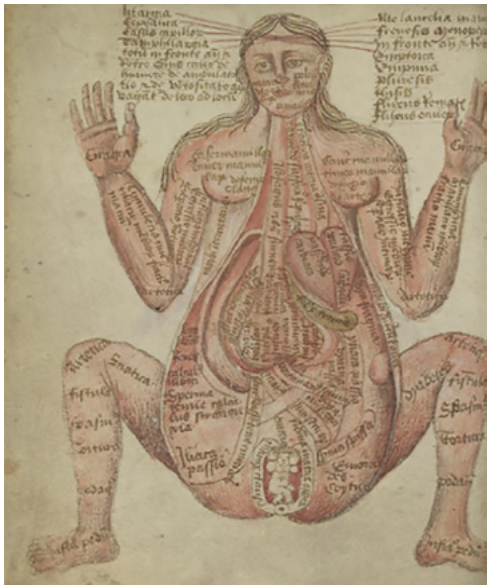
While alchemy was a quasi-religious, mystical search for the *lapis philosophorum, elixir vitae* and *spiritus mundi*, it was also an intensely practical activity, based on observation, use

of the senses and adherence to controlled laboratory procedures, not far removed from cooking. On the kitchen table and in the oven, milk was turned into cheese and flour into bread. 'So the leaven of bread, yeast, rennet and some poisons, excite and invite successive and continued motion in dough, beer, cheese, or in the human body; not so much from the power of the exciting as the predisposition and yielding of the excited body,' wrote the natural philosopher and Lord Chancellor of England, Francis Bacon (1561–1626). In the laboratory, in the kitchen and in the human body, living spirits regulated transmutation and transformation.

THE INTERNAL ALCHEMISTS OF THE RENAISSANCE BODY

The insights and discoveries of the alchemical laboratory suggested how the body worked, how nutrition and generation were mediated by archaei, 'internal alchemists' or 'workers of Nature's mysteries', also called, 'harmonious blacksmiths', 'master craftsmen' and 'workmen of generation'. Archaei presided over and governed all bodily processes, and were especially active in the stomach in turning food into flesh, as Paracelsus explained:

> All our nourishment becomes ourselves; we eat ourselves into being ... For every bite we take contains in itself all our organs, all that is included in the whole man, all of which he is constituted ... We do not eat bone, blood vessels, ligaments, and seldom brain, heart, and entrails, nor fat, therefore bone does not make bone, nor brain make brain, but every bite contains all these. Bread is blood ... for the master craftsman [archaeus] in the stomach is good ... he is there daily and shapes the man according to his form.



The female body, from Johannes de Ketham, 1491

The Renaissance body was a place of metamorphosis, operating like a furnace generating transformative spirits. Like the body of the ancients, it was seen as a system of channels interconnecting its internal organs, of which the heart was the foremost. As the seat of the 'vital spirit' or the *sensitive soul*, presiding over the emotions or passions, the heart, for Aristotle 'the principle and origin of the embryo', was responsible for suffusing the body with the most vital of fluids – blood. Infused with pneuma, this nourishing and vivifying humour expanded and contracted its sinews, as described by the German physician, Eucharius Roesslin (1470–1526), in his *Birth of Mankind* (1513):

> The heart and arteries have two contrary motions: the one is enclosing itself and the other is opening

itself, which sort of movings we call the beating of the pulse. When arteries open themselves they attract, draw in or suck fresh air to temper the heart of the body. When they close themselves they do expel misty fumes, hot breaths and unnatural vapours.

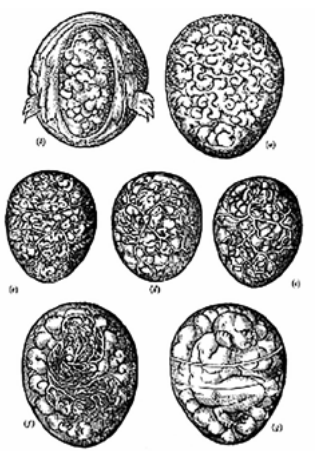
The liver, the seat of the 'natural spirits' or the *vegetative soul*, governed nutrition, growth and metabolism and was responsible for the manufacture of blood from chyle, to nourish the body. The brain, the seat of 'animal spirits' or the *rational soul*, governed movement, thought and choice. These three vital organs of the body – heart, liver and brain – were the mines or laboratories of its three domains that determined all bodily functions and activities. The archaei were at work in all these 'mines', to transmute blood into semen, and flesh and milk, as described by Roesslin:

> The metals of which man is made derive from the mines in the body of man, the first being the mine of the blood, the liver, the second, the heart, the third, the brain, and the fourth, the testes. Semen is whitened blood and mother's milk blanched blood.

Generation involved the combination of male semen with coagulated blood within the female womb, and after birth the conversion of mother's blood into milk.

> When Nature is disposed to make a transmutation of any matter this she cannot do unless she have a mine, shop or workhouse wherein by continuous circulation of the matter transmuted, she may bring her purpose to pass ... The transmutation of blood into semen is not only in colour but also in properties and absolute perfection. What greater miracle is there wherein we may knowledge and behold the omnipotency of God.

The formation of the baby in the womb from the coagulum of blood and semen was like the formation of the chick from the white of a hen's egg. The physician and astrologer, Jacob Rueff (1500–58), illustrated the process: 'After the womb hath conceived the seed of man, it doeth admix and mingle her seed also to it ... therefore both seeds mingled, blended together are soon compassed and enclosed about with a certain little coat or caule.' Wrapped in the fetal membranes (caule) there appear three 'white bubbles not unlike coagulated milk'. The blood vessels springing from the heart spread over the surface of the embryo, which assumes the outline of a fetus, with first a head and then whole body.



Coagulum of blood and seed in uterus, from Jacob Rueff, 1580

Gestation was a form of fermentation: 'the blood boileth and fermenteth in the womb, and swelleth into three bubbles' forming the vital triad of bodily organs, liver, heart and brain, which were to become the seats of the vital, natural and animal spirits or souls. Semen was infused with pneuma, the vital spirit which gave it its white foamy nature and appearance. After conception nutriment and vitality flow from mother to the unborn baby by the umbilical cord, and 'through these [umbilical] arteries lively spirit and fresh air is derived out of mother into the chylde, wherewith the natural heat of the chylde is vivified and refreshed'. The placenta was an organ of transmutation, like the liver:

> Forbecause that she [nature] would that the pure blood coming from the matrix [mother's] veins should be made yet purer, she suffereth not the same to enter immediately into the infant, and send it into the Chorion or the Loope caule [placenta] where truly it hath a certain circulation and another digestion, whereby it is desecate [dried] and cleansed very exquisitely, by the diligence of Nature attenuated and fined, and so at last sent forth into the infant leaving all the grosser part in the spongy body of the Loupe caule.

The artist and inventor, Leonardo da Vinci (1452–1519), depicted the human fetus *in utero* wrapped in the membranes composed 'when the earthly portion [blood] solidified all around its outer surface'. He wrote that 'Nature places in the bodies of animals the soul, the composer of the body' and it was from the blood carried from mother to fetus by the umbilical cord that it reached the unborn baby: 'the soul of mother, which first composes, in the womb, the shape of man and in due time awakens the soul which will be the inhabitant thereof, which first remains asleep and under the tutelage of the soul of the mother which through the umbilical vein nourishes and vivifies it'.

Leonardo's depiction of the fetus in the womb was not simply a reiteration of the views of Galen, Aristotle and Clement, but informed by his dissection of the pregnant uterus of women and other mammals, from which he illustrated the fetal membranes, umbilical cord and placenta, noting that 'the veins of the child do not ramify in the substance of the uterus



Leonardo da Vinci, *Pregnant uterus*, c. 1490

of its mother but in the placenta which takes the place of a skirt in the interior of the uterus which it coats and to which it is connected but not united'. He went on to say:

> Note how the fetus breathes and how it is nourished through the umbilical cord and why one soul governs the two bodies, as you see the mother desiring food and the child growing because of it ... Breathing is not necessary to the embryo because it is vivified and nourished by the life and food of the mother ... The child lies in the womb surrounded by water, because heavy things weigh less in water than in air.

Leonardo also noted that the child in the womb secretes urine, has excrement (meconium) in its guts and chyle in its stomach. After birth the newborn baby was nourished on mother's milk, made from the blood diverted from the womb to the breast, which 'Coming from afar off the blood is better digested and more easily converted into milk.' Galen had taught that 'Nature brings blood and pneuma to the breasts, not from vessels nearby, but from those that have traversed a very long interval' and 'since the breasts and the uterus were created to perform the same function, they have common arteries and veins which extend between them'. The blood vessels to the womb were connected to those passing through the chest so that blood could be diverted to the breast and turned into milk, as Roesslin wrote:

> When the time of birth arrives, does Nature, the worker of all hidden mysteries drive to the breasts that fluid and blood that previously was in the womb, and this is whitened by much heat and complicated elaboration so that it may cherish the beginnings of light and life, and afford a known and familiar food.

Such was how human milk was concocted from blood. The anatomist, Andreas Vesalius (1514–64), described the vessels connecting the womb and breasts in his *De Fabrica*, published the year before Phayre's *Boke of Chyldren*:

> These vessels that travel upwards take their origin from the great artery and the hollow vein as they are about to pass through the groins into the leg ... Though they do not come forth from the same root as the veins that go to the uterus, they lie so close to the uterus and are such near neighbours of it that it is believed that the blood that gathers here in the veins of the uterus is able to be taken up by the vessels and carried upwards [to the breasts].

At birth the whitened blood was immediately available to the baby.

> When the fetus is given forth into the light of day, it sucks the milk as its own nourishment from the breasts, untaught by anyone. The breasts have their location in the chest and are furnished with nipples; they are built up of a glandulous material which, by an innate force, converts the blood brought to them by the veins into milk.

Translations of classical works from Latin and Greek and the publication of printed books in vernacular languages, often illustrated with woodcuts, such as Thomas Raynalde's

English translation of Roesslin's *Byrth of Mankynde* (1545), refer to Vesalius's *De Fabrica* (1543) alongside medieval illustrations of the various positions that the fetus might assume in the womb. Fusion of the 'old knowledge' of Galen and his contemporaries with the 'new anatomy' of Vesalius and his modern contemporaries perpetuated ancient errors and medieval suppositions. However, these new conceptions of the body, rooted in Aristotelian doctrine, Christian theology, medieval alchemy, hermetic philosophy and animal dissection, including the origin, production, digestion and nutritional effects of human milk, found coherent expression in distillation books, childbirth manuals, medical treatises, didactic poems, bestiaries, herbals and scriptural commentaries, which blended naturalistic and descriptive information with a mass of literary, etymological, biblical, moral, mythological, astrological and metaphorical meanings.



Fetus in the womb, from Eucharius Roesslin, 1545

Medieval animal lore gave way to knowledge gathered by observation on the habits and habitat, physiology and utility, diseases and diets of animals, often with illustrations. Florals included 'materia medica' and were practical, listing the properties and medical uses of spices and herbs, many from the Orient and Africa. In medicinal, physic and botanical gardens, native and exotic herbs and other plants were cultivated and exhibited. Distillation books described chemical processes, apparatus and recipes involved in separating, isolating and purifying essences that had healing, curing and health-promoting powers.

PICTORIAL AND POETIC REPRESENTATIONS OF HUMAN MILK AND INFANT FEEDING

Written and published in native languages, this 'new' knowledge was not accessible to the illiterate. In a world in which many people could not read, images of the holy child on his mother's breast served to illustrate the dual nourishment and vitality of human milk. Human milk was a metaphor for nutrition and vivification: a miraculous fluid, the source of spirit, life, and growth. The holy womb was the saintly oven in which Christ was incubated and the holy breast the 'sacred fount, the nurturer of man's body' on which He is fed, with milk bearing nutritional and spiritual goodness and life, by God, via the holy mother to His only son.

Human milk was also a very real expression of charity, provided by wet nurses to foundlings in homes and hospitals for abandoned children which were to be found in many European cities. The Ospedale degli Innocenti, for instance, was a home in Florence responsible for the welfare of orphaned babies, sometimes abandoned in a basin located in the front



Jean Fouquet, *Madonna del Latte*, c. 1453

portico. It represented an expression of the social and humanistic culture of the early Renaissance. Babies were taken in, as described by a visiting monk:

> Within the walls of the City of Florence [there is] a place where exposed infants of uncertain parentage are cared for, more than 200 of both sexes. Customarily they are first given over to wet nurses for breastfeeding. When they are weaned they are diligently cared for within this institution.

Ceramic tondi of babies in swaddling bands in the spandrels of the arcade of the Ospedale, cast by Andrea della Robbia (1400–82), proclaim the public charity and humanistic values of the foundling hospital of Florence. Many of the children received into the *Innocenti* were suckling infants, abandoned because mothers were too poor to support them or were even hoping to apply to become wet nurses themselves.



Andrea della Robbia, medallion on
Ospedale degli Innocenti, Florence, 1487

Wet nursing was a thriving occupation throughout Renaissance Europe, not just for foundlings but also for the offspring of the aristocracy, whose mothers were 'too delicate or too haughty, or they do not like the inconvenience' of nursing their baby. Urban parents of the merchant and upper classes employed live-in nurses or sent their children out to be nursed, and the 'business of wet nursing' was organised by men, usually the fathers of the children to be nursed and the husbands of those who nursed them. The majority of nurses were married women who had recently been confined but lost their baby and might care for their charges, as nurse-cum-governess, until they reached adulthood. The great sculptor, Michelangelo (1475–1564), attributed his talent to his wet nurse who was a stone-cutter's wife: 'With my nurse's milk I sucked in the hammers and chisels that I use for my statues.'

Wet nurses were to be found within the households of royalty, as well as artisans and aristocrats. Diane of Poitiers (1500–66), mistress to King Henry II of France, takes a bath



François Clouet, Diane of Poitiers, *Mistress of King Henry II*, c. 1550

while a wet nurse suckles her baby. Cool, beautiful, aloof, bejewelled, accompanied by the trappings of her state, she holds a passion flower in her hand. Demotion of her wet nurse to the background of the painting makes it clear that feeding babies was not the job of a royal mistress, whose breasts were reserved for the pleasure of the king.

A didactic poem on the care and rearing of babies was dedicated to the king's son, Henry III. Composed by Scévole de St Marthe (1536–1623), another learned humanist and mayor of Poitiers, *Paedotrophia – the Art of Nursing and Rearing Children* (1584) offered practical advice and guidance in three books on pregnancy, childbirth and infant care in Latin iambic pentameters. Theoretical thinking about gestation and the nutrition of the fetus and newborn are combined with practical instruction on how to feed infants. St Marthe reminds the reader that blood bears both nourishment and the spirit of life to mother and unborn baby:

> The blood conveys it [spirit] to the child within,
> While, latent in the womb the child abides,
> The mother's blood thro' his thin vessels glides,
> Feeds both alike, diffusing o'er the whole,
> And both are filled with one informing soul.

Mother's blood, the source of nourishment, passed to the baby in the womb, bearing also soul. It was also channelled through mother's breasts, where it was transformed into milk (white blood), while retaining its vital properties. St Marthe explained how the unborn baby:

> While yet imprisoned in the womb he lay
> Was given by Nature for his earliest food,
> And filled his slender veins with circling blood.
> The dye just changes, when by winding ways,
> Swift through the breast the vital current strays;
> Through glands pure and white the exulting juices flow,
> Leave the firm red, and melt in tides of snow;
> Of milk the colour, and the name, they take,
> But yet their ancient nature ne'er foresake.

Mother's milk was, of course, as St Marthe writes, the proper and best milk for the newborn, just as it was for the young of other mammals, such as:

The bristly boar on the cold mountain's head
The spotted tigress in low valleys bred
And all the monsters of the savage throng
With their rude nipples feed their infant young.

Nature taught that the newborn should be allowed to suck as he wishes, on demand, as St Marthe advised:

And I, for suckling, no fix'd hour prescribe;
This nature teaches best the nursing tribe:
Let her your mistress be; and when, with cries
The hungry child demands his due supplies,
Forbear not you the wish'd relief to bring.
But, for his use, unlock the sacred spring;
Nor then be loth your snowy breast to bare,
That he may suck, and streaming fragrance share.

Human milk was transmuted from blood by the 'harmonious blacksmith' (archaeus) who used fire to turn coal into life-bearing sulphur with methods comparable to those used by the alchemist in his laboratory, in which the black stone passes through every hue as it is heated in the flask, until pure white milk is concocted. Alchemy was at work within the body, turning blood into milk.

So when the blacksmith hast his work to frame,
And the huge bellows blow the rapid flame,
The sooty coal to living sulphur turns,
And bright the mass within the chimney burns;
But if the metal gentler heat require,
And sprinkled water quench the liquid fire,
The changing coal its former hue regains,

But red, or black, the substance still remains.
That snow-white colour too, most undefiled,
Suits best the nature of the infant child,
Who ne'er should tinge his tender jaws with blood,
As if, from recent slaughter, came his food.

Paedotrophia was a poetic distillation of contemporary thinking about fetal nourishment, maternal nursing and infant care. It was translated from the French soon after its publication in 1584, went through many editions and was compared favourably with Virgil's *Eclogues*. St Marthe intended his work chiefly for the use of mothers and nurses, but 'it was besides, during his life, publicly read and interpreted to the youth in some celebrated schools and universities, in exactly the same manner as ancient authors are', and in dedicating it to the king of France St Marthe begged to point out:

> that although the subject of [the poem] seems at first view too low and vulgar to be presented before the eyes of so great a monarch, seeing it only treats of the method of nursing children at the breast, and of preserving those young and tender plants against an infinite number of storms and tempests which menace and frequently destroy them as soon as they are born, which design, nevertheless, to those who consider it thoroughly, will not be found altogether unuseful for your majesty's service, whose power and dominion extends not only over countries, cities, castles and other things inanimate, but also principally over many millions of souls and of living persons in the preservation of whom your majesty has a notable interest.

St Marthe rose to be Treasurer-General of France, and sought to draw the king's attention not just to the ignorance of the medical profession of the care of infants but also to the frailty and mortality of the newborn, and the consequences of this to 'the health of the French nation'. How infants were fed and reared had personal, domestic, medical and national implications; knowledge of the nature of human milk, and how red blood was transmuted into white milk, formerly restricted to classical scholars, was becoming known and written about, in prose and verse, by physicians of man and nature, alchemists, theologians and statesmen.

COCTION, GENERATION AND TRANSMUTATION ARE FERMENTATION

Fermentation was the fundamental process of transmutation. In the kitchen, in the laboratory and in the living body archaei effected transformations of foods and drinks. For the baker, the dairyman, the brewer, the vintner and the distiller, culinary knowledge and artisanal craft were combined to produce bread, butter, cheese, beer and spirits. As the German physician, Daniel Sennert (1572–1637), wrote:

> Thus in milk there are butter, curds and whey. And what else are digestions and coctions – not only those that are carried out by art [artificially, al-chemically], but also those that are brought about by nature in the bodies of plants and animals – than first a resolution of the bodies to be mixed into their minimal parts, and again a concretion according to the proper nature and use of each thing.

These processes of separation (resolution) and unification (concretion) of 'natural bodies' observed in the kitchen also occurred in living things. Vegetables were prone to acid fermentation; grape juice turning into vinegar, and meats were prone to putrefaction; flesh becoming ammoniacal or alkaline. Milk underwent coagulation; it curdled and separated (more acescent than alkalescent). Fermentation, with its ebullition and effervescence, played a visible part in brewing and baking, and was what happened to foods in the stomach too. Fermentation, wrote the fourteenth-century alchemist, Petrus Bonus of Ferrara:

> denotes seething or bubbling, because it makes the dough rise and swell, and has a hidden quality which prevails to change the dough into its own nature, rectifying and reducing it into a better and nobler state. It is composed of divers hidden virtues inherent in one substance. In the same way that ferment which is mixed with our quicksilver makes it swell and rise, and prevails to assimilate it to its own nature, thus exalting it into a nobler condition.

Leavening flour, just like the transformation of quicksilver with sulphur, involved the action of the archaeus, the same invisible, hidden, 'magical' spirit responsible for raising dough into bread and mercury into gold.

Paracelsus had argued that an understanding of nature could only be achieved by the rejection of the authority of the ancients and its replacement with divine knowledge obtained from chemical observation and investigation of God's created universe. Jean Baptiste van Helmont (1579–1644), who succeeded him and followed his teachings, agreed that God had

created nature, but that his work could be imitated by chemists; experiment would reveal knowledge of how God worked and that such knowledge could be used for the good of man. 'Nature called not Divines to be her Interpreters, but desired Physicians only to be her Sons,' argued van Helmont, whose explanation for the existence of all things was based on a system of elements and their lifecycles. The transformative action of the archaeus of Paracelsus was a process of fermentation.

In the human body a series of six fermentations mediated transformations. The first, coction, occurred in the stomach, the second ferment occurred when the acid chyle passed into the duodenum and was neutralised. The third occurred when bile and chyle passed through pores in the walls of the intestines to be converted into blood by a fourth in the liver. From the liver the transmuted blood passed to the left ventricle of the heart where a fifth fermentation transformed venous into arterial blood, rich in a volatile spirit (*spiritus vitae*). Vitalised blood then passed to the brain and other tissues where a sixth fermentation produced a pure, volatile 'animal' spirit which effected sensation, movement, cognition, or was assimilated into flesh. Fermentation was a fundamental process of transformation.

Van Helmont thought that everything was ultimately composed of water, which was the 'materia prima'. Water was an 'empty' medium and all bodies were its 'fruits', begat by semina that bore 'prolific spirit'. He thought that gas was inseminated water and the purest form of a body, containing the seed or spirit; when a solid body was turned into gas, the gas was the body in a spirit-carrying state, rather than the pure essence of the body, separated and released from it, as Paracelsus had held. Van Helmont perceived that this volatile, wild *spiritus sylvestris*, or aerial nitre, given off by burning charcoal, was the same as that produced by fermenting must (unripe grapes). Its origin was the insemination of water, which accounted for the growth of plants and trees, for instance.

> I call this spirit, unknown hitherto, by the new name of Gas which can neither be constrained by vessels, nor reduced to a visible body unless the seed being first extinguished. But bodies do contain this spirit and so sometimes wholly depart into such a spirit not indeed because it is actually in those very bodies, but it is a spirit grown together, coagulated after the manner of a body and is stirred up by an attained ferment, as in wine, the juice of unripe grapes, bread, or water and honey.

For van Helmont fermentation was a chemical and spiritual force, integral to a body, capable of multiplying itself *ad infinitum*, subjugating and seminally impregnating any object, making it similar (assimilating it) to itself, and perfecting it by effervescence and by acidity. The vital spirit was a volatile alkaline salt, a gas.

FROM ALCHEMY TO CHEMISTRY

The Renaissance body and the Renaissance world were places of metamorphosis. In a vitalistic universe, directed by God the divine alchemist, spiritual forces in the form of *semina, anima, archaei* and *spiritus mundi* mediated all natural phenomena, including nutrition (digestion, metabolism, growth) and generation (conception, gestation, lactation). Human milk was at the heart of human generation and nutrition, and just as the heart was central to the workings of the body, so was the sun

at the heart of the universe. In the ordered harmony of macrocosm and microcosm, with its correspondences of heart, sun and God, astral seeds with human semen, human milk was a vital fluid with nutritional properties and spiritual meaning.

A new physiology based on anatomical dissection, including vivisection, questioned classical ideas about how the humoral body worked; permeable to the flux of fluids via invisible pores (in the septa of the heart) and unseen blood vessels (connecting the womb to the breasts), for instance. Observation and experiment cast doubt on Galen's teaching and the authority of the ancients. Anatomic knowledge of the male and female genitalia, and the content of the womb, was revising notions of generation. The 'arts' of chemistry and physic were revealing the secrets of nature, which was God's creation. The practice of the mystical, hermetic and occult arts, of alchemy, magic and astrology, with their reference to the correspondence between macrocosm and microcosm, was declining in the face of material explanations of the natural world, tested by experiment and expressed in quantitative and mathematical terms, albeit within frameworks of thought in which religious belief persisted and God remained the author and controller of all things on Earth and in the heavens.

4
Science

CORPUSCULAR FLUID

Some consider it [coction] to be liquefaction: some grinding and cutting and special attraction by individual parts; others a kind of putrefaction and fermentation; others a distillation through descent and retort. All have spoken partly correctly, partly incorrectly, because it is not something wholly of itself alone. Therefore philosophically coction is change of the whole substance with generation and corruption. Chyle and blood from food and drink mixed. Chyle is first.

IN HIS LECTURES on the 'whole of anatomy' to the Royal College of Physicians in the 1620s, William Harvey (1578–1657), yet to publish his revolutionary treatise on the motion of the heart, *De Motu Cordis* (1628), reviewed the various ways in which gastric digestion was thought to occur. He listed non-humoral, alchemical and culinary explanations of how substances might be transformed from one form into another in the stomach. In whatever way coction came about (most favoured fermentation), it produced a milky liquid called chyle.

The practice of vivisection, spurred by the publication of Vesalius's *De Fabrica* and a shift from alchemical to corpuscular theories, prompted experiment inspired by speculative observation. Harvey professed 'both to learn and to teach anatomy,

not from books but from dissections; not from the propositions of philosophers, but from the fabric of Nature'. His lectures showed how anatomy could illustrate not just how the body was made, but also how it worked. Nature was alive: coction might resemble 'distillation through descent and retort' as alchemists suggested, or 'putrefaction and fermentation' as was observed in the kitchen, but its secrets were to be found in the study of the chemical and mechanical workings of God's living creatures, including man.

Coction was a fundamental process, 'a change of the whole substance with generation and corruption', a transformation which played a central part in gestation, lactation and digestion, and at the heart of these was human milk. 'If we would define or describe what milk is, it seemeth to be nothing but white blood', wrote the English physician Thomas Muffett (1553–1604, whose daughter sat on a tuffet eating her curds and whey). This received view, which had come down from the ancients, elaborated by medieval authors and revised by alchemical theories, was that blood was transmutable into milk, and milk into chyle, the milky white product of gastric coction which passed from the stomach to the liver where is was transformed into nutritious blood.

The processes of nutrition and generation were governed by fermentations – in the stomach, in the liver, in the womb and in the breasts – and that which took place in the stomach (coction) was the most accessible to direct study. The stomach was the chief and first site of coction – the *prima via* where food was first fermented. 'Digestion, or the fermentation of what is in the stomach, is the prime work of the body ... *Chyle is first*,' said Harvey.

For the physician Thomas Willis (1625–75), fermentation was a transformation of substances brought about by internal

movements of their component parts. Fermentation, or inner motion, occurred in the blood and was an expression of its organic vitality. The human body was inhabited and governed by vital forces. A flame-like spirit circulating in the blood was responsible for heating it, but the heart itself was not the seat of vital heat, as the ancients taught; rather blood communicated its warmth to the cardiac organ during passage through its chambers.

Nutrition was extraction and movement of spirits, or as Willis put it in his *De Fermentatione* (1659), spirits are 'substances highly subtil, and aetherial particles of a more divine breathing, which our parent Nature hath hid in the sublunary world, as it were the instruments of life and soul, of motion and sense'.

Fermentation (coction) initiated this refinement, and it was a chemical and mechanical process of reducing food to a chyle of fine, small, subtle particles that passed easily into, and mixed most freely with blood. 'This we conceive to be the true progress of Nature, from the first reception of the spirits contained in the aliment, to their education into the chyle, their sublimation in the heart, their gradual exaltation to the highest degree of volatility,' concluded the natural philosopher, Walter Charleton (1620–1707).

> Fermentation is an ebullition [bubbling, boiling] raised by the spirits that endeavour to get out of the body, for meeting the gross earthly parts that oppose their passage, these swell and rarifie the liquor until they find their way out, now in this separation of parts the spirits do divide, subtilise and separate the principles so as to make the matter of another nature than it was before.

The 'spirits that endeavour to get out' were the most volatile, pure and vital. Fermentation separated the pure from the impure, the 'flour from the bran', but it also released the spirit – the lightest, most subtle parts. It caused spirits to go from fixation to volatility.

THE BODY IS A MECHANICAL, HYDRAULO-PNEUMATICAL ENGINE

William Shakespeare (1564–1616) had aptly characterised the late Tudor conception of the body as a warehouse and workshop, with three domains, presided over by its principal organs: 'Liver, Brain and Heart, these sovereign thrones', each the seat of a governing spirit. The liver 'receives the general food at first which you do live upon [and] send it through the rivers of blood to the court of the heart, to the seat of the brain'.



The body as warehouse, workshop and laboratory, from Tobias Cohn, 1708

This conception of the body as a warehouse and workshop was elaborated, questioned and revised by a group of seventeenth-century Oxford physiologists and physicians, Robert Boyle, Thomas Willis, Walter Charleton and Francis Glisson, who blended anatomy and chemistry into a mechanical corpuscular philosophy. Robert Boyle (1627–91) described the body as a hydraulic and pneumatic machine.

> I look not on a human body as on a watch or a hand-mill, i.e., as a machine made up only of solid, or at least consistent parts; but as an hydraulical, or rather hydraulo-pneumatical engine, that consists not only of solid and stable parts [organs]; but of fluids, and those in organical motion. And not only so, but I consider that these fluids, and the liquors and spirits, are in a living man so constituted, that in certain circumstances the liquors are disposed to be put into a fermentation or commotion [coction] whereby either some depuration [purification] of themselves, or some discharge of hurtful matter by excretion, or both, are produced.

This hydraulic notion of fluids in motion became widely adopted, and informed the debate about the mechanisms of digestion (coction), as posed by Harvey. The digestive organs acted together like progressively finer sieves, filtering out the subtler from the coarser and the digestible from the indigestible material, according to the size, shape and motion of particles. The finest particles of food, which possessed the greatest activity and motility, were charged with ethereal matter and insinuated themselves, through their motive force, into the mass of the blood, and by sanguification the most vaporous

and volatile parts were carried throughout the body and to the brain. Coarser particles passed through the wall of the gut to lacteal vessels, thence to the liver and right side of the heart, while the heaviest particles, which were most passive and inert, were expelled in the faeces.

This was a corpuscular conception of digestion, in which the archaei ('master craftsman', 'chemical director', etc.) were discarded. They, the *ignis digestionis* (digestive fire) or natural heat of Galenic coction, and the heat of fermentation of Paracelsus and van Helmont, were replaced by a chemico-mechanical model in which digestive fluids – saliva, gastric and pancreatic juices, and bile – separated chyle into its component parts as it passed down the gut. 'Fermentation was chylification' brought about by chemical means.

In addition to the employment of furnace, alembics and retorts to determine the elemental composition of intestinal juices, the microscope focused the scientific gaze deeper into living matter, revealing thitherto unseen and unimagined worlds of wonder and complexity, including the minute particulate structure of foods and fluids, such as blood and milk.



Robert Hooke's microscope, late 1600s

The ingenious inventor and maker of scientific instruments, Robert Hooke (1635–1703), assistant to Boyle and Willis in Oxford, pioneered the use of a two lens (compound) microscope in his role as curator of experiments for the Royal Society of London. In *Micrographia* (1665) he published engravings of a flea, a louse and the eye of a drone-fly, magnified 300 times and spread across two folio pages. Alongside the microanatomy of insects, Hooke illustrated pictures of magnified seeds, spores, crystals and the cells of cork wood. In the Netherlands, the Dutch naturalist and microscopist, Antonie van Leeuwenhoek (1632–1723), corresponded with the Royal Society about his own discoveries using a powerful monocular lens to reveal tiny 'swarming animalicules' in a drop of pond water, wriggling spermatozoa and teaming red corpuscles (erythrocytes) in blood.

The Italian physician, Marcello Malpighi (1628–94), observed under the microscope lens the movement of these red blood corpuscles passing through tiny vessels between the pulmonary artery and veins of the transparent lung tissue of frogs. They were only slightly smaller than the smallest diameter of



Antoine van Leeuwenhoek's blood corpuscles, from *Arcana Natura*, 1695

capillaries, and in *De Polypo Cordis* (1665) he concluded that 'the blood is not a mixture of four humours, but its substance consists of almost an infinite number of particles, white serum and red atoms [erythrocytes]'. Boyle analysed blood and listed its nature and properties: its colour, taste, temperature, weight, combustibility and component parts; red and serous portions, volatile and fixed salts, oil, mucous, and its reddening when shaken in air. Clearly the blood in the arteries and veins was not a uniform substance. Just like chyle and blood, milk was a corpuscular fluid with vital properties.

NATURE AND PROPERTIES OF HUMAN MILK – ACIDS AND ALKALIS

Human milk was composed of fine, motile particles that passed freely through pores in the gut wall and via the portal vein to the liver where sanguification occurred. The natural philosopher and physician, Francis Glisson (1597–1677), summarised its nature and properties: 'Breast milk is the most salubrious and agreeable nourishment of tender age, especially when it is sucked from the Breasts: for it is simple meat, full of nourishment, easie to concoct, and friendly and familiar to the constitution of infants.' Milk was a 'soft, sweet and subtil substance', free of 'coarse parts' and easily turned into chyle in the stomach, without 'grinding and cutting' (trituration) or 'fermentation or putrefaction'. The milk of cows, for instance, could be curdled, congealed and separated into parts with a little chemical manipulation, as the French apothecary, Nicolas Lemery (1645–1715), observed:

> If we consider the natural composition of milk, we shall find it to be nothing but a creamy substance swimming on the serum and mixed superficially with it, by the intermixture of some salt, so that it is in a fitting state of separation, as soon as the salt gains a little more motion than it had, whether it be by Fermentation or by increasing its activity by an Acid of its own nature.

The milks of cows, asses, goats and sheep shared the same essential nature; made up of creamy and serous (watery) parts. 'Thus when the heat of the summer, or fire, has stirred up the acid that is in the milk, or else some acid is poured onto it, the edges of the acid do cut and divide the creamy part, to gain a free motion in the serum, and separate into curd all the butter and cheese.' Milks were not 'uniform' substances; they could be separated into constituent portions which could be combined to make many dairy products, from junket to custard.

Different milks served different purposes. Asses' milk, for example, was a good alternative to human milk for children and invalids. 'Neither is women's milk best onely for young and tender infants, but also for men and women of riper years, fallen by age or by sickness into compositions. Best I mean in the way of nourishment, for otherwise asses' milk is the best.' However, the long-held view that the milk imbibed by babies could affect their characters should not be forgotten, 'for as lambs sucking she-goats bear coarse wool, and kids sucking ewes bear soft hair, so fine children degenerate by gross woman's milk, losing or lessening that excellency of nature, wit and complexion which from their parents they first obtained'.

Digestion was a chemical process, an 'acid ferment' in the stomach, and acid was a ubiquitous and fundamental property of nature. 'There is no salt in Nature besides the Acid [salt], out of which all other salts are made, and that the Alkali salt

has no natural existence in mixt bodies,' stated Lemery, following van Helmont: 'All salts are derived from fossil or gem salt formed from an acid liquor flowing in the veins of the earth. Acid liquor insinuates itself into the pores of stones and after concoction from primordial salt.'

Foods and drinks could be classified according to their acidity and alkalinity. The method used to assign them to one or other category was exposure to fire, to heat salts to yield their constituent parts. Vegetable salts, derived from terrestrial salts by absorption into plants, were composed of a crystalline acid salt from the juice of the plant, a volatile alkaline salt from distillation of macerated fermented seeds, and an alkaline fixed salt from the ashes of the combusted plant. Substances that were acids tended to combine with those that were alkaline.

> There are as many different alkalis as there are bodies that have different pores, and this is the reason why an acid will ferment with one strongly and with another not at all, for there must be a due proportion between the acid points and the pores of the alkalis.

Acid salts had sharp pointed spikes, visible when crystals were examined under the microscope, which accounted for their prickly sharp taste, while alkaline salts had 'pores' which could admit the spikes of acid salts. Moreover when acid and alkali salts were combined, ebullition and effervescence ensued: fermentation was a chemical process.

Lemery established a pharmaceutical business in Paris where he offered a course of lectures about these matters to apprentice pharmacists, which also attracted the 'curious intelligentsia to his scientific expositions'. He defined chemistry as the art of separating purer substances from mixed bodies – the



Acid and alkali

useful parts from the unuseful parts – and how to join them together again; principally through the 'art of fire' – pyrotechnia. 'If we would come as near as may be to the true principles in nature, we cannot take a more certain course than that of chemistrie ... [which] ... will give us the figure [shape, properties, form] of the first small particles [elements, atoms, corpuscles] which have entered into the composition of mixt bodies.'

Lemery's *Course of Chemistry* (1689) offered physicians 'an easy method of preparing those chemical medicines which are used in Physick, with curious remarks upon each preparation for the benefit of such as desire to be instructed in the knowledge of this Art'. The products of the 'Art' were essences, tinctures, extracts, elixirs and potions, with healing powers and therapeutic properties. One of Lemery's principal quests was to distinguish acid from alkaline substances and purify them for medicinal uses.

> Coral, Pearl, Crabs Eyes, burnt Harts horn, all being Alkali, the acid points do stick in it, and suspending its parts do render them imperceptible, and this is the reason that Vinegar doth lose all its Acidity, because the acidity did only consist of the activity of its points which do now sheath themselves in the Alkali.

The white precipitate of the dissolution of coral, pearl, crab's eye and hart's horn was a *magistery*, a 'most exquisite and subtile principle of nature having transmuting or curative properties', a pure alkaline preparation which neutralised acid, and could thereby restore the chemical imbalance of the sick body. Milk was transformative, nourishing and healing, but it could easily be corrupted if not properly constituted or digested, and here was a remedy.

CHEMICAL MEDICINE AND THE ACID BODY

The English physician, Walter Harris (1647–1732), was among those who attended Lemery's lectures and translated his *Cours de Chymie* into *A Course of Chemistry*. Three years later he published his own work on the diseases of children entitled *De Morbis Acutis Infantum* (1689). Claiming that children's diseases were 'easily cured when skilfully handled', acknowledging his debt to the physician, Thomas Sydenham (1624–89), 'far from despising chemistry ... elated by new and useful inventions – telescopes and microscopes', and 'having seen with great wonder the blood of animals hurried in a torrent through the arteries to the extremities, and return [to the heart] with no less celerity through the veins', Harris regarded himself as a modern physician acquainted with the latest scientific discoveries, and attached great importance to acidity as the primary cause of infantile ailments:

> He who knows that there are only two sorts of sharp salts of contrary natures, a lye (alkaline) and a sowre (acid) salt, and as they meet more or less pure do make an effervescency or opposition, often accompanied with heat, seldom with cold, may easily conjecture that one or both of these salts are amiss in the infant's body.

Harris wrote that 'all diseases to which the human body is subject are perfectly the same as to their manner of production, their whole diversity arising from the difference of the parts affected'. Blaming excess acidity for children's complaints, he took the view that:

> The antecedent and more distant Causes of the Diseases of Infants, however numerous or various they may be, all center, at last, in one immediate Cause, viz. In an Acid prevailing through the whole Habit ... Seeing an Acidity of the humours is the original cause of all of these diseases to which infancy is exposed, the whole method of cure depends entirely on subduing or expelling that acidity.

Harris argued that because children's diseases were caused by excess acidity, they must be treated with alkaline medicines. Strong herbal medicines designed to reverse humoral imbalance were to be avoided.

> This Preparation then of the Humours, of which we are now treating, is by no means to be attempted by hot Sudorificks [cause sweating], which can never be of any Service to tender Infants, but on the contrary are extremely hurtful and pernicious. But there are other medicines of a perfectly mild Nature, which efficaciously absorb any prevalent Acidity, subdue any preternatural Commotions in the Humours, and perform the Function of Anodynes both effectually

and safely. Such are Crabs Eyes and Claws, Oyster-shells, Cockel-shells, Bone of the Cuttle-Fish, Egg-shells, Chalk, Coral, Coraline, Pearls, Mother of Pearl, both kinds of Bezoar, burnt Hart's Horn and that of the Unicorn, Bole Armeniack, sealed Earth, Blood Stone etc.

Disordered gastric coction was the cause of 'excessive acidity', and the curative property of testaceous medicines used to counteract it was derived from both its alkaline nature and the vitality of the sun.

> If in such a variety of Testaceous Medicines [derived from shells] almost of the same Nature any of them were to be preferred to others for their Virtues, I would chiefly recommend common Oyster-shells, as they are found on the Sea Shore after they have long been exposed to the Sun, and ripened, as it were, by the kindly Beams ... That the above-mentioned Powders readily absorb Acids is so notorious [well known] to every Body that it needs no proof.

Harris prescribed a Pearl Julep to treat the harmful excess acidity: 'Take Black Cheery Water, four ounces, Citron Water, two ounces, Aqua Mirabilis, two Drachms, Prepared Pearls, two Drachms, While Sugar, half and ounce, Mix them ... Always to shake the Glass carefully before it be poured out.' This medicine was deemed ideal for the treatment of babies with gripes, colic and flux caused by disordered gastric digestion.

> The stomachs of infants, from whatever cause that disposition [gripes etc] may originally proceed, always contracts a remarkable sowerness, whence their food is not concocted into pure chyle, as it ought, but is rather converted into a kind of posseted milk. From this deprived quality of the chyle, or nourishment, loathings, vomitings and sower belchings are at first produced.

When milk was not transformed into pure chyle in the stomach then the infant suffered; and all its symptoms were caused by disordered digestion.

> That all these Symptoms, and others of the same Nature, proceed from a Coagulation, or grossness of the Aliment, whence it cannot be duly assimilated to the Animal Nature [finest particles] by the tender Organs of the Infant, or rendered capable to pass through the slender canals; and that such a Coagulation is either always, or at least, more frequently produced from a certain Degree of Acidity than from any other Cause, is abundantly evident, if we can credit our own Senses, or dare to draw any Conclusion from the Method of Cure, which is chiefly founded upon antacid Remedies, and such as serve to resolve the Coagulations.

This was not a trivial or rare problem. Walter Harris was well aware of the toll taken of babies who were improperly or insufficiently fed, and thereby suffered 'loathings, vomitings' and worse, especially on the breasts or in the hands of mercenary wet nurses, whose 'neglect, nastiness, barbarity or intemperance ... expose their tender charges to such imminent dangers'.

> The rector of a parish twelve miles from London [Hayes in Kent] told me that his parish, which was not small in either its bounds or inhabitants and was situated in very wholesome air was, when he first came to it, filled with suckling infants, and yet in the space of one year, that he had buried them all except two, and one of his own, and that the same number of infants being soon twice supplied according to the usual custom of hireling nurses, from the very great and almost exhaustible city [London], he had committed them all to their parent earth in the very same year.

NURSING THE NEWBORN

The practice of wet nursing, formerly favoured by royalty, the rich and well-to-do, had in England spread to the middling classes a century after the physician, Robert Pemell (d. 1653), had criticised the growing practice of 'low-born ladies farming out their babies to irresponsible women in the country'. Now the families of merchants, lawyers, physicians, clergymen and the gentry employed wet nurses. However, in Puritan Britain there was a backlash against this practice. Maternal nursing was a religious duty, an exhibition of motherly love, and it also precluded the dire consequences of contact with 'inferior, mercenary, unhealthy and inappropriate women'. Elizabeth Brand (d. 1636), for instance, the wife of a Suffolk squire, had inscribed on her tombstone by her proud husband that she bore him twelve children, all of whom she had nursed on her own 'unborrowed milk'. Nevertheless:

> Many children [are] sacrificed yearly to the barbarous treatment and ill usage of their nurses, what with bad milk of their own, and feeding the young infant with mixed meats and drinks, as yeasty new ale or stale beer, will make it puke or give it the gripes.

Wet nurses too often gave opiates or alcoholic beverages to their charges to keep them quiet. Some were not even 'proper' wet nurses, but fed babies on bread and water pap or other unsuitable cereal foods and gruels rather than on their breasts. Birth registers in country parishes around London, as Harris had learned, recorded hundreds of nursling deaths, many of farmed-out babies.

There was also the risk to nurse and nursling of syphilis, which from its arrival in Europe in the 1490s had become endemic. It was an occupational hazard of wet nurses. Foundling hospitals, where unwanted babies of unknown parentage were accepted, were a particular breeding ground for the disease. Abandoned infants showed no clinical signs, but once infected wet nurses could infect other nurslings. Syphilis was only one of many afflictions that wet nurses were prey to, as the Italian physician Bernardino Ramazzini (1633–1714), author of *De Morbus Artificium Diatriba* (Diseases of Workers), recorded:

> Nurses [who] take over the newborn and feed them are exposed to various ailments: gradual wasting, hysterics, pustules and scabies, headache, vertigo, respiratory troubles and weak eyesight, and they are liable to many other disorders, especially in the breast when milk is too abundant, when it curdles in the breast, when they become inflamed or suffer from an abscess or cracks in the nipple.

'Nurses are infected because the more beneficient part of the blood or chyle flows to the breasts and is converted into milk, so that there remains to nourish the body [of the nurse] serous and saline humours and these presently produce cutaneous pustules and scabies.' The nutritious creamy parts of chyle might reach the suckling baby, but 'the bodies of nurses are robbed of [these] nutritive juices with which they ought to be nourished, and so from exhaustion they gradually become thin and reedy' and unable to adequately feed their nurslings. Failure to expel the coarser impure parts of chyle compounded their condition, as the Spanish physician, Francisco Vallés (1524–92), wrote: 'Women when suckling suffer very seriously from the retention of those impure excrements that they normally get rid of every month (in the menses); they keep these and lose the pure milk sucked by the child.' Because the nurse's blood could not be discharged monthly, 'everyone knows how many breast troubles nurses suffer from, such as abundance of milk and its excessive flow when it is too thin, whence ensue debility, atrophy and curdling of the milk'.

THE SEEDS OF GENERATION AND THE FLUIDS OF NUTRITION

No-one doubted that mother's milk was the best thing for babies, but there was controversy about how they were nourished in the womb, and exactly how they were conceived. A few women wrote 'midwife manuals', generally in the vernacular (rather than in medical Latin). Jane Sharp's *Midwives Book* (1671), for instance, addressed fellow midwives and child-bearing women, and although it included simple anatomical engravings, such as the fetus in the womb of a woman ready to give birth, it reiterated Aristotle on the subject of how the baby was formed.



Baby in the womb, from Jane Sharp, 1671

The herbalist and physician Nicholas Culpeper (1616–54), 'having buried many of my children young, caused me to fix my thoughts intently upon this business'. He was especially interested in 'the difference between the Ancient and Modern Physicians touching the women's contributing seed to formation of the child'. Presenting his thoughts in his *Compleat and Experienced Midwife* (1651), Culpeper outlined Galen's teaching and Aristotle's observations that women's bodies were the inverse of men's, both anatomically and physiologically, and the male seed and female egg contributed equally. 'There are in the generation of the fetus two principles: active and passive. Active is man's seed elaborated in the testicle out of the arterial blood and animal spirits. The passive principle is the ovum or egg, impregnated by the man's seed.' Culpeper spelt out the old and the new ideas of how conception leads to the formation of the fetus:

> For Aristotle the Seed of man is the principal, efficient and beginning – Action, Motion and Generation ... Woman affords and contributes to procreation ... But against all this our Modern authors affirm ... that ... the 'testicles' of women do not afford seed but are 'two eggs' like those of fowls and other creatures. They are an ovarium or receptacle for eggs wherein these eggs are nourished by sanguinary vessels dispersed though them, and from thence they are fecunded by the man's seed, and conveyed into the womb by the oviducts.

This model gave equal and reciprocal weight to the man and woman in reproduction, whereby the male 'dynamic' element gives shape to the female 'plastic' element.

> The most spiritous part of man's seed, in the act of copulation, reaching up to the ovarium, or testicles of the woman (which contain divers eggs) impregnates one of them which being conveyed by the oviducts to the bottom of the womb presently begins to swell bigger and bigger and drinks the moisture that is plentifully sent thither, after the same manner that seeds in the ground suck in the fertile moisture thereof to make them sprout.

After sprouting, the unborn child grew and was nourished in the womb by the placenta, which 'resembles the form of a cake and is knit both to the navel and the chorion, and make up the greatest part of the after-birth. The flesh of it is like that of the milt or spleen, soft, red and tender and tending to form something to blackness, and hath many veins and



Jan van Neck, *Anatomical lesson* by Frederik Ruysch, 1683

arteries in it, and the chief use of it is for the containing the child in the womb.' The anatomy and function of the placenta was well understood.

Joined by members of the Board of Surgeons of Amsterdam, the Dutch professor of anatomy and botany, Frederik Ruysch (1638–1731), lifts the umbilical cord, extending from the baby to the placenta, while his son Hendrik holds up the articulated skeleton of a dead neonate. The placenta was of enormous importance to the baby in the womb, but 'as the newborn infant is come into a new world, so now it must have a new way of nourishing itself, which must be by taking it in by mouth whereas before it received its nourishment at the navel by the umbilical vessels'.

The switch, at birth, from nourishment in the womb via the placenta with blood, to nourishment on the breast

with milk, was a momentous transition from one vital fluid to another. The nutriment of the fetus and the newborn baby was provided by mother, as Harvey pointed out in his treatise on the motion of the heart and the circulation of the blood (*De Motu Cordis*), when making apt comparison between the flow of blood and milk, defending his view of how and why the former circulated around the body.

> If anyone shall here object that a large quantity [of blood] may pass through [the heart] and yet no necessity be found for a circulation, that all may come from the meat and drink consumed, and quote as an illustration the abundant supply of milk in the mammae – for a cow will give three or four, and even seven gallons and more in a day, and a woman two or three pints whilst nursing a child or twins, which must manifestly be derived from the food consumed; it may be answered that the heart by computation does as much and more, in the course of an hour or two.

While this was further evidence of the action of the heart in circulating the blood around the body, it was a restatement of the views of Hippocrates, that the nutritious portion of the chyle of mother is the milk of her child:

> The milk flows into the breasts provided the mother suckles the child; for as long as the breasts are giving milk and being sucked the small veins [ducts] in them are enlarged and this enables them to draw out the fatty ingredients from the stomach and convey them to the breasts ... So the child's sucking is sufficient to keep up with the flow of chyle, but failing that suction the sources of the chyle dry up.

However, the big questions now interesting Harvey were how was the fetus formed, and who or what was responsible? Clearly the vital fluids – blood, chyle, semen, milk – were involved in both nutrition and generation, and the transmutation of one into another explained the growth and development of the body. The growth of the fetus in the womb was a puzzle – what animated it, and what governed its development? Was it 'preformed' or 'composed by assembly of parts'? Was the seed or the egg the origin and bearer of vital spirit to blood and milk? These were questions that had been debated ever since the time of Aristotle.

Culpeper had likened the 'testicles of women' to ova or eggs, and the womb to the eggshell of fowls. Harvey had come to regard eggs as the fundamental receptacle from which all living things were born. The frontispiece of his *De Generatione Animalium* (1651) depicts Zeus seated on his throne holding the two halves of a hatched egg from which emerge plants, insects, fish, amphibians, reptiles, birds and mammals – the full 'chain of beings' from lowest to highest. *Exo Ovo Omnia* (everything comes from the egg).

'Mother's blood is the nutriment of the fetus in the womb and it is at first a part of mother, sustained by her blood and quickened by her spirit,' Harvey wrote, but 'the chicken in the egg enjoys his own blood, which is bred in the liquors contained within the egg, and his heart has his motion from the very beginning and he borroweth nothing, either blood or spirit, from the hen, towards the constitution either of the sanguinous parts or plumes.' Mother and offspring have their own, separate blood circulations. Harvey noted that yolk supplied

the place of milk 'and is that which is last consumed, for the remainder of it (after the chick is hatched and walks abroad with the hen) is yet contained in its belly ... The yolk is the hottest part of the egg and the most nourishing', he continued, 'an egg is an exposed womb, wherein there is a substance concluded, as the Representative and Substitute, or Vicar of the breasts', providing nutriment in the form of 'uterine milk'.

The debate about how the embryo grew into a fetus and then into a fully-formed baby was generally couched in Galenic and Aristotelian terms, whereby the humours and elements, and the faculties they governed – formative, transmutative – mediated generation. 'Generation was made by aggregation of like parts to pre-supposed like ones; or by speficial workers [archaei] within; or by compounding of seminary matter with the juices which accrueth from without. The concocting and immutative, the nutritive and augmenting faculties, do operate



De Generatione Animalium
by William Harvey, 1651

with as much artifice and as much designed end, as the formative faculty.' Harvey rejected these notions, saying:

> It is the usual error of philosophers to seek the diversity of the causes of parts out of the diversity of the matter from whence they should be framed. So physicians affirm that the different parts of the body are fashioned and nourished by the different material of blood or seed; namely the softer parts, as the flesh, out of a thinner matter, and the more earthy parts, as the bones, out of the grosser and harder.

All things have substance, form, use and purpose, as Aristotle had taught, but 'those who make all things out of atoms, as Democritus, or out of elements, as Empedocles; as if generation were nothing in the world but a mere separation, or collection, or order of things, they are deceived. Generation is a thing quite distinct from them all. These men derogate from the honour of the Divine Architect, who hath made the shell of the egg with as much skill for the egg's defence as any other particle, disposing the whole out of the same matter and by one and the same formative faculty.'

> Out of the same white of eggs all and every parts of the chicken, whether they be bones, claws, feathers, flesh, are procreated and fed ... but ... assigning only a material cause, deducing the cause of natural things from only a causal concurrence of the elements, or from the several disposition of atoms [neglects] the operations of Nature, and in the Generation and Nutrition of animals, namely the Divine Agent, and God of Nature, whose operations

are guided with the highest artifice, providence and wisdom, and do all tend to some certain end.

The foundation of Harvey's view was his religious belief, that 'all things are full of deity (*Jovis omnia plena*) – in the little edifice of a chicken, and all its actions and operations, the finger of God (*digitus Dei*) or the God of Nature doth reveal himself'. There was divine order to the universe: as the heart sat at the centre of the body (microcosm), so the sun sat at the centre of the universe (macrocosm); the primacy and vitality of blood as a source of life was akin to the sun's rays. Just as the movement of blood throughout the body, powered by the beating heart, was 'the foundation of life', so too was the traffic of milk from mother to baby the lifeblood of its early existence.

> The heart is the beginning of life; the sun of the microcosm, even as the sun in his turn might well be designated the heart of the world; for it is the heart by whose virtue and pulse the blood is moved, perfected, made apt to nourish, and is preserved from corruption and coagulation; it is the household divinity which, discharging its function, nourishes, cherishes, quickens the whole body, and is indeed the foundation of life, the source of all action.

Harvey's attempts to explain the workings of the human body were based on the dissection and examination of all sorts of living things. His experimental outlook was dynamic – 'morphological movement' – the observation and measurement of the flux and flow of fluids between organs via veins, arteries, ducts and nerves. It was mechanistic but also vitalistic. The shadow of the ancients, his reverence for nature and worship

of God deterred Harvey from believing that the body was simply a machine, as he confessed in *De Motu Cordis*, where he expressed his worry that his 'invention' of the circulation of the blood was of:

> so novel and unheard-of character that I not only fear injury to myself from the envy of a few, but I tremble lest I have mankind at large for my enemies, so much doth wont and custom, that become as another nature, and doctrine once sown and that hath struck deep root, and respect for antiquity influence all men.

GOD, MAN, CHEMISTRY AND PHYSIC

By the mid-eighteenth century, in spite of a general respect for antiquity and belief in God, a coherent mechanico-chemical, corpuscular conception of how the body worked, proposed by Boyle and outlined by Harvey was articulated by Nicolas Lemery's son, Louis (1677–1743), who like his father was particularly interested in how food sustained life, nourished the body, repaired its tissues and healed it.

> The machine of man's body ought to be considered as a wonderful complication of several sorts of parts, which by the mutual help they offer one another concur together to perform and support the life of this composition. Each of these parts, having a considerable motion, undergo a continual dispersion of their substance, and consequently stand in absolute need of food, to repair and restore them.

In his *Treatise of All Sorts of Foods* (1745), Louis Lemery catalogued the nature and properties of foods, both beneficial and harmful, offered guidance to physicians on how knowledge of their 'virtues' might be put to good use.

> If foods contribute so necessarily to the preservation of life and health; they also produce the greatest part of those distempers to which we are subject, and many times, by the ill use of them, cause even death itself. Everything that is proper for recruiting the solid or fluid parts of our body deserves the name of food; and according to this definition, the air ought to be looked upon as real food. All foods consist of four principles, viz. oil, salt, earth and water, and so the difference that is between one sort of food and another consists exactly in the conjunction and different proportion there is between these same principles.

While all foods consisted of four elemental principles, they had to be reduced to their component parts from a milky chyle before they nourished, repaired and vivified the body:

> Food, before it is fit to recruit the solid parts of our body, is prepared several ways and undergoes various changes: it is first cut, divided and chewed by the teeth; after which the salivary glands, which are numerous enough, and whose secretory channels discharge themselves into the mouth, afford a liquor which serves to water the food and to bring it into the form of a paste. When it is in this state it goes down the throat into the stomach, where by

> fermentation caused in the parts of it, it assumes a new form and is changed into an ash-coloured liquor called chyle.

This conception of the process of digestion hardly differed from that proposed by William Harvey more than a century earlier. What was new was a chemical explanation, based on the acidity or alkalinity of the foods and fluids (juices) within the gut, and the corpuscular nature of all things. 'In the first place the salivary liquors which continually supply the glands of the stomach.'

> Some pretended it was acid and even that its acidity was prevalent enough since it must be such as could dissolve the greatest part of the food we take; others have thought that this juice not only contains acid parts, but also salt, alkaline and sulphurous ones, etc, by the help of which it is proper for attenuating the different parts of the foods and serves to menstruate [dissolve] the same.

The 'acid theory' of health and disease, proposed by van Helmont, developed by Nicolas Lemery and applied by Walter Harris, focused attention on the nature and properties of foods, especially milk, and how:

> When the chyle has been sufficiently wrought and perfected in the stomach it descends into the duodenum where it obtains a new degree of perfection by its meeting with the pancreatick juice and biles. These liquors coming to mix therewith help to make it more fluid, attenuate it anew and precipitate its

> gross parts, after which it easily gets into the milky veins [mesenteric lymphatics] which convey it into the adjacent reservatory [cysterna chyli], where it is steeped anew by the lympha, which draws nigh in great plenty.

The system by which nutriment-rich chyle passed from the mesenteric lymphatics to the thoracic duct and thereby via the vena cava to the right heart was observed and described in the 1650s.

> When this chyle is mixed with blood it is rarified anew, by the volatile and exalted parts of the blood, by the saline and nitrous parts of the air that are continually mixing themselves with this liquor, and lastly by the repeating beating of the heart and arteries. It is moreover necessary that for some time it should retain yet its chylous consistence whereby it is fitted for nourishing and repairing the solid parts.

Just as Harvey had said 125 years earlier, that 'chyle is first', a pure chyle as a result of sound gastric digestion was the key to healthy nutrition.

> For the better understanding of how the chylous parts [of blood] yield nourishment you must know that the chyle, according to its degree of attenuation, does more or less pass through the pores of the different parts of the body; insomuch that in one condition it is proper for nourishing the flesh, in another the sinews, in a third the gristles, in a fourth the bones, and so on.

The body might be 'a wonderful complication of several sorts of parts', operating as a mechanical, hydraulo-pneumatical, chemical engine, but its healthy function, especially generation and nutrition, depended on the production, supply, digestion and metabolism of the corpuscular fluids that flowed through it. The fetus in the womb was nourished by the placenta, as the chick in the egg was nourished by the yolk and white, and from birth by mother's milk, concocted from mother's food. Milk and chyle shared physical appearances and chemical properties. Without human milk the newborn baby's fortunes were precarious.

Physic, based on chemistry, might correct this acid-alkali imbalance caused by alternative foods, but human milk was as much the preventative as the cure. Maternal nursing was self-evidently nature's way of nourishing the young, and what God intended. Wet nursing was a poor substitute, though frequently the choice of the well-to-do and the lot of orphans. All too often nurses were poorly nourished, multiparous women with little milk, desperate women who risked transmitting syphilis, or feckless women tempted to feed their charges by hand and quieten them with opiates. Foundling hospitals did their best to care for many unwanted children, but in London, Paris and other European cities they were overwhelmed.

5
Nature

NATURE'S BOUNTIFUL URN

It is a melancholy object to those who walk through this great town or travel in the country, when they see the streets, the roads, and cabin doors, crowded with beggars of the female sex, followed by three, four or six children, all in rags and importuning every passenger for alms. These mothers, instead of being able to work for their honest livelihood, are forced to employ all their time in strolling to beg sustenance for their helpless infants.

JONATHAN SWIFT'S (1667–1745) *Modest Proposal (for preventing the children of the poor from being a burden to their parents or the country, and for making them beneficial to the public)* might have seemed shocking and absurdly fanciful when published in 1729. It drew attention to the dire condition of children starkly visible not just in Dublin but also in many other cities of the British Isles, especially London. To have poor parents was a grave handicap, but to lose your mother at birth or to be abandoned by her soon after could be a death sentence. To be born into a wealthy family, on the other hand as Swift had been, was a distinct advantage, though there was no avoiding the cold reality that the chief determinant of whether you survived early infancy was how you were fed and with what. Swift

knew this all too well, not just from what he saw around him, but because he himself had been sent away to be wet-nursed in England.

Looking out of the window of a Georgian town house in the London parish of St Giles some years later, the grim scene below was an even more desperate picture than that penned by Swift. Its streets, according to the novelist and magistrate, Henry Fielding (1707–54), once a foundling himself, were places 'adapted to whoredom, so are they no less provided for drunkenness, gin being sold in them all at a penny a quartern [quarter pint]'. Swift's cousin, Charles Davenant (1656–1714), had warned that gin 'is a growing fad among the common people and may in time prevail as much as opium with the Turks', and the local apothecary, James Nelson (1710–94), observed 'there is a practice among the vulgar, that of giving drams [of gin] to the children themselves, even while infants, mothers pour the deadly poison down the poor babe's throat, even before it can speak'.

London was in the grip of a craze for gin, which wrought havoc on all society, especially the most vulnerable – the poor and the young. By 1750 over a quarter of all premises in St Giles parish sold the spirit, and many also received stolen goods and were houses of ill repute. The 'damp and unwholesome' narrow streets and alleyways, divided by cesspits and criss-crossed with open sewers, were places of desperation, despair, decay and death. William Hogarth's (1697–1764) *Gin Lane*, just like Swift's *Modest Proposal*, was cutting satire on the causes of poverty, squalor and crime, depicting the evils and effects of the consumption of gin: it showed shocking scenes of infanticide, starvation and madness.

The focal point of Hogarth's engraving is a mother who, addled with alcohol and driven to prostitution by her habit,



William Hogarth, *Gin Lane*, 1751

lets her baby fall from her breast into the stairwell of the gin cellar below, signed above with: 'Drunk for a penny, Dead drunk for two pence, Clean straw for nothing'. Images of children on the path to destruction populate the scene: an infant is quieted by its mother with a cup of gin, and in the background a naked baby child watches as its dead mother is loaded into a coffin. A lunatic cavorts in the street, beating himself over the head with a pair of bellows while holding a baby impaled on a spike – the dead child's frantic mother flees screaming from the house. Three hanging signs – tankard, pawnbroker's balls and coffin – symbolise the origin, effects and consequences of gin. Gin was 'mother's ruin'.

The London parishes on the northern edge of the city were a mixture of hopeless poverty and polite gentility. The rookeries of St Giles bordered on the smart squares of Bloomsbury. Each parish was responsible for administering poor law relief, which included the care of children without relations living or able to rear them, born or abandoned within its boundaries. Poorhouses made no provision for unwanted babies or unaccompanied infants, nor were they suitable places to bring up a child. Of 187 infants born or received into the St Giles workhouse between 1757 and 1763, only eighteen survived to the age of three years. However, they did not die just of neglect. Judith Dufour, who worked twisting silk into thread, reclaimed her two-year-old child from the workhouse where it had been given new clothes; she then strangled it and left the body in a ditch so that she could sell the clothes (for 1*s.* 4*d.*) to buy gin. For the motherless newborn the workhouse was a children's morgue. It was only too obvious to the philanthropist, Jonas Hanway (1712–86), a founder of the Magdalen Hospital for 'fallen women', that:

> to attempt to nourish an infant in a workhouse where a number of adults are assembled in one room and consequently the air becomes putrid, is but small remove from slaughter, for the infants must die ... these children are put into the hands of indigent, filthy and decrepit women, three or four to one woman, and sometimes sleeping with them. The allowance of these women being scanty they are tempted to take part of the bread and milk intended for the poor infants. The child cries for food and the nurse beats it because it cries. Thus with blows, starving and putrid air, with the addition of lice, itch, filthiness, he soon receives his quietness.

Hanway believed that 'parish officers never intend that parish infants should live' and noted that an infant of one to three years might on average survive only a month in a London workhouse. Some lucky babies might be boarded with needy families and wet-nursed, often by poor widows who were themselves receiving parish relief and took several at a time to earn a living. Parish wet nurses were paid between 1*s.* and 2*s.* per infant per week, but their milk was often far from sufficient to nourish more than a single baby. Moreover, sleeping draughts (usually opiates) contributed to their early demise, as Hanway observed:

> Would not any man in his senses conclude, after the death of three or four children in one woman's hand, that the nurse was very unfortunate; after five or six that she was very ignorant or wicked? But when in so short a period the mortality of seven or eight had happened, would it not create a suspicion that she starved them, or gave them sleeping potions?

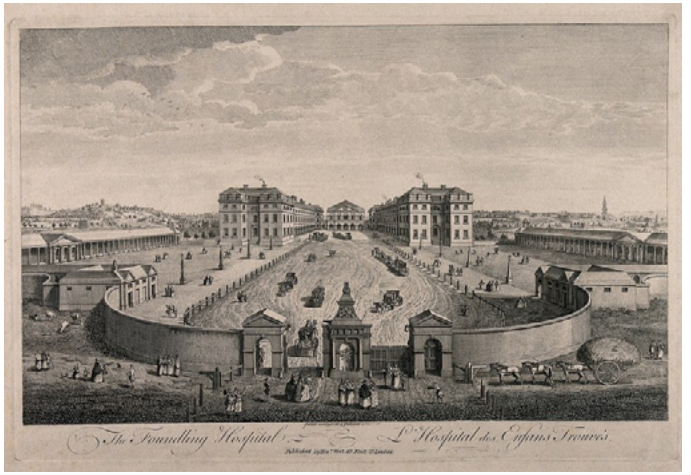
Opiates had long been used to quieten babies. In one of the first printed books on child health, Paolo Bagellardo (1472) reported that 'our common people give infants a little of the so called "quietness", a decoction or boiled-down extract of black poppies and poppy seeds', and the seventeenth-century bills of mortality (1639–59) frequently recorded the cause of death of babies as 'overlaid and starved at nurse', the one sedated with opium and the other saturated with gin. Sleeping

potions were widely available, such as *Dr Benjamin Godfrey's Cordial*, advertised as:

> of excellent use for young children who are weakly or restless; for it quieteth froward children and those that are greatly troubled with gripes, vomitings and looseness. It is of great use to those children that breed their teeth hardly. The manner of taking for children: a large spoonful at night to one year old; half a tea-spoonful to a one half year old.

The sight of abandoned children in the streets of London moved a retired sea captain to agitate for a foundling hospital in London. About the same time as Swift was saddened by what he saw walking through the streets of Dublin, Captain Thomas Coram (1668–1751) was shocked by the numbers of infants left forsaken on the roadside and dung-heaps of London. He laboured for ten years to raise interest and funds for a home for children and orphans who could not be properly cared for and 'persuaded twenty-one ladies of quality and distinction' (eight duchesses, eight countesses and five baronesses) to sign a memorial to this intention. A royal charter was granted in 1739 for a 'hospital for the maintenance and education of exposed and deserted young children' and considerable sums were donated. It was built in open fields, at the head of Red Lion Street in Bloomsbury, not far north of St Giles, and began to admit children in 1741.

King George II (1683–1760) subscribed £2,000 for the building of a chapel, the composer George Frideric Handel (1685–1759), 'performed vocal and instrumental music' and donated an organ, the artist William Hogarth painted a portrait of Thomas Coram, and subscriptions poured in. By 1753



Thomas Bowles, *The Foundling Hospital*, 1753

over one hundred infants each day were offered to the hospital, but in spite of its size and grandeur, its capacity to meet the demands of caring for so many children was soon exceeded. Parliament voted funds to allow it to admit more children, but it was overwhelmed by babies brought by the destitute from far and wide, attracting criticism that its open doors encouraged the 'progress of vulgar amours, the breeding of rogues and the increasing of whores'.

For women who did not qualify for poor law relief but were too ashamed or frightened to confess having an unwanted baby and tempted to take desperate measures to conceal or dispose of it, the foundling hospital might be their saviour. The artist, Joseph Highmore (1692–1780), depicts the choice faced by some. On the lap of a fashionably dressed young lady, her feet in silk shoes, lies a naked gasping baby. Between the mother's hands extends a delicate pink ribbon, looped around the baby's neck. To her left cowers a cloaked figure in grey,



Joseph Highmore, *Angel of Mercy*, 1746

resolutely turned away from her, and to her right a stern angel points towards the Foundling Hospital.

FEEDING THE FOUNDLINGS

The majority of children admitted to the London foundling hospital, many from local parish workhouses, were less than a year old, orphaned by their mother's death in childbirth, born out of wedlock or deposited, often reluctantly, on account of family destitution. The governors were faced not only with the challenge of accommodating but also feeding them all. They took note of the experience of other foundling hospitals in Europe (particularly Paris) and sought advice from the medical men within their ranks. The distinguished and fashionable physician, Dr Hans Sloane (1660–1753) ('eminent in his skill in Physic, Natural History and Philosophy'), reminded his fellow governors that:

> Infants which by the management of parish nurses, in giving them opiates to quiet them when fretting with diseases occasioned by their bad nourishment, generally sweetened with sugar, and the want of the breast by wet nurses, scarce ever live to two years old ... This proceeds from deviating from the orders of God and Nature, to follow men's inventions. I have always immediately advised the breast as the first and best remedy, which seldom fails unless the child would not suck, in which case, breastmilk given with a spoon is the best remedy.

Sloane was opposed to dry nursing – the feeding of babies by hand or spoon with anything other than human milk – on account of a survey he undertook comparing how they fared when wet- or dry-nursed. The mortality of the dry-nursed babies was three times that of the wet-nursed, and the governors concluded that 'experience shewed wet nurses to be the only safe method of nursing children and resolved to send all foundlings to the country until they were three years old and all such as would suck should be nursed by wet nurses only'.

Nevertheless, with the death of the majority of babies admitted to the hospital in their first year, owing to 'the profuse waste and imperfect workmanship of Nature', the governors sought further advice from the Bristolian physician, Dr William Cadogan (1711–97), asking him to look not just at the vexed question of the feeding, but also the general care and medical treatment of their wards.

Cadogan echoed Sloane's advice that 'If we follow Nature instead of leading or driving it, we cannot err. In the business of nursing, as well as physic, art is ever destructive if it does not exactly copy the original.' Presenting his views to the governors in an *Essay upon the Nursing and the Management of Children from their Birth to Three Years of Age* (1748), he expressed the 'great pleasure I feel at last [that] the preservation of children [has] become the care of men of sense', confessing himself 'quite at a loss to account for the general practice of sending infants out of doors to be suckled or dry-nursed by another woman'. As a 'man of sense' by whom 'philosophic knowledge of nature is acquired only by learned observation and experience', Cadogan believed that the feeding of foundlings, like the young of all living things, must obey the laws of nature:

> In all the other productions of Nature we see the greatest vigour and luxuriancy of health the nearer they are to the egg or the bud: they are indeed then most sensible to injury, and it is injury alone that destroys them. When was there a lamb, a bird or a tree that died because it was young? These are under the immediate nursing of unerring Nature and they thrive accordingly.

Mother's milk was a natural substance, perfect for feeding the young of all animals, including humans, as William Buchan (1729–1805), physician to the foundling hospital of Ackworth in Yorkshire had pointed out. All creatures 'obedient in everything to the impulse of nature, nurse their off-spring ... not only the inhabitants of the howling wilderness, the she-wolf and the fell tigress, but even the monsters of the great deep, draw out the breast and give suck to their young.'

Cadogan saw mother's milk as 'poured from an exuberant overflowing urn by a bountiful hand that never provides sparingly'. God provided, working through nature. 'The Call of Nature should be waited for to feed it with anything more substantial, and the Appetite ever precede the Food. Thus for Nature, if she be not interrupted, will do the whole business perfectly well.' Human milk was clearly the best food for babies, but more could be done to improve its supply. Cadogan agreed with the governors that:

> Sending the children out to country nurses under the care of inspectors is undoubtedly the best method they could take; but how far these nurses and their inspectors (who I suppose are to be some good gentlewomen in the neighbourhood) may be persuaded out of their old forms, to treat their nurslings a little more reasonably, is a matter of much doubt.

'The good gentlewomen in the neighbourhood' were overseen by the local clergy, gentry, apothecaries and surgeons, who made sure that prospective wet nurses were suitable; meaning married (occasionally widowed) and in good health. The majority were illiterate, in their early thirties and the middle of their child-bearing years. Their husbands were agricultural labourers or artisans; blacksmiths, shoemakers, carpenters, tailors, weavers, sawyers, basket and spoon makers, gardeners and wool-combers. Foundlings generally stayed with their wet nurses for around thirty-three months, if they survived. The Rev. Stephen Hales (1677–1761), natural philosopher and vicar of Teddington, kept a close eye on his parishioners who were employed as wet nurses, expressing his views concerning all three methods of infant feeding in writing to the governors of the Foundling Hospital:

> Objections to wet nurses are the danger of their mental and physical maladies being communicated to their sucklings. Their milk is frequently prejudiced by numerous irregularships, as regard to the quantity and quality of their food ... Drinking tea, the consequence of which naturally call in spiritous liquors, may affect the child's health, as dram [alcohol] drinking without teas assuredly does.

Hand, or dry feeding, was not much better, because 'Bread, of which the pap is made, is rarely well-baked. In the country, rye, which has generally a griping quality, is often mixed with wheat. The sweetness of the bread is everywhere spoiled by the yeast and leaven. Milk and flour, when boiled, are glutinous.' And finding milk that was suitable for consumption by babies was not easy:

> The procuring at all seasons of the year, the proper milk is no small difficulty; as brew houses and turnips supply the greatest proportion of cows in the winter months, at least about this city [London]. It has been surmised that grated biscuit, wherein neither leaven or yeast are mixed, with a little water, and cow's milk boiled, and not put too hot in it, would be an unexceptional food for infants.

Cadogan was not alone in his views that dry feeding and cow's milk were generally unsuitable, but believed that wet nursing was the only 'better' alternative, even though the fortunes of those babies sent to rural wet nurses were far from rosy. Having taken advice, done experiments, and referred to the experience of other foundling hospitals, the governors stuck to their policy of trying to feed all the infants under their care on human milk.

THE PARISIAN FOUNDLING HOSPITAL AND BUREAU DE NOURRICES

Across the English Channel the French had struggled with the challenges of feeding foundlings for half a century or more. The Paris foundling hospital, formerly part of the *Maison de la Couche* (maternity hospital), near the cathedral of Notre Dame had become the *Hôpital des Enfants Trouvés*, and by 1747 accommodated more than 3,000 foundlings in three small houses near the *Hôtel Dieu*. There was only one wet nurse for four or five children, who were often given laudanum to keep them quiet and sometimes sold to professional beggars who used them to inspire pity and donations. The mortality rate of *les enfants trouvés* was 69 per cent, owing to overcrowding, lack of ventilation, malnutrition and epidemic diseases; figures much the same as those in the London poorhouses.

Outwith the foundling and maternity hospitals, the employment of wet nurses to feed and rear babies was well organised, not just amongst the well-to-do but especially amongst working families upon which the economy of Paris and other big towns depended. The French capital was full of small businesses and workshops that employed young women as seamstresses, shop-girls, domestic servants and artisans, and sent nearly all of its newborns to the suburbs and beyond for the nursing period. Wet nurses came mostly from the departments surrounding the city, Normandy, Picardy, Champagne and Burgundy, and they were 'ordinarily very poor' and suckled their own babies for six to ten months before taking on a nursling from outside the family.



Étienne Aubry, *The Departure Home of the Nursling from the Country*, 1776

In contrast with the English Poor Law, which made the parish authorities responsible for the care of abandoned children, in France wet nursing was a business, regulated by judicial authorities on behalf of licensed *recommandaresses*, who had exclusive rights to control the supply of wet nurses in Paris. A Royal Decree of 1715 had declared the 'protection of children' to be a national cause and by the 1730s of about 19,000 babies born in Paris almost half (about 9,000) were placed with distant wet nurses. The enormous movement of babies to and from Paris and the resources to effect it became the responsibility of a *Bureau de Nourrices,* which regulated intermediaries called *meneurs* or *meneuses*, who were the links between parents and wet nurses, organising the transfer back and forth of infants, payments, packages, clothing and messages. During the *Ancien Régime* Paris was a 'city without babies'.



Jean-Baptiste Greuze, *The Arrival Home of the Nursling from the Country*, 1767

The artist, Étienne Aubry (1745–81), recorded the scene of a wet nurse taking leave of her young charge. Attended by her respectful husband, she makes an emotional display of her feelings as she hands her weaned ward to its posh but passive mother. The *meneur* watches the transaction with impatient detachment. The homecoming of the toddler, weaned, toilet trained and walking, was a cause for celebration, as depicted by Jean-Baptiste Greuze (1725–1805).

This wet nursing business upon which the economy of Paris and many of its surrounding towns and villages depended, guaranteed wages of 7 livres per month to rural nurses who supplied their own milk. The cost was borne not just by the mothers but also by the babies. Of 66,259 Paris nurslings sent to country wet nurses between 1770 and 1776, a third were dead by six months. When the professor of midwifery in Paris,

Alphonse Leroy (1742–1816), was asked to look into why so many infants were dying, he concluded that it was due to loss of the 'vital principle' which occurred as soon as milk, whether human or animal, was exposed to the air. This might explain why hand-feeding was so dangerous.

The mortality of rurally wet-nursed babies of 33 per cent was higher than that of infants nursed by their own mothers at home, but much lower than that of orphans. The number of babies abandoned to the foundling administration of Paris increased four-fold through the eighteenth century from around 1,700 at the start to 7,700 in 1772. Much of this increase was due to the large numbers sent from the country, often from far afield. Another Royal Decree, of 1770, required provincial hospitals to care for abandoned babies in their region instead of transporting them to Paris. Before this reform 90 per cent of newborn foundlings died in transit to the capital.

HAND FEEDING WITH PAPS, PANADA AND GRUELS

The business of feeding babies, whether at home by mothers who nursed their own, by country wet nurses employed to relieve urban working mothers of the task or by wet nurses hired by foundling hospitals to rear abandoned children, demanded a ready supply of human milk. However, sooner or later it was necessary to feed babies foods other than milk, at weaning. Alternatives to human milk, such as the milk of cows, goats, asses or sheep; of pap (flour or breadcrumbs cooked in water with or without milk), panada (cereals or bread cooked in broth) or gruel (thin porridge from boiling cereal in water or milk) had long been used, but none could equal nor compare favourably with mother's milk for the newborn baby, at least until around six months or so when the first teeth appeared.

The cutting of the teeth 'gives a sort of hint of the use to which they may be applied'. Their eruption was a signal to introduce 'solid' foods in addition to breastmilk. Weaning from the breast completely might not occur until months or even years later, and the time period between these two events was often fraught with gripes, colic, looseness, diarrhoea and other diseases, including rickets. Human milk was sweet, soft, subtle and easily digestible. However, what was the right food to wean children on to when their teeth appeared? William Cadogan looked to the 'new chemisty' of digestion as a guide to what was best, reasoning that:

> The mother's milk, when it is perfectly good, seems to be the true mixture of the animal and vegetable properties that agrees best with the constitution of a child; readily passes into good blood, requiring but a gentle exertion of the powers of circulation to subdue its particles and make them smooth and round and easily divisible.

Cadogan had studied at Leyden where the great physician and chemist, Hermann Boerhaave (1668–1738), taught and practised, and the subject of his MD thesis, *De Nutritione Incremento et Decremento Corporis* (1737) concerned the nutrition and growth of the human body. Boerhaave regarded human milk as intermediate between vegetable and animal matter because, derived from her vegetable diet, it was a 'fluid, as proceeding originally from a vegetable has felt the vital forces of the body [digestion], mixed with blood, passed through the arteries and veins, and soon separated again. And this can be no other than chyle from vegetables, turned to milk, and separated in the breasts.'

Milk differed from chyle in being more concocted. What babies consumed (human milk) had to be converted into what they were made of (flesh), and if mother's flesh and milk were made from both animal and vegetable stuffs in her diet, so too must her milk be composed of both. 'Animals must necessarily be composed of what they take in as aliment; which by their vital powers is converted into their own substance,' taught Boerhaave, echoing the words of Paracelsus and van Helmont. Plant foods were generally acidic and animal foods alkaline, and as Boerhaave pointed out, the 'animalisation' of plant foods by digestion rendered them more alkaline and therefore suitable for babies: 'I would advise therefore, that one half of infants' diet be thin light broths, with a little bread and rice boiled in them, which last is not so acescent [acidic] as any other kind of meal or flour.'

Van Helmont had recommended panada, made of 'bread boiled so long in thin ale with clarified honey, if not with sugar, until they will come together in the likeness of a mucilage, or glew or jelly, sufficient to serve instead of drink.' However, in the eyes of those who were familiar with the perils of weaning, such as Richard Conyers (1707–59), physician to the Foundling Hospital and also a graduate of Leyden, pap was 'a viscous and crude paste more proper to bind books than for the nourishment of infants'.

Many recipes for pap, panada and gruels were recommended and used. Cow's milk was often mixed with them, especially for weaning, but was not alone to be recommended for young babies. Hand feeding, or dry nursing, 'is almost entirely as yet confined to the very poor, that is to say to newborn babies thrown upon the public charity for their sustenance', observed the physician and novelist, Tobias Smollett (1721–71), and if cow's milk was to be used:

> The milk itself should not pass unanalyzed; the produce of the faded cabbage leaves and sour draff, lowered with hot water, frothed with bruised snails, carried through the streets in open pails, exposed to the foul rinsings discharged from the doors and windows, soot and tobacco quids from foot passengers, overflowings from mud carts, splatterings from coach wheels, dirt and trash chucked into it by roguish boys for the joke's sake, and finally the vermin that drops from the rags of the nasty drab that vends this precious mixture under the respectable denomination of milkmaid.

The quality of cow's milk hawked in the streets of London was appalling and its effects on children dire, leading to diarrhoea. The Liverpool surgeon, William Moss (d. 1802), who regarded human milk as the 'perfect blend of animal and vegetable matter', argued that 'it is of the utmost importance to have this subject properly understood and attended to':

> as the number of children who suffer in their health and lose their lives by the gripes and looseness is very considerable: and there is no complaint which, at this tender age, they suffer so frequently and so much from, and which is to be more dreaded, especially with those who are dry nursed.

The longer babies were nursed on human milk, the greater their chance of life. Of 15,231 London infants christened in the early 1740s, 10,765 (71 per cent) were dead by the age of two years, and 'Teething' was recorded as the cause of their death in 1,708 (16 per cent) of them.

Weaning and the feeding of babies on foods other than human milk was laden with risks, often leading to gripes, colic, looseness and diarrhoea. Ideas about how foods were digested in the stomach were changing, from fermentation generating heat to a series of chemical acid-alkali interactions mediated by the alimentary fluids, saliva, gastric and pancreatic juice and bile. The fact that digestion occurred in cold-blooded animals implied that it could come about without the 'heat of combustion', and inspired the French naturalist, René Antoine de Réaumur (1683–1757), and the Italian priest and natural philosopher, Lazzaro Spallanzani (1729–99), to explore what happened to food in the stomachs of birds and dogs. The stomachs of these animals were acid, and when food was put into them and removed, it was found to be neither fermented nor putrified but simply softened. Heating food in a pot did not produce chyle. Heat was clearly not essential for digestion.

This chemico-mechanical concept of digestion made sense, but the challenge of finding safe alternatives to human milk, and weaning foods that were digestible by infants without causing gripes and diarrhoea, preoccupied those that wrote about the care and feeding of children. The deaths of babies deprived of human milk, and too often fed unwholesome mixtures, delivered by horn, spoon or boat with leather or linen teat, or even the finger of glove, were not sudden or unexpected. They were the end result of diarrhoea and other diseases. Cadogan's conception of the causes of disease was founded on humoral theories of health and hygiene:

> Most distempers have two causes; the one a particular state of the solids and fluids of the body, which will dispose it to receive certain infections and impulses; the other the infections or impulse itself ... Tho' this predispondent state or habit of the body be heritable, yet the diseases incident to these wretched heirs may be avoided by preventing the active cause, which may be done in many cases by due attention to the non-naturals, as they are called; in plainer words by a regular, temperate life: in children by good nursing.

Good nursing with mother's milk was, of course, the ideal way of feeding newborn babies, and Cadogan stressed that 'no child should ever be cramm'd with any unnatural mixture ... Nor afterwards fed with any ungenial alien diet whatever, the first three months ... A disproportioned nourishment might occasion great disorders, not only in the *primae viae* [stomach], but also in the turnings and many circumvolutions in the guts and several glands of the body, which might occasion rickets and the King's Evil.'

> The mischiefs that arise from want of breastmilk are gripes from the disproportioned food turning generally sour, giving green stools, causing pain and irritating the guts to discharge them ... When looseness and green stools happen to infants, testaceous powders, as chalk, crab's eyes, claws etc helps more than rhubarb, which purges them more, and is no way to be depended upon for strengthening the bowels.

As Walter Harris had taught a century earlier, the best treatment was to reverse the acidity of the stomach with

alkaline medicines, and when the child was older and ready to take foods other than mother's milk, they must be easily reducible into small assimilable particles.

> It is not enough that their [infant's] food should be simple, it should be also light ... any substance that is easily separated and soluble in warm water. Good bread is the lightest thing I know; the power due to fermentation, in which consists the whole art of making it, breaks and attenuates the tenacious particles of the flour ... and makes it the fittest food for young children. Cow's milk is also simple and light and very good for them. But it should not be boiled, for boiling alters the taste and properties of it, destroys its sweetness and makes it thicker and heavier, and less fit to mix and assimilate with the blood.

'Gripes and looseness' were all too common in babies who were dry-nursed, and all too frequently led to premature death. A spell of wet nursing was the only way to prevent and cure diarrhoea: 'For although a child who is wet nursed may suffer a good deal by improper food, yet it is but for a short time, and as he gets the breast in two or three days, the cause is removed, and he generally, sooner or later, overcomes the effect of a short irregularity: yet puny, weak children may, and often do, lose their lives from it in that short space of time.' Human milk had restorative as well as preventative properties.

> But when children are dry nursed, and confined to such like food, no wonder so few should thrive and do well: those who live are most commonly teased with a frequent griping and looseness, which keeps them always weak, puny, and spiritless, and gives them a pallid, sickly look: and daily experience but too fully convinces us that numbers are carried off by it.

While such concerns and advice about infant feeding were well-articulated by the medical staff of foundling hospitals and children's dispensaries, a new breed of medical practitioners – man-midwives, accoucheurs and obstetricians – also took an interest in infant feeding.

MIDWIVES, MAN-MIDWIVES, ACCOUCHEURS AND SURGEONS

Physicians, philosophers, philanthropists and other 'men of sense' might pronounce about proper and improper infant foods, but it was mothers and midwives who had immediate hands-on responsibility for the care of the newborn. Childbirth was a domestic female affair attended by family and friends – soap, towels and candles, birthing chair and layette – conducted at home by women, including a female midwife, who had generally acquired her skills through practical experience. Men were excluded from the birthing chamber, except when some sort of surgical assistance was required, such as for an obstructed labour. Those skilled in dealing with such complications of childbirth were few and far between and their services beyond the financial means of the poor.

The obstetric forceps, invented by Peter Chamberlen (1560–1631), were kept a family secret for a century until they became known in England through William Smellie's (1697–1763) *Treatise on the Theory and Practice of Midwife* (1751). The mechanism of normal labour and the common complications of childbirth were the subjects of the teachings of Smellie and William Hunter (1718–83), author of *The Anatomy of the Human*



The gravid uterus, from William Hunter, 1774

Gravid Uterus (1774). This dispersal of knowledge of instrumental deliveries amongst medical men spurred the rise of a new species of medical practitioner: man-midwifes. They expanded their interests and services to beyond the disorders of childbirth to include the surgical treatment of breast abscesses and childbed fever, and advice about nursing with nipple shields, feeding bottles, porringers and spoons.

The midwife Elizabeth Nihell (1723–76), who had trained in the *Hôtel Dieu* in Paris, was an outspoken opponent of man-midwives and instrumental deliveries, which she condemned in her *Treatise on the Art of Midwifery, setting out various abuses therein, especially as to the Practice and Instruments: the whole serving to put all rational inquirers in a fair way of very safely forming their own judgements upon the question; which is best to employ in cases of pregnancy and lying-in: a Man-Midwife or a Midwife* (1760).



Silver nipple shield, 1800

The title of her book expressed her strong feelings. There was resistance to the incursion of man-midwives into what was, for centuries, deemed an exclusively female province. The Irish caricaturist, Isaac Cruikshank (1764–1811), depicted the tensions between man-midwives and (female) midwives, representing the former as a man of action standing in his dispensary before his instruments, and the latter as a practical matron in a warm bedroom preparing for a delivery. In his right hand the man-midwife holds a metal 'lever' and behind him hangs a pair of forceps, boring scissors and a blunt hook. On the shelves below stand medicine bottles containing love water, *eau de vie* and the aphrodisiac cantharides. The female midwife stands before a domestic grate on which a pan of water is heating. In her left hand she holds a pap boat for feeding the baby, and on the mantlepiece sits a bottle of smelling salts.

This was an exaggeration of the man-midwife who, although adept with forceps, learned the advantages of 'masterly inactivity' with an expectant and patient approach to the conduct of labour. By the 1770s many surgeon-apothecaries throughout provincial England were styling themselves 'surgeon-apothecary and man-midwife'. Their greater understanding of the management of childbirth, based on antenatal



Isaac Cruikshank, *A Man-Midwife*, 1793

and surgical knowledge, improved the life chances of babies by reducing stillbirths and obstructed labour, but childbed fever and the care of the newborn, especially their feeding, remained challenging.

Wet nurses were employed or supplied by man-midwives, many of whom kept a 'nurse book' listing the names and addresses of local women who offered their services. Because lying-in hospitals, which were springing up in many towns, were largely patronised by the well-to-do, these wet nurses were generally a better class of women and hired by the quarter, half or whole year, at a cost of 10, 16 or 25 guineas respectively. However, the lying-in hospitals, just like the foundling hospitals, were faced with the task of dealing with babies of mothers

who died in childbirth or who were unable to feed or provide for their offspring because of their ill health.

Joseph Clarke (1758–1834), Master of the *Rotunda* (the Dublin Lying-in Hospital), recorded that the mortality of babies there not nursed by their mothers was 99 per cent, and that 'want of mother's milk' was the principal cause. Their mortality exceeded those of babies in foundling hospitals, many of whom had survived the vulnerable early months of life before admission. The statistics from foundling hospitals were sober reading:

Paris, 1771–1777	of 39,951 admitted, 24,476 died during first year (61 per cent)
Moscow, 1786–1806	of 87,604 admitted, 53,587 died during first year (61 per cent)
Dublin, 1781–1791	of 19,420 admitted, 17,420 died during first year (89 per cent)

The Dublin foundling hospital had an atrocious record and reputation because of 'corruption, embezzlement, inept management, appalling hygiene and general disregard for the lives of infants entrusted to it'. It was under the same board of management as the city's workhouse and accepted all infants that were left in the cradle at the gate. Unwanted newly born babies were sent from all over Ireland, often packed on to panniers of carriers; many died *en rou*te and were discarded by the roadside, just as in France. Those who made it had a low chance of surviving, not just because of the absence of effective methods of feeding them but because of the high risk of catching measles, whooping cough, smallpox or dysentery due to cross-infection in overcrowded wards from nurses and feeding equipment.

BREAK WITH THE ANCIENTS: FROM NATURE TO ENLIGHTENMENT

In addressing the vexed question of infant feeding, Henry Bracken (1697–1764), author of the *Midwife's Companion* (1737), questioned the traditional view of the effects of the nurse's milk on her suckling, saying that 'Former authors were much of a belief that the child sucked the temperament and disposition of its nurse; that is, the vices of both the nurse's body and mind are impressed upon her milk, insomuch that the child shall become alike unto her; and the better to confirm this notion they give us instances of young lions being tamed by sucking domestic animals, such as cows, asses, goats etc., and that dogs will grow fierce and voracious in a greater degree if they are brought up by wolves.' Bracken regarded this as an absurd outdated notion, even as he accepted that some harmless physical traits might be conveyed in human milk.

> Now I must freely own that I cannot acquiesce in this opinion of the Ancients, seeing (like many of their simple notions) it will not bear a scrutiny, neither does experience in the least confirm it, any further than that sometimes the child's hair will grow red by suckling a red hair'd woman, altho' its parents were of another hue ... But for a physician to argue that there is so much to be attributed to the milk, as most of them pretend, is much folly and mere quackery.

Ancient notions of the propensity of human milk to transmit the characteristics of the nurse were being questioned, as were archaic explanations of its composition and how it was produced and digested. Determined to present a modern, enlightened and reasoned argument, free of the misapprehension and fallacies of the past, the English physician, Hugh Smith (1735–89), addressed child-bearing women directly in his *Letters to Married Women* (1767), reminding them that:

> Milk is the natural support which the great author of our being has provided for our infant state, and I am heartily sorry the present manner of bringing up children put me under the necessity of proving [human] milk to be the best food that can be given them. [Human] milk is a nourishment produced from the kinds of foods taken in by the mother. Her stomach breaks and digests the aliment, which, after various operations of nature becomes so far animalised as to be a kind of white blood, from whence animal bodies at all times receive the constant support and recruit. Until an infant's powers are sufficiently strengthened to perform so great a business as that of digestions, the mother, by an all-wise appointment, from her own breasts supplies it with the means of life.

While human milk, provided by God, is the best food for babies, Man, using the art of chemistry, has come to understand how it is produced by mother and nourishes her child. In spite of his intelligence and reason Man should not disobey nature.

> How provident is Nature in all her works! How wonderfully indulgent to man, and other helpless animals in their first state of existence, by thus enabling the mother to feed her young with

> nourishment drawn from her own body, until such time as the offspring obtains strength sufficient to provide for itself. This gracious bounty is abused only by man, the most intelligent of earthly beings, whose misuse of reason leads him astray, whilst humble instinct directs all other parts of creation aright.

Smith bolstered the argument that nature knows best with shocking statistics, that two-thirds of children born in London died young. 'Disease and death are the usual consequences of the present erroneous methods of bringing children up by hand. Scarcely one in four of these little innocents lives to get over the cutting of their teeth; and the vitiated blood of those that escape, occasioned by improper nourishment, generally renders them infirm or short lived.'

> A little observation will convince us that greater numbers of the human race are lost in their infancy than of any other species, for near one half of deaths, within our bills of mortality, happen below the age of five. And further, compare the opulent with the rustic, the success is still exceedingly different. How many children of the great fall victims to prevailing customs, the effects of riches? How many of the poor are saved by wanting these luxuries? Again, examine the success of such as suckle their own offspring with that of those who commit them to the care of nurses, or bring them up by hand, and we shall there likewise find an amazing difference.

Alternatives to human milk were beyond the power of 'art' (chemistry and physic) to provide, or to protect against the

adverse effects of paps. 'From these considerations it is evident that nature is always preferable to art, whence the brute creation succeed better than the human in preserving their own species. And the peasant, whom necessity compels to follow nature, in this respect is happier than the lord.'

> Art cannot produce a diet with the affinity to animal blood, as to render it proper for the tender bowels of a new born child. The cries of an infant are generally occasioned by the uneasiness it suffers ... The complaints of children in these early days proceed almost intirely from this wrong practice. Watery gripes, offensive stools, and most disorders of the bowels are altogether occasioned by improper food.

Not only do individual babies suffer, and always have suffered, but also the human race. 'Ancient history never could have boasted of so many strong and valiant men had not mothers in their infancy given strength and vigour to their constitutions; and the cause of the present pusillanimous, feeble, weakly and diseased race of mortals may in great measure be ascribed to the want of this earliest maternal care.'

> Milk was before remarked to be a kind of white blood, prepared by the mother for the support of the young. In different animals therefore it is reasonable to suppose, and fact confirms our supposition, that the qualities of milk are also different, hence by first examining into its general properties, and from those principles, setting forth the peculiar variations in the milk of different animals, we shall arrive as the desired conclusion.

The composition of human milk was no different chemically from that of other animals, made up of cream, curd and whey, but human milk was the unique and perfect food for the newborn baby.

> In milk, by stepping into the dairy, we may discern three principal component parts. After it has remained some time in an undisturbed state, the cream floats upon the surface, it is the least in quantity though the most nourishing, of an oily balsamic substance and inflammable in its nature, as the butter which is made from it plainly demonstrates ... The cream being taken off the remaining milk appears bluish and thinner than before, and when thus robbed of its thick creamy part, it consequently is not so smooth to the palate. On the addition of rennet, or indeed any acid, a separation of the two remaining parts soon takes place, and we discover the curd. This being the heaviest, when separated from the whey, falls to the bottom. It is the least valuable part of the milk, glutinous in nature and composed of the most earthly particles, being also of an astringent quality. The third and only remaining part, being the whey of the milk, is the largest in quantity, of a diluting and cleaning property.

Smith was not alone in basing his arguments and explanations on physic and chemistry. The medicalisation of infant feeding was a subject that was being addressed by a new breed of physicians who dedicated their scientific interests and clinical practice to the care of sick babies and children.

6
Paediatrics

MEDICALISATION OF INFANT FEEDING

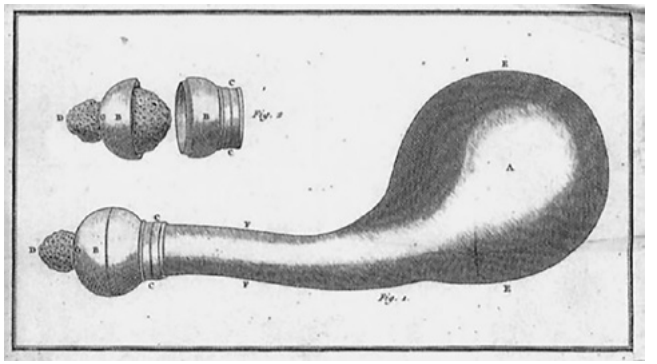
> *A child ought to get sufficient quantity of good nourishment if it is to thrive well. The best food for it is, no doubt, the mother's milk. We therefore find that children thrive well suckled by their mother's milk, tho' that should not stand all the proofs which are required towards approving that of a nurse. Thus if another child should suck the same milk it would immediately grow sick. For this reason alone mothers ought to suckle their own children, by this they gain a great deal; they will at least have easier deliveries, avoid several diseases, as the milk-fever, purpura puerperum [childbed fever] and inflammation of the womb.*

THESE ARE THE words of the Swedish Royal Physician, Nils Rosén von Rosenstein (1706–73), author of *Diseases of Children and their Remedies* (1776). In the opening chapter he promotes human milk, ideally mother's. Her health is also considered in relation to the consequences to her of not nursing her baby. In this, the first modern textbook of paediatrics, Rosenstein regards human milk as the primary matter to be addressed at the beginning of the book rather than at the end, for instance, of midwife manuals or textbooks of midwifery. This is not to say that Rosenstein disapproves of wet nursing.

> But should it happen that the mother has no milk, her nipples either being too small or large, too soft, too hard, or too sharp-pointed that the child cannot suck them or should have sore ones, or herself be too sickly or weak, having the consumption [tuberculosis], gravel [kidney stones], or any other disorder by which the milk thus affected might be propagated to the child, or if she is of a temper too easily moved by joy or sorrow, or in a situation where she cannot suckle her child, procure a good nurse.

After enumerating the essential qualities of the ideal wet nurse, in much the same words as everyone back to Soranus, Rosenstein lists five ways in which the 'goodness of the nurse's milk may be tried', using the senses: by its colour, smell, taste, consistence (sic) and touch. He concludes with an experiment, that 'by keeping it for several hours in a glass because if it then gives much cream it will also prove bad. The same is to be observed upon weighing the milk, for the more cream it gives the lighter it will be found.' With this comprehensive definition of the nature of human milk Rosenstein, following Cadogan and Smith, turns to hand feeding:

> If we cannot procure a nurse and the mother cannot suckle her child then we must accustom the child to suck by means of a little instrument, or sucking bottle (called biberon) ... but this machine ought always be kept clean. It is to be made of horn, the smaller end of which may be fastened to a tanned skin of a cow's teat, or if that is not to be procured, we may use any other thin skin pierced with many small holes. Pour in this as much cow's and goat's



Glass biberon, c. 1750

> cream (unboiled) as you think the child will use at once, dilute it with water and sweeten it with sugar.

The feeding horn should be filled with a mixed resembling as closely as possible the composition of human milk. Rosenstein then turns to the gripes, colic and diarrhoea, which all too often befall the newborn, dealing with both their cause and treatment.

> Stools thin and loose and more frequent than usual are called diarrhoea. By the peristaltic motion of the intestines the stools are promoted, by the natural mucus filtrated from the blood by their glands the bowels are kept smooth, by means of that vapour, or steams, arising from the pores of the vasa exhalantia [glands] in the oesophagus, stomach and intestines, the excrements are prevented from becoming hard. This vapour is again absorbed and re-enters the blood by the vasa lymphatica or bibula.

A mysterious vapour secreted by invisible pores in the guts is responsible for their smooth function (peristalsis) and this is facilitated by the juices secreted in the mouth, pancreas and liver.

> The saliva or spittle which is swallowed promotes also the same. The gall [bile] is diluted by that humour which the sweetbread [pancreas] separates from the blood, and is continuously flowing to the largest of the intestina tenuia [ileum], both these promote the digestions and stools; but it is chiefly owing to the gall that the bowels are excited to their peristaltic motion.

Saliva, bile and pancreatic juice all contribute to digestion, and diarrhoea is a consequence of disordered peristalsis and digestion.

> Diarrhoea may arise from whatever occasions a greater quantity to remain in the bowels than usual, or by anything causing the above-mentioned humours to be discharged in too great a plenty, or from anything preventing the vasa bibula from absorbing those liquids and by whatever increases the peristaltic motion. By eating and drinking in too great quantities the stomach and intestines are unable to digest the food, and from thence will arise indigestions and crudities which by their acidity irritate in part and increase the motus peristalticus and in part occasion a greater flux of humours.

The proper circulation of the humours (fluids and vapors) ensures proper digestion. This explanation of the 'pathophysiology' of diarrhoea caused by maldigestion, leading to acidity, is free of any reference to coction or fermentation. Nevertheless the remedies that Rosenstein recommends employ antacids:

> The nurse ought not to suckle the child immediately after eating, as the milk would then grow acid in the child's stomach and occasion gripes ... Gripes are a very common disorder among children of the poorer people, especially in the summer season, as their mothers then live chiefly on sour milk, which occasions gripes in their children. ... Their mothers, to remedy this, should give them as much oyster-shell powdered as will lay on the point of a knife, in a little water, and repeat it, till the green colour and sour smell of the excrements are quite corrected ... Magnesia Alba is the best remedy as it corrects the acidity and occasions stools.

In spelling out so clearly the relations between 'improper' feeding and infant diarrhoea, with a description of the mechanism by which diarrhoea occurs, Rosenstein puts infant feeding squarely within the realm of children's medicine (physic) and underlines the vital importance of human milk to prevention and treatment. Children's physic was emerging as a distinct branch of clinical medicine, as a result of new ways of thinking about the causes of diseases. Instead of viewing them as due to an imbalance or disturbance of the humours, many diseases were to be found localised within the body, particularly in its internal organs.

One of the first to advance this novel approach was the Italian anatomist and physician, Giovanni Battista Morgagni (1682–1771), who collated the records of more than 600 post-mortem dissections with the symptoms of the patients before they died. In many cases the precise location of disease could be determined, and the symptoms associated with them he regarded as 'the cries of the suffering of diseased organs'. *On the Seats and Causes of Diseases Investigated by Anatomy* (1761) incorporates distinct clinical accounts and pathological descriptions, offering a new system for the classification of diseases.

Following this approach, George Armstrong (1719–89), performed an autopsy 'in a child that died at the age of ten months of obstructions in its bowels', reporting in his *Account of the Diseases Most Incident to Children* (1767) that 'the child was never thriving from birth, had been ill a month before I saw him and was very much reduced. He had a slow fever almost constantly upon him, and his complexion was very sallow, like a person's in the beginning of the jaundice.' Armstrong then described the post-mortem findings:

> When [the body was] opened, the gall [bile] in the vesica fellea [gall-bladder] was as thick and ropy as a strong mucilage of quince feeds, and of a deep saffron colour. The abdominal viscera [organs] appeared very sound, nor could anything be discovered to account for his complaints, except the above viscid quality of the bile in the gall-bladder, which had tinged the neighbouring parts of a deep orange colour.

Examination of the abdominal viscera revealed the 'seat' of the disease. Armstrong recorded many cases of sick children with diarrhoeal diseases, writing:

> As to vomiting and green stools, there are few infants that are not subject to them at times. The disease has been called the watery gripes, from the stools being as thin as water, attended by violent gripes. Sometimes they are colourless, sometime mixed with little streaks of blood, and sometimes of a brownish cast, like a kind of putrid sanies, of a very strong and offensive smell, but always very thin.

The character of the stools was a guide to treatment, as the physician-accoucheur, Michael Underwood (1737–1820), taught in his *Treatise of Diseases of Children* (1815) that 'Regard is to be paid to the kind of stools that come away, which are seldom healthy and natural, and are usually distinguished into the sour and curdled, slimy, mucous, green, pale, clayey, watery, over-tenacious, and bloody, some of which are at times fetid.' Rejecting bookish aphorisms as a guide in favour of direct inspection, and employing chemical remedies, especially alkaline powders designed to restore the stools to normal, Underwood, following the teachings of Harris and Rosenstein, advised:

> When the stools appear very slimy, and more especially sour or curdled, or when the child is much disposed to the cough, the magnesia and other absorbent powders, are calculated to afford peculiar assistance, and may be warmed by any suitable aromatic. When the stools are very green, or white or clayey, a drop or two of the aqua kali [alkali] may be occasionally put into the other medicines, or a little almond soap be dissolved in the clysters [enemas], which are essentially necessary when much griping attends this complaint.

Although a few medical men, such as Armstrong and Underwood, were taking a special interest in the diseases of children, there were hardly any institutions dedicated to their treatment. Dispensaries were the main source of medical care for the poor. As charitably funded concerns supported by voluntary contributions and donations, they catered for a range of conditions and clinical needs. Treatment was generally free to those who brought a subscriber's letter and by the 1810s London had thirty or more general dispensaries, vaccination establishments, refuges for the destitute and asylums for the blind and orphanages, but only one devoted to the care of sick children. George Armstrong established this, the first dispensary exclusively for the medical care of the young, at Red Lion Square in London, close to the Foundling Hospital. However, in spite of treating more than 35,000 patients over nine years, it closed when he died.

Children with scalds, burns and broken bones might be admitted to orthopaedic or general hospitals. Women's hospitals might take children in with their mothers, and babies might be treated in Lock hospitals (for the treatment of venereal diseases), but most hospitals, as a whole, refused to admit them, stating sternly: 'No woman big with child, no children under six years of age, no persons disordered in their senses, suspected of having smallpox, itch or other infectious distemper, that are apprehended to be in a dying condition or incurable, be admitted.' Parents were reluctant to take their children to general dispensaries 'expecting them to be neglected while grown-up persons were attended to', and in a competitive medical market sick children did not stand much of a chance – they could not pay, nor all too often could their parents.

There was little economic or professional incentive to establish a dispensary or hospital for sick children because their diseases were generally regarded as neither curable nor lucrative. There were exceptions to this dismal state of affairs. The physician, John Bunnell Davis (1780–1824), detained in Paris during the Napoleonic wars, where he was impressed by the revolutionary way in which the new 'clinico-anatomic' approach to medicine was being applied in its hospitals, conceived the idea of a children's dispensary in London:

> The British metropolis has long felt the want of a medical establishment which, by exclusively directing its efforts to the preservation of health and the prevention and cure of diseases in infancy and childhood, may counteract the causes of those premature deaths annually to be deplored. It is a fact greatly to be lamented that a very large portion of those who are born in London, particularly amongst the poor, die before they attain five years of age.

The death rate of under-fives in London in 1815 was 36 per cent, below the figures recorded by Hugh Smith fifty years earlier, but still over one in three, which was 'more than at any subsequent period of life'. Davis argued that the care of such children deserved attention not just for philanthropic reasons, but also because:

> it is important to abate disease in early life, which tends to produce a feeble race of beings, unfit for the active duties of the great mass of the people ... It is in the hope of diminishing so great a mortality that an Institution is proposed ... where a physician with

proper medical assistants may examine patients and administer advice and medicines.

Davis pointed out that children who remained healthy until the age of twelve were unlikely to become diseased later, so fewer workhouses and hospitals would be needed. He promoted and provided vaccination, pioneered by Edward Jenner (1749–1823) in the 1790s, and claimed that his dispensary 'had given birth to a school of medicine in which the theory of disease is elucidated and confirmed by practice in the very imperfect department of science relating to children's diseases'. His attempt to expand his children's dispensary into a children's hospital ended with his death in 1824. Although a few children's hospitals were founded earlier in other European cities, they were small, charitable institutions which, responding to a local concern for the plight of sick children, were also not long-lasting.

Paris was the first city in Europe to establish a viable modern hospital dedicated to the care of sick children. Children were formerly to be found in most of its great hospitals. The *Hôtel Dieu*, for instance, had a crèche where frail newborns were wet-nursed and some fed by spoon or feeding horn. Infants were sometimes admitted to the general wards, but there were no facilities exclusively for the care of sick children. To separate children from adults and to 'safeguard them from corruption', the seventeenth-century foundling hospital, *L'Hôpital des Enfants Trouvés*, intended primarily for the reception of abandoned babies (with infant mortality rates of foundlings of over 60 per cent), was designated *L'Hôpital des Enfants Malades*. With 300 beds, described as 'vast, airy and clean' and supported by the new French state, it took in both medical and surgical cases, although children under two years

of age were generally excluded. It was allied to the *Maternité* at Port Royal, which also cared for the newborn. Children with gastroenteritis, pneumonias, typhoid fever, exanthemata (eruptive fevers), ophthalmia (eye infections) and tuberculosis filled the wards, and in the *infirmerie de la crèche* of the *Maternité* one-third of sick neonates died – of thrush, sclerema neonatorum, fevers, convulsions, jaundice or diarrhoea.

Wholesale reorganisation of the Paris hospitals after the Revolution of 1789 was accompanied by the appointment of full-time salaried staff with particular medical interests, who could dedicate their time and energy to teaching and research rather than private practice, and by 1804 it was recorded that:

> Every infirmity, every need, every stage of life has now, in Paris, institutions that are devoted to it ... those illnesses that cannot conveniently be treated



Musée de l'Assistance Publique-Hopitaux de Paris

> [in general hospitals], which require special care and regimen, which must be isolated for the benefit of those who suffer from them and in the interests of those who do not, have special hospitals.

Learning the art of observation at the bedside became the core of clinical instruction. 'Read little, see much, do much' was the maxim that epitomised the approach to medical training in post-revolutionary Paris. These momentous developments shifted the emphasis of the study of medicine from the library to the clinic and from the recitation of classical texts to the examination of diseased and dead patients. They were the foundation of further advances, such as physiological experimentation and laboratory investigation, establishing the hospital as a dominant locus of the medical and surgical care of the sick, and the primary site for the study of the causes of disease and of clinical teaching.

The clinico-anatomic method which had impressed Davis became widely adopted, replacing symptom-based descriptions of disease with classifications founded on pathology. However, the newborn baby represented a special problem. While some infants that died soon after birth had gross external abnormalities obvious to the naked eye, such as anencephaly or anogenital abnormalities which accounted for their demise, as the practice of autopsy was extended to infants, a search for internal abnormalities to explain their death revealed lesions of the heart, lungs and guts, for instance. However, many babies seemed to succumb for no explicable reason. Their viability was insufficient to sustain them and their deaths were ascribed to 'debility', 'atrophy' or 'prematurity'.

François Chaussier (1746–1828), one of the architects of the post-revolutionary reforms of Paris medicine, as well as occupying the chair of anatomy and physiology, was physician in charge of the newborn at the *Maternité*, where he invented an apparatus to resuscitate them and, inspired by a search for an index of viability, measured the maturity of infants by weighing them at birth. Chaussier had written his doctoral thesis on infanticide and his interest in birth weight was forensic: the outcome of legal cases of disputed inheritance, legitimacy and infanticide could turn on proof of viability. In *L'Hôpital des Enfants Trouvés* nearby, Charles-Michel Billard (1800–32), also took an interest in the newborn, writing:

> Viability is the capability of extrauterine life; it should consist not only in the normal state of the organs of the infant, but likewise in the absence of all physiological and pathological causes capable of opposing the establishment or prolongation of independent existence.

Billard set about investigating the pathology of the newborn, describing his findings in *Traité des Maladies des Enfants Nouveau-Nés et à la Mamelle* (1828). He was 'particularly struck [how the] distinguished observer [Giovanni Morgagni], after having enumerated the affections to which new-born children are liable [complained that] little progress has been made in their pathology'. Billard made detailed descriptions of sick infants, including their dimensions, based on observation, measurement and autopsy and concluded that 'the newborn infant may be born healthy, diseased, convalescent or entirely

recovered from a former condition'. Using the weighing balance and the surgical scalpel to understand the physiology and pathology of sick infants, he was able to distinguish the viable from the non-viable.

As a foundling hospital, *L'Hôpital* received infants from birth to two years. Healthy babies weighing over 6 lbs were separated from the small, weak and dying by a skilled nurse and the hospital physician. Those that were judged viable were transferred to the 'Suckling's Ward' where they were wet-nursed. Billard measured their weights, claiming that variations at birth were as great as at older ages, and saying 'it is impossible to assign any size in common to all young infants; they differ in this respect almost as much as adults. All the varieties of size, strength, shape and colour exhibited in the human species, are evident in the cradle.'

Billard came to the conclusion that it was not just the weight of the newborn alone that determined its viability, nor



Jean-Henri Marlet, *The Sucklings Ward in the Paris Foundling Hospital*, 1831

the presence of disease in particular organs, but also their prenatal health in the womb:

> It appears that it is not after birth only, as has been asserted by philosophers, that man for the first time experiences that set of maladies which afflicts his race, but the origin must be sought in a much more remote source; it commences with the organisation ... as soon as the ovum, the embryo, the fetus, and the adult become more perfect in their organisation, their functions undergo a peculiar change in a state of health, and whence present corresponding peculiarities of symptoms in disease, the forms of which will change according to the different phases of organisation.

Billard concluded that 'the alterations of the functions, or the diseases resulting from any disturbance in the organs, vary equally according to the different subjects [organs] affected, and according to the different epoch [stage] in the life of the same subject.' This conception of disease as due to disruption of the organisation of the growing child was a development from Xavier Bichat's (1771–1802) assertion in his *Recherches Physiologiques sur la Vie et la Mort* (1800) that 'Life is that set of functions which resist death'. Billard elaborated this definition further as 'there is a superabundance of life in the child. In the child the reaction of the system is superior to the action, which is made upon it from without ... In living bodies, such in fact is the mode of existence; that whatever surrounds them tends to their destruction.'

By the 1830s the new clinico-anatomic method recognised tissues and membranes as 'seats of disease', and

embryology and development as shaping the expression of diseases in children. While children's physic was slowly emerging as a clinical specialty, with its own dispensaries, clinics and hospitals, staffed by physicians and surgeons with a dedicated interest in the diseases of infants and children, apothecaries were applying chemical methods to the analysis of food, drinks, herbs, spirits and other organic and mineral substances, and the preparation of medicines, beverages and special mixtures with healing properties.

ALIMENTARY CHEMISTRY, CALORIMETRY AND APOTHECARIES

Physicians had long regarded foods, drinks and medicines as having humoral properties, determined by their degrees of hotness, coldness, wetness and dryness. They prescribed them accordingly, to restore the humoral balance of the body and to calm disturbances of its organs, including the guts and liver. Chemists and pharmacists now started to interest themselves in the chemical nature of foods and their fate within the body, and new thinking, derived from alimentary chemistry and the analysis of the chemical composition of plants, vegetables, meat and beverages started to inform dietary advice.

Floury and sugary foods derived from plants were observed to be subject to fermentation, while animal foods tended towards putrefaction. The former were described as 'mucilaginous' and the latter as 'gelatinous', and within plant substances there was a hierarchy whereby the further from the roots the more mucilaginous were their parts. Milk was regarded as an intermediate substance which, with vegetable and animal origins, combined both mucilaginous and gelatinous properties. It was high in the hierarchy of plant–animals–man: as a substance elaborated by woman it was close to a perfect food, promoting health and defending against disease, containing, by definition, all the newborn baby required to thrive and grow. However, food alone was not sufficient to thrive. The newborn also needed air to breathe, as well as food to digest. Air was a material substance.

The discovery that air had material substance gave chemistry a new dimension and helped to explain thitherto inexplicable bodily processes. New apparatus, such as the air pump, vacuum chamber and calorimeter, widened the scope of natural philosophy and experimentation. Van Helmont had shown that 'aerial nitre' was given off by burning bodies, Boyle that air was necessary for combustion, and John Mayow (1641–79) that 'spiritus nitroaereus' was a vital part of air. Now the chemist, Joseph Black (1728–99), found that limestone (calcium carbonate) heated or treated with a strong acid (calcination), yielded calcium oxide and 'fixed' air, which extinguished a burning flame and animal life. Joseph Priestley (1733–1804) focused sunlight onto mercuric oxide, releasing a 'pure' form of 'dephlogisticated' air (oxygen) which supported combustion and respiration. These experiments inspired the imagination of fine artists and provoked the wonder of the public.

Antoine Lavoisier (1743–94) found that phosphorus and sulphur both gained weight when burned in air. These solid substances bound elements of the air. He showed that animals use and reconstitute atmospheric air in the same way as a burning body: oxygen is consumed, carbon dioxide is generated and respiration produces heat. Using an ice calorimeter, he measured heat generation and carbon dioxide production concurrently and showed that 'animal heat' was a product of slow combustion. The body was a 'heat machine' and respiration was:



Joseph Wright, *An Experiment on a Bird in the Air Pump*, 1768

> A combustion, very slow to be sure but nevertheless strictly comparable to that of carbon. It takes place within the lungs [and] the heat produced by this combustion is communicated to the blood which traverses the lungs and from there is distributed throughout the body. Thus the air which we respire serves two functions equally necessary for our preservation: it removes from the blood the base of the fixed air [carbon dioxide] whose superabundance is quite deleterious, and the heat which this combination [carbon plus oxygen] releases in the lungs, restores the heat continually lost.

The concept of the living organism as a heat machine conformed with the newly invented steam engine, which



Henry Lascelles, *The calorimeter of Lavoisier and La Place*, 1801

manifestly converted heat into work, and with the voltaic pile, which produced electricity that could generate heat and light. One physical process could be converted into the other and be expressed in precise numerical terms. These similarities between the animate and inanimate gave strength to mechanistic explanations of the life forces. Inorganic and organic chemistry converged. Lavoisier proclaimed, 'Rien ne se perd, rien ne se crée, tout se transforme,' (nothing is lost, nothing is created, everything is transformed).

The mechanical, hydraulo-pneumatical model of the body, as an engine, which served to explain the circulation of the blood and the flow of digestive juices through the gut, for

instance, was now also a heat machine in which the combustion of food and drink powered its actions and movement. Food became regarded more than simply of what it was made, but of what role it played in the economy and workings of the body. Human milk clearly fuelled the baby and made it grow, and therefore it must contain both combustible and plastic elements. These elements must be released by gastric digestion, as Underwood had taught:

> Milk itself, like all other animal juices, is produced from food taken in by mother, and is the richest part of it. It is in her stomach that the aliment is digested, which, by a combination of powers in the chylopoetic [chyle-making] viscera, is so far animalised as to be converted into a kind of white blood, from which every animal body is daily recruited [replenished]. And before an infant has acquired strength enough to convert solid food into this wholesome chyle, the parent, by the wise substitution in nature has, in a great measure, previously accomplished this work for the infant she is to nourish. During infancy, therefore, both Nature and Reason most clearly point out the expediency of a milk diet.

Milk was 'a kind of white blood' derived from chyle, just as Harvey had stated two centuries earlier, and in spite of the discoveries of physicians and natural philosophers, there was nothing that the chemical arts could offer that was better. The experiments of the English physician, William Prout (1785–1850), led him to conclude that 'the principal alimentary matters [foods] employed by man and the more perfect animals [mammals]' might be reduced to three great classes, namely,

the *saccharine*, the *oily*, and the *albuminous*, but he shared the reservations of children's physicians, such as Richard Evanson (1800–71) and Henry Maunsell (1806–79) that when it came to artificial feeding:

> It should be as like the natural nutriment as possible. This rule is easier laid down than acted upon 'for Nature' says Dr Prout, 'will not permit the chemist to officiate as her journeyman, even in the most trifling degree'. It is vain to attempt any preparation upon chemical principles, of a food resembling human milk. It will be better to be satisfied with employing the food of some other animal, and modifying it, so as to make its sensible properties, as nearly as possible, similar to the milk in question.

Evanson and Maunsell advised that 'for this purpose, good cow's milk, is usually the most convenient; and as it is thicker and whiter, and not so sweet as human milk, we may add to two parts of it, one of very thin barley water, and sufficient white sugar to make the necessary increase in its sweetness'. A certain amount of manipulation of the elements of cow's milk might make it more like human milk, but it was a mistake to reject the latter, as William Buchan reminded readers of his still widely read household manual, *Domestic Medicine*, that 'nature not only points out the food proper for the infant, but actually prepares it. This is not sufficient to prevent some who think themselves wiser than nature from attempting to bring up their children without her provision.'

Nevertheless, there were occasions when animal milks, such as that of goats, cows, asses, sheep or mares, might be used for medicinal and health-promoting reasons. For the

very young or in bad cases of diarrhoea, ass's milk was helpful because 'it is thinner and has less curds than other milks' wrote Underwood. Efforts to make artificial feeds more digestible led to a variety of other substances being added to, or incorporated with, cow's milk including wheat flour, barley water, beef extract, malt, and arrowroot.

Although milk had 'animal and vegetable origins', the inferiority of plant sources for infant feeds (in accordance with the hierarchy of food substances) was confirmed by the observation of the indigestibility of 'vegetable aliment'. Cereals with a lot of starch (representing respiratory or 'combustible' ingredients) were noted to lack the 'plastic' element (necessary to promote growth) and to be associated with the accumulation of starchy deposits along the lining of the infant gut.

The German chemist, Justus von Liebig (1803–73), making the chemistry of foods one of his chief interests, used simple gravimetric methods to determine the nutrient composition of milks. After evaporation of samples to dryness, he extracted the fats with ether and precipitated out the proteins and sugar. Knowing the chemical nature of foods served to explain how they were digested, broken down and separated into parts, which could be characterised as elemental, containing a few common elements, particularly carbon, hydrogen, oxygen and nitrogen, or compound, such as gelatin, albumin and fibrin, as well as sugars, fats and minerals (ash). Such substances came to be classified into three essential groups: calorifacient or combustible matter (fuel – sugars and fats); plastic or nitrogenous matter (proteoids); and mineral matter (ash) or salts.

The purification of foods composed of a single substance, such as gelatin (derived from animal bones) led to the marketing of proprietary foods, which claimed health benefits. A convergence of gastroenterology and gastronomy, and of



Wilhelm Trautschold, *Justus von Liebig's Chemical Laboratory in Giesen*, 1842

commerce and chemistry, informed the recommendations of medical men, replacing humoral classification of foods and their purported health-promoting properties and therapeutic effects with dietary advice based on chemical principles.

FROM MEDICINE AND SCIENCE TO PUBLIC HEALTH AND PUERICULTURE

Chemistry was informing physic, but few physicians or surgeons beyond Armstrong, Buchan, Davis and Underwood devoted their medical practice solely to sick children. Rather the opposite was the case, in spite of the view expressed by Miles Marley (1798–1854) in his *Nature and Treatment of the Most Frequent Diseases of Children* (1830):

> Many [physicians] consider the management of the diseases of children more difficult than those of adults; but a little experience will teach the

> observant practitioner that, though words are denied their little patients, they have a language which may always be interpreted ... The expression of the eye, the numerous gestures and cries indicative of pain and uneasiness ... the appearance of the tongue and skin, the secretions, excretions etc..

The capacity to interpret the language of symptoms and signs and correlate them with post-mortem findings showed that the clinico-anatomic methods could be effectively applied to sick children. However, Armstrong argued that most medical men were frightened, ignorant and, therefore, incapable of treating sick children, writing:

> I know there are some in the physical tribe who are not fond of practising amongst infants; and I have heard an eminent physician say that he never wished to be called in to a young child because he was really at a loss to know what to order for it. Nay I am told there are physicians of note who make no scruple to assert that there is nothing to be done for children when they are ill – this I am told was the doctrine of the late Dr Hunter, who though a great anatomist was no adept in physic.

He may have been right, as the celebrated anatomist and obstetrician, William Hunter, writing about the diseases of infants, lumped together rickets, red gums, sore eyes, gripes, fits, inoculation, teething and scabby face at the end of his lectures on midwifery. Obstetricians took some interest in the fetus and newborn, were prepared to give advice about infant feeding, but diseases of children were not their forte. All the same it was obstetricians who, although confessing that babies were not the easiest of patients, knew and wrote most about babies as they saw more of them than other medical men.

Children's dispensaries remained few and far between, and there was strong resistance to children's hospitals in Britain. A powerful medical establishment which controlled the general infirmaries saw them as a threat to their professional livelihoods. They argued that even when, for instance, out of 51,000 people dying in London in 1843, 21,000 (40 per cent) were under ten, there was no need for them. A survey done the same year revealed that of some 2,400 patients in all of the capital's hospitals, only twenty-six were children. Opponents of children's hospitals stressed the deleterious moral and social effects of bringing sick children together, the risks of spread of infection between them and the adverse consequences of removing them from their families, warning that:

> To relieve the parents wholly from the burthen of maintaining their offspring, would be absurd, even if it were possible; and every scheme which has for its object the gratuitous maintenance of poor children, may safely be pronounced dangerous to society, in proportion as it directly relieves the parent from his burthen. It removes the only check on improvident marriages, and one of the principal guards of chastity.

These views concealed a fear that charitable assistance to poor families might lead to an unwanted rise in the birth rate, and with it the proliferation of 'undesirable traits'. While the medical establishment shunned children's hospitals and at the same time made no accommodation for children in general hospitals, a growing sanitary movement preached that fresh air,

the drainage of cesspits, the closure of refuse dumps and the provision of clean water would benefit all, including children. Public health professionals were joined by philanthropists and a few politicians in calling for action to improve child health. The plight of mothers and babies, especially those living and working in the rapidly burgeoning cities, and employed in factories, mills and workshops, was attracting their concern and attention. Hospitals were not the place to prevent babies from dying from improper feeding, nor did they offer much that might save them. It was a few determined medical men, obstetricians and proto-paediatricians, who were the loudest voices speaking out and taking the lead. What they argued for was public health initiatives focused on the quality of milk and the care and protection of mothers and babies in the community.

7
Puericulture

MATERNAL AND CHILD WELFARE

> *Meat, potatoes, often gin; scant nourishment drawn from the breasts whose secretive power cannot eliminate milk from a half-starved frame, and the unwholesome diluted milk of unhealthy badly-fed cows; such is the nourishment afforded to thousands of children on this day of an enlightened age, in this capital city of a civilised country.*

THIS WAS HOW the foremost British medical journal, *The Lancet*, characterised the plight of London babies in 1858. In an editorial provocatively entitled 'The Murder of the Innocents', it argued that sick and starved mothers, and sick and starved cows, caused the 'awful mortality amongst children'. Asserting that 'the natural substitute for the mother's milk is cow's milk', it urged that 'poor mothers are supplied gratuitously with feeding bottles, and with each are given sensible counsels and warnings as to child feeding'. Clean milk was the answer because:

> at the root of the unfitness which undoubtedly exists in the ranks from which our soldiers are drawn is the question of proper infant feeding. It cannot too often be repeated that a child wisely fed for the first two or three years of life has every chance of growing

> up into a strong man or woman; a child rendered rickety and puny by ignorant feeding will in all probability never make up the ground it has lost.

Concern was not just for the life and health of babies, but also about the long-lasting effects of poor nourishment on adult health, and on later generations.

> A great number of infants, especially in towns, have from one cause or other to be fed artificially. At present cow's milk is too often, when it reaches the houses of the poor, in a state which renders it dangerous to life. Can any reasonable mind be surprised at the great infant mortality and at the unfitness of the majority of the survivors? Without clean milk there will be continued death and unfitness; the moral is that every effort should be made to get clean milk ... Then and only then will this great national problem be satisfactorily solved.

Such articles forced public attention on the health of mothers and children, and also on cattle. The dangers of unclean cow's milk, not only when fed to babies, but also more generally, were well recognised. Cows were frequently housed in cramped conditions in towns, where they had neither exercise nor fresh air, and were milked without care or cleanliness. Only in dairies on the edge of town were cows put out to grass. Confined to stalls in stone-flagged yards, fed on grain and turnips and a truss of hay shared between ten animals, metropolitan cattle never saw a meadow. In St Pancras, London, for instance, there were ninety-two cowsheds, which were condemned because:

> Their size is often insufficient ... the drainage is very bad ... very few are ventilated ... without water supply ... in a most filthy condition ... the manure is kept too long ... vegetable matter [is] lying about in a rotten state ... pigs are kept as companions to the cows ... [whose] ... coats are either an entangled mass of filthy hair, or else free from hair, owing to the diseased state of their skin.

George Scharf (1788–1860), who documented the London he knew in the 1820s, sketched a milk shop in Golden Lane. A cowman tops up a churn of milk, a mangy dog licks up the spills and a boy pitches dirty hay into the cellar beneath the shop. The dark and airless sheds behind were the source of a milk which was far from fit for consumption, frequently



George J. Scharf, *Cow keeper in Golden Lane*, London, 1829

contaminated, sometimes adulterated or diluted with water and thickened with chalk.

In France, ironically, the accommodation for wet nurses in Paris was not far different from that of cows in London which supplied the milk given to many hand-reared infants. As the demand for wet nurses in Paris grew, there developed a traffic not just of babies from town to country but also of wet nurses from country to town, often under duress:

> These women are conducted to Paris into domiciles that do not seem ever to have been intended to receive human creatures. They are huddled together in miserable offensive rooms, without air and where even there are not cradles for the infants. It is to such persons, and in such places, that a great part of the Parisian population confines its children; no wonder that the mortality should continue beyond all proportion in early childhood.

In Paris and London the horror of the conditions of wet nurses and cows excited the concern of medical men, philanthropists and welfare reformers, who determined to draw attention not just to the plight of babies but also to the social costs of wet nursing, the dangers of cow's milk and neglect of the welfare of mothers. By highlighting the scandalous conditions of wet nurses and cattle, albeit with vivid and extreme examples, the virtues and vices of wet and dry feeding were brought into sharp relief, forcing a debate about the choices between them.

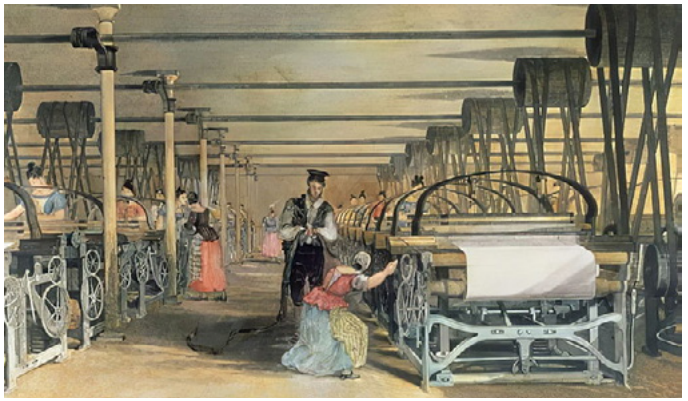
> It is only of late years that the awful mortality amongst children in this country has attracted such attention; and the plain figures whereby it can be proved, together with the limited range within which the causes are included, have led to much careful sifting of the subject. It is fully time that some protest should be entered against the culpable carelessness of which little children are the victims, and some measures attempted to remedy the increasing wrong.

Breastfeeding was recommended by most medical men. Wet nursing was not a very practical alternative and 'farming out' babies, as it later became known, was pretty much their death sentence.

MIASMA, MORTALITY AND MONSTER SOUP

Feeding babies was a national concern, and outside London things were no better. The rapid growth of cities from the movement of people from country to towns in search of work led to overcrowded homes, slums with little sanitation or sewerage and 'dark satanic mills' where young mothers, and even young children, laboured for long hours to make a meagre living and support fragmented families.

The report by the social reformer, Edwin Chadwick (1800–90), *On the Sanitary Condition of the Labouring Population of Great Britain* (1842), documented the especially high mortality of children living in these big industrial and manufacturing towns. Of children of labourers, artisans and servants dying before the age of twenty in Manchester and Liverpool, one in two were under five years, as opposed to one in seven of the children of farmers and tradesmen in rural Wiltshire and Rutland. In the urban centres 'it is not infrequent for mothers of the



Thomas Allom, *Lancashire Cotton Mill*, 1835

tenderest age to return to their work in the factories on the second or third week after confinement, and to leave their helpless offspring in the charge of mere girls or superannuated old women', who too often resorted to *Godfrey's Cordial* or *Mother's Kindness* to 'quieten them, sometimes with fatal results'.

Legislation to improve access to medical services and strengthen the public health was piecemeal and patchy. The Poor Law Amendment Act of 1834 restricted aid to only the most needy and helpless in England and Wales, but required parishes to provide for those in their care. District medical officers were appointed to treat the sick poor in public institutions and their homes, further exposing the magnitude of child ill-health, disability and neglect. The public health acts of the 1840s aimed to tackle miasmas by improving sanitation, sewerage and the water supply, but had negligible impact.

The 'Great Stink' of 1858 brought to inescapable attention the inadequacy of London's antiquated sewerage system comprising more than 200,000 cesspits and over 350 sewers draining directly into the River Thames. The hot summer

magnified the ever-present smell of untreated human waste into an unbearable stench of a 'most head-and-stomach distending nature'. 'Near the bridges the feculence rolled up in clouds so dense that they were visible at the surface ... The smell was very bad and common to the whole of the water; it was the same as that which now comes up from the gully-hole of the streets; the whole river was for a time a real sewer,' wrote the chemist, Michael Faraday (1781–1867). Carbolic acid was poured into the river to ease the stench and tons of chalk lime were dumped at the mouths of the sewers and spread along the foreshore at low tide.

The satirical artist, William Heath (1794–1840), depicts a fashionable lady dropping her cup and saucer in alarm as she peers at 'a correct representation of that precious stuff doled out to us: Monster Soup commonly called Thames Water', swarming with 'prodigious things, hydras and gorgans and chimeras dire'. The miasma from the effluent discharging into the Thames was



William Heath, *Monster Soup commonly called Thames Water*, 1828

thought to be the cause of outbreaks of cholera which, from its arrival in Britain in 1831, had visited London three times. Contamination of fresh water, often drawn for domestic use from public wells, with waste water from cesspits and drains, was not uncommon and served to explain and later confirm the belief of the physician John Snow (1813–58) that cholera was a water-borne contagious disease and not due to miasma. Investigating a fatal outbreak in Soho, Snow found that:

> Nearly all the death had taken place within a short distance of the [Broad Street] pump. There were only ten deaths in houses situated decidedly nearer to another street-pump. In five of these cases the families of the deceased persons informed me that they always sent to the pump in Broad Street, as they preferred the water to that of the pumps which were nearer ... With regard to the deaths occurring in the locality belonging to the pump, there were sixty-one instances in which I was informed that the deceased persons used to drink the pump water from Broad Street, either constantly or occasionally.

The Broad Street pump supplied water from a well that was later found to be only three foot from a leaking cesspit into which the cloth nappy of a baby who had contracted cholera had been washed. Snow's report to the *Medical Times and Gazette* in 1854 was ignored, but the Great Stink precipitated a sewerage modernisation programme designed to abolish cesspits and make sure that sewers discharged downstream of drinking water supplies.

Coupled with these public health and legislative initiatives was the rise of self-help friendly societies, working men's associations and other mutual and collective organisations. The custom of charitable patronage was declining, replaced by movements for the reform of social institutions such as jails, schools, workhouses, foundling hospitals and factories, in which the poor could be supervised, educated, trained, rescued and protected. These reforms combined philanthropy, science and economic theory to the betterment of both society and the individual.

Such enlightened thinking, informed by social and medical statistics (measures of disease prevalence, occupation, physique, mortality, etc.), faith in the benevolence of institutions and public commitment to improve them, extended to the plight of children. Surveys carried out for the factory and child labour acts of the 1830s aimed at limiting employment in mines, factories and chimneys, included measurements of the heights, weights and health of working children, and added statistical ammunition to the case for child labour reform.

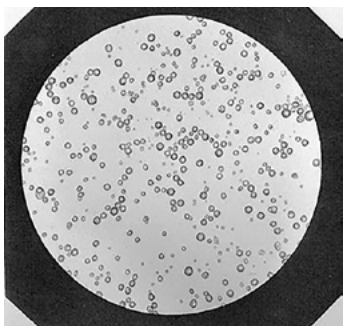
The collection of mortality statistics focused attention on young children, and with it emerged a potent new statistic: the infant mortality rate (IMR). With rates of 150 or more deaths per 1,000 live births it became a subject of social and then political concern because of its implications for society as a whole. Annual reports of the registrar generals of England and Scotland confirmed unequivocally that children had far higher mortality rates than adults, and that infants were particularly vulnerable.

Identification of infancy as the most dangerous time of life shone the medical gaze on the newborn. Comparably high infant mortality rates were recorded in France, Germany and other European countries, and this information was shared through publications in journals and at national and international congresses on hygiene (the first held in Brussels in 1876)

which addressed the causes of 'infantile mortality'. At successive gatherings the question of injudicious infant feeding and what to do about it assumed greater importance. A nascent child public health movement drew together politicians, philanthropists, public health professionals, paediatricians and obstetricians dedicated to what became termed *Puériculture*, the rearing and hygienic care of children, with particular concern for the unborn, the newborn and the health of mothers.

OBSTETRICIANS AND PAEDIATRICIANS

The French obstetrician, Alfred Donné (1801–78), was an enthusiast for new technology, pioneering the clinical use of the microscope, thermometer and weighing balance. The microscope had revealed 'hydras and gorgons and chimeras' in Thames water, but it also revealed more wholesome bodies in human milk. Donné compared the different appearances of human and bovine milks under the lens, noting that the globules of fat were smaller and fewer in the latter, just as the amount of fat, measured chemically, was less.



Microscopy of milk showing fat globules, from Alfred Donné, 1854

As *chef de clinique* at the *Charité Hôpital* in Paris, Donné took a special interest in children's health, in particular the nutrition of infants, rejecting 'demand feeding' made fashionable by the preachings of Jean-Jacques Rousseau (1712–78) and recommending regularity. He urged physicians to monitor infant development, feeding and growth remarking, for instance, that 'the weight of a child of medium strength, suckled by an ordinary nurse, increases about a pound a month, till the age of six months'. His popular book on infant care and feeding, *Mothers and Infants, Nurses and Nursing* (1839), argued for scientific childcare, in which the physician assumed medical responsibility for both mother and baby. The latter became a 'patient' receiving attention equal to that of the former, and the health and growth of the baby demanded as much consideration as the quality of the mother's milk.

In Britain, Charles Routh (1822–1909), physician to the Samaritan's Hospital for Mothers and Children in London, also took a special interest in the newborn, publishing a series of articles in the *British Medical Journal* on the 'conditions which favour infant mortality and viability', addressing the contributions of feeding to the causes and prevention of infant deaths. He had studied in the hospitals of Paris, Prague and Vienna and became a friend of the Hungarian obstetrician, Ignaz Semmelweis (1818–65), 'whose researches, whose struggles and whose quarrels played so prominent a part in conferring an inestimable boon on womankind – the establishment of aseptic midwifery in lying-in hospitals'. Routh was the first to publicise Semmelweis's work to an English medical audience, reporting that in the Vienna General Hospital:

> There was a midwives' clinic and a students' clinic, the wards in the former were not so large and not

> so airy as those in the latter, yet the mortality in the fine wards where the students were instructed was scandalous. It ranged from 1 in 9 to 1 in 34, while in the midwives' clinic the range was from 1 in 92 to 1 in 34. The student was instructed on the dead body of some female, and each patient in his clinic was examined by at least five different persons. The midwife pupil was instructed on the leather phantom and not upon the dead body, yet each patient was examined as frequently as in the students' clinic.

The childbed, or puerperal, fever of mothers that resulted from a lack of hand-washing by medical students moving between teaching rooms and lying-in wards, was deadly, but Semmelweis's findings were dismissed by his colleagues and superiors, who persisted in their unhygienic practices. Every mother lost was another baby orphaned, if it survived.

Puerperal infection presented the same challenges as post-operative infections. The majority of deaths following childbirth and surgery were due to fevers, which were much more common when these procedures were carried out in hospital than at home. Mortality from domestic surgery was less than 10 per cent, compared with 40 per cent in hospital, and mothers delivered of their babies in maternity wards were ten times more likely to die than mothers giving birth at home.

Florence Nightingale (1820–1910) believed that fatal sepsis, suppurating wounds and eruptive fevers arose from miasmas, the malodorous vapours, or 'bad air', that emanated from rotting matter. The term 'hospitalism' was coined to describe the morbid conditions and dangers of the wards, and prompted vigorous efforts to clean and aerate them, to expel fevers, pyaemia, gangrene and abscesses, so prevalent, especially after surgery. Nightingale argued that the best way to prevent their spread amongst children was to admit them to adult wards, ideally spacious, clean, open and well-ventilated. The Edinburgh obstetrician, James Y. Simpson (1811–70), though not believing in the miasma theory of infection, stressed the 'importance of sufficient ventilation in the nursery', citing Clarke's achievement in reducing infant mortality in the Dublin Rotunda Hospital from 16 per cent to 5 per cent, largely through aeration of hospital wards.

Inspired by Louis Pasteur's discovery that the putrefaction and fermentation of rotting food occurred if micro-organisms were present, even in anaerobic (without oxygen) conditions, the Glasgow surgeon, Joseph Lister (1827–1912), adopted carbolic acid as an antiseptic in surgery to sterilise surgical instruments and clean open wounds. His practice of washing his hands, wearing gloves and applying 5 per cent carbolic acid solution in the operating room – just like Semmelweis's practice of hand-washing in the labour ward – was not widely shared.

Drawing on the writings of Donné and Semmelweis, Routh documented the close association of infant mortality with 'improper feeding', which included everything other than maternal nursing. The debate about how best to feed babies formed the core of his *Infant Feeding and its Influence on Life* (1860), in which Routh reminded readers that 'bringing up a child on its mother's breastmilk is, without doubt, far safer than entrusting it to another wet nurse. The worst that can be done under any ordinary circumstances for a child is to bring it up exclusively by hand.'

To strengthen his argument he referred to the annual reports of the Clinical Hospital for the Diseases of Children in Manchester. Founded in 1856, the hospital was designed to address 'the appalling rate of mortality amongst the children

of the poor, amounting, during the first two years of life, to thirty-five per cent, and within the first five years, to fifty per cent'. Seventy-nine per cent of the deaths of children less than two years old were due to diseases arising from 'defective or faulty nutrition'. The authors of the reports, August Merei (1804–58) and James Whitehead (1812–85), observed that atrophy, marasmus and defective assimilation in infants 'almost invariably may be traced to bad nursing, erroneous diet, impure air, or want of cleanliness'.

> If the injudicious feeding of a child is often a cause of death, so the defective hygienic conditions in which a child is placed will materially influence its chance in life ... hospital aggregation must necessarily make children more obnoxious [vulnerable] to contagious disease.

Defective hygiene owing to overcrowding and leading to infectious disease shared prime of place with injudicious feeding as the principal cause of infant mortality. Aligning himself with the nascent sanitary movement and drawing on the Registrar General's statistics, Routh sought to challenge the ignorance and complacency surrounding the causes of infant mortality. However, 'the voice and practice of the profession were against me', he complained, appealing for the adverse effects of both injudicious feeding and of wet nursing to be recognised and acted upon. While battling complacency, promoting breastfeeding and preferring wet nursing to bottle-feeding, Routh's book had chapters on the new scientific developments in artificial feeding, dealing with the chemical composition of the milks of mammals, including women, and alternatives to human milk. Nevertheless, a large part of it was devoted to wet nursing.

The job of the obstetrician, after delivering the baby, was to deal with the care and feeding of the newborn. He might leave this to mother or midwife but many made it their business to recommend a wet nurse. Simpson kept a list of the names and addresses of suitable women, and alongside each he added a note of their civil status (m/unm – married or unmarried), domestic circumstances, 'nice & clean', 'seems good', 'destitute' or a reminder such as 'recommended by Dr King'. Some families seeking a nurse might put an advert in the local newspaper: 'WANTED Immediately, a WET NURSE to take Charge of Child ten days old, in her own home. One from the country preferred', or respond to a notice such as:

> WET-NURSING WANTED – A Healthy, respectable Married Woman would be glad to Wet Nurse a Child at her own home (which is comfortable and in a fine part of the country, and near a town). Most respectable references given.

Simpson warned his students that 'You will often be asked whether you recommend a married woman or an unmarried. Many object to the latter – but the former is apt not to make so good a nurse having her own family to think of.' An alternative was a young live-in wet nurse, such as one advertising herself as: 'A healthy young woman, most respectably connected, is desirous of obtaining a situation immediately, as Wet Nurse in any genteel family; her own child is two weeks old.' In this case Simpson warned:

> Avoid if possible taking a woman confined for the first time, as she generally has less milk, and after first labour menstruation is apt to return sooner, besides she will not be so expert in handling the child. You have to see that the woman is in good general health, not tubercular, and has no eruptive disease.

Taking a wet nurse into the home, rather than sending the baby away to one in the country, allowed mother to keep an eye on her diet, conduct and childcare. However, this was only possible for well-to-do families who had the space and money to accommodate her. Wet nurses ranked low down in the hierarchy of domestic servants. Mrs Isabella Beeton (1836–65), in her *Book of Household Management* (1861) offered detailed advice about her supervision, diet and proper behaviour, warning that 'on no account allow her to sleep with the baby' in case it be 'accidently overlaid'. Before employing a wet nurse Simpson advised:

> Be careful to examine both mamma and both nipples, for one may be defective, also take care that she is not partly feeding her own child artificially; this she will if possible conceal from you, but it shows she has not sufficient milk.

Apart from the poor health of the wet nurse and the poor quality and quantity of her milk, there was the possibility that she might be 'fallen' and pose a moral risk to a respectable household. Nevertheless, there were arguments that the employment of fallen women as wet nurses could be a benevolent and charitable act. Ultimately, the debate about the selection or rejection of unmarried wet nurses was fuelled by demand.

> Hundreds of mothers are physically unable to nurse their own children; hundreds more ought not to, and are told by their medical attendants that they ought not to, on account of disease or debility; and for years past, and every year more and more largely, this want has been supplied to a certain extent by single women.

William Acton (1813–75), a London obstetrician, argued in *The Lancet* that 'the employment as wet nurses is, beyond all comparison, the most harmless and the most effectual means of reclaiming fallen women', asserting that 'No accoucheur in extensive practice can shut his eyes to the demand for wet nurses. He has to meet that requirement every day; and I ask him if he has ever been able to supply it exclusively from the ranks of married women?'

However, unmarried, fallen women had their own newborn babies to provide for. Too many infants of young urban working mothers who were lucky enough to keep their babies (and which were lucky enough to survive), and had no close family to look after them, were forced to put them in the hands of older women who accepted such infants as a source of livelihood, bringing them up by hand, with indifferent care and tragic outcomes. Such 'baby farming', as the practice was known, became notorious, and measures were taken to stop 'homes for the reception of infants from becoming charnel-houses', leading to Lord Shaftesbury's (1801–85) Infant Life Protection Act (1872), which obliged families and nurses to register all children under the age of two who were nursed away from home.

The qualities of the ideal wet nurse were well enough known, but hard to meet where demand for their services was high. Routh argued that too often wet nursing is:

> an evil in more ways than one, both to the nurse and her neglected infant ... The number of wet nurses is but small, and inefficiency is fraught with danger to the child ... The next important thing to a supply of maternal milk is the purity of that which forms its best substitute ... That very substance which last week was grazing in the field or waving in the milk-pail, is now become part of man ... In Paris it is compulsory that only pure milk be sold, and a heavy fine is inflicted on the transgressors.

There was no escaping consideration of alternatives to human milk. The dangers of raw cow's milk were well known. The obstetrician was the best qualified person to select a suitable wet nurse and check that she was physically fit, healthy and capable of delivering plentiful and nutritious milk. When it came to milk supply there were three kinds of wet nurse: the healthy nurse, one afflicted with galactorrhoea (excessive milk) and one with defective lactation. The obstetrician's clinical expertise extended to the medical treatment of these problems. Galactogogues (to stimulate lactation), such as whiting and conger eel soups, and drugs to suppress galactorrhoea, such as iodide of potassium and belladonna, might be prescribed. However, the prescription of artificial feeds required knowledge of their composition and preparation, an understanding of the new fields of nutrition, alimentary physiology and the chemistry of foods, and access to a safe supply of substitutes for human milk. This was outside the province and competence of most obstetricians.

Commercial companies were appearing in Europe and North America devoted to the manufacture of artificial milks for babies. Von Liebig, who had pioneered methods of analysing the chemical composition of foods, invented a way of combining cow's milk with partially digested starches called dextrins. Liebig's baby food, composed of wheat flour, cow's milk, malt flour and potassium bicarbonate, was launched in 1867, setting in motion an infant food industry that was to become global within two decades. Claiming to be 'the most perfect substitute for mother's milk' and a 'complete substitute for that provided by nature', Liebig's formula spawned many imitators. Its attraction lay not just in convenience, but also cost, saving the expense of a wet nurse.

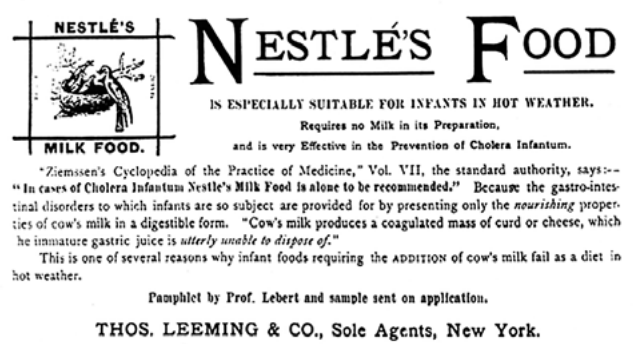
Henri Nestlé (1814–90) developed *farine lactée* – 'a wholesome Swiss milk and cereal component baked by a special process of my invention'– and opened his first plant for its manufacture in 1868. By 1874 he had sold his company (which had an office in London to deal with overseas demand) for CHF1,000,000. In the Netherlands the *Steam Dairy Factory* in Zoetermeer (which became the headquarters of *Nutricia*)



Advertisement for Liebig's Food for Infants, 1869

obtained the exclusive rights to produce infant feeds from cow's milk. Designed to mimic and replace human milk and weaning diet, these 'proprietary' foods became rapidly popular amongst those that could afford them. Varying in composition, they all contained or dissolved easily in cow's milk or water, and by 1883 there were more than twenty-seven patented brands on the market.

Mrs Beeton condoned such products with reservations, but advised mothers to prepare them themselves at home. 'As we do not for a moment wish to be thought an advocate for an artificial, in preference to the natural course of rearing children, we beg our readers to understand us perfectly on this head: all we desire to prove is the fact that a child *can* be brought up as well on a spoon dietary.' Indeed, it was perfectly possible to prepare suitable feeds for infants in the kitchen: 'The articles generally employed as food for infants consist of arrowroot, bread, flour, baked flour, prepared groats [cereal grains], farinaceous food, biscuit powder, tapioca and semolina,' she wrote, followed by instruction as to how to turn them into baby foods. When it comes to the care of the newborn she advised:



Advertisement for Nestle's Milk Food, 1888

> Many persons entertain a belief that cow's milk is hurtful to infants, and consequently refrain from giving it; but this is a great mistake, for milk should form a large portion of every meal an infant takes, but it should be mixed with a proper proportion of water, [cow's] milk being heavier than human milk.

She had the support of members of the medical professions, such as the paediatrician Henry Maunsell, who agreed that feeding babies with modified cow's milk was generally preferable to chemically-constituted commercial substitutes:

> It is vain to attempt any preparation upon chemical principles of a food resembling human milk. It is better to be satisfied with employing the food of some other young mammal, and modifying it so as to make its sensible properties as nearly as possible to the milk in question.

The dilution of milk with water was generally adopted as a ready way of making cow's milk more like human milk. Chemical analyses revealed that human milk 'abounds in fatty and saccharine matters, but contains only a small portion of the nitrogenous element, the caseine'. The higher protein (mostly casein) content of bovine milk could be reduced by dilution with water, and its consequently lower fat and carbohydrate contents augmented with cream and loaf-sugar.

Mrs Beeton advised that 'Many kinds of nursing bottles have been lately invented and some mounted with India rubber nipples, the common glass bottle, with the calf's teat, is equal in cleanliness and utility,' and recommended that 'the nursing bottle should be thoroughly washed and cleaned every day

[but] the nipple [teat] need never be removed till replaced by a new one, which will hardly be necessary oftener than once a fortnight.'

However, the insanitary conditions of many homes, with no running water, made it difficult to ensure cleanliness and keep bottles clean. Poor families could not afford commercial foods and continued to use raw cow's milk and paps fed to babies with dirty spoons, wrapped in a rag or given with a bottle and a linen or leather teat. For those who could afford one, the handy 'bubby-pots' and 'pocket nurses' with long rubber tubes were difficult to wash and a breeding ground for infection, becoming known as 'murder bottles'.

Mrs Beeton's *Book of Household Management* dealt with 'the Arrangement and Economy of the Kitchen' with thirty-seven chapters of recipes for cooking everything from shortbread to quadrupeds, concluding with a chapter on the



A 'murder bottle', 1880

rearing and management of children. Under the heading of 'The Stomach' she dealt with the 'gastric physiology' of the infant, ending: 'This is the simple process of a baby's digestion: milk is converted into cheese (by acid, like rennet, in the stomach), cheese into chyle, chyle into blood, and blood into flesh, bone and integument – how simple is the cause, but how sublime and wonderful are the effects.' These words, and this simple conception of the digestion and metabolism of milk, echoed the thinking of a century before, expressed by Buchan, whose *Domestic Medicine* was still in print, and Cadogan's advice, which Mrs Beeton might easily have been paraphrasing:

> As Nature has placed in the bosom of the mother the natural food of her offspring, it must be self-evident to every reflecting woman, that it becomes her duty to study, as far as lies in her power, to keep that reservoir of nourishment in as pure and invigorating condition as possible.

Mrs Beeton's homely, domestic, yet practical and self-reliant handbook instructed mother how to be a good housekeeper and also urged her to look after herself, for her own sake as well as that of her child. However, for many poor mothers who found themselves leaving the labour ward and who were not so literate and lucky, the opportunity to successfully breastfeed after birth was small, as Robert Ellis (fl. 1850–60), obstetrician to the Chelsea and Belgrave Dispensary in London and author of *Disease in Childhood* (1852), recounted:

> The abominable dietetics of the lying-in chamber are regarded by every reflective medical practitioner with abhorrence, and indeed with dismay. Under the

> idea that breastmilk is too poor for the little infant, it is drenched with stews of biscuits, bread, farinaceous compounds, and cow's milk, often rendered fermentable with sugar, and dangerously irritating by the addition of various spirituous stimulants.

Midwives had better things to think about than feeding the baby, and with its 'feeble state of the power of life' caused by 'defective nutriment' and 'privation of breastmilk' it would too often 'die without much suffering, its little life gently extinguished like the flame of a taper in moving air'. Ellis's colleague, Routh, reported the results of a 'statistical survey' from the Manchester children's hospital, where 1,041 babies had been studied, showing 'the direct and baneful agency of want of good breastmilk', in a table illustrating 'the extensive operation of two noxious agents – insufficient and unwholesome breastmilk, and early bread-feeding'. Dividing babies into percentage categories of 'well-developed', 'medium-developed' and 'badly-developed', he showed it was abundantly clear that 'the longer the supply of breastmilk and the more exclusively it is given the better the child is developed and vice versa'. Weighing babies provided objective, 'scientific' evidence of the harm caused by 'improper feeding'.

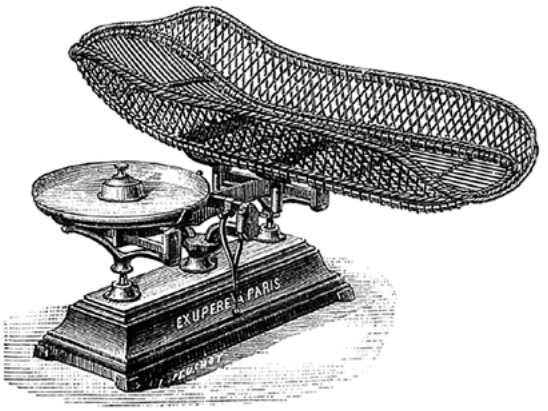
Studies such as these that employed the weighing balance to judge the development of newborn babies demonstrated clearly that human milk was the chief determinant of their growth, development and survival. They also demonstrated how such scientific measurements could be effectively carried out on the lying-in wards. In Paris, where there was a culture of experimental medicine in many of the big hospitals, weighing babies became a routine.

GROWTH AND METABOLISM – FROM ORGANS TO ORGANISATION

Paris had two main maternity units, one the *Maternité* at Port Royal and the other at the *Charité* in Rue des Saints-Pères, as well as *L'École des sages-femmes* (School of Midwifery). These offered opportunities to study the nutrition and growth of the newborn. Natalis Guillot (1804–66), professor de clinique médicale in the faculty of medicine, and an obstetrician at the *Charité* and *Maternité* introduced the practice of weighing newborn babies daily to assess their nutritional well-being, writing:

> To judge the health of many infants weighing is necessary. It is evident that if the first weighing [at birth] demonstrates a weight of 2000g, for example, and that the next day, or the day after that, the infant loses weight, down to 1950g and to 1800g, then it is clearly in an unfavourable state; the infant who, on the other hand, gains weight regularly at 10-15g each day, will be in a better condition.

Guillot drew attention to the transient drop in infant weight that followed birth, and inspired Jean-Baptiste Bouchaud (1831–1917), a young intern in the *Maternité*, to use the weighing balance to measure the amounts of milk babies consumed, especially those that were failing to thrive. Bouchaud recorded that 'On January 1863, seeking to evaluate the sanitary state of the maternity wards, I recorded in my notes: twenty-five pregnant women ill, sixteen infants dead and nine living, of which five very poorly. A mortality rate so frightening as to merit profound attention.'



Infant weighing balance, from Pierre Budin, 1907

Bouchaud regarded 'the use of the weighing balance in the *Maternité* as a strong means of assessing if the infant is in a good state, and it has already been used by Madame Alliot. I quickly gained the sad conviction through the use of this instrument that many babies were succumbing to starvation.' Angélique Alliot (fl. 1850–65), the formidable midwife-in-chief at the *Maternité*, and her pupil midwives, helped him with his research project.

> I am happy to pay my respects to Madame Alliot, the distinguished midwife of the *Maternité*, who generously put at my disposal all that I might need, and within the limits of what is possible, gave me free access to the wards. I also wish to acknowledge each of her good and intelligent assistants, or pupil midwives, who helped me with my observations; if one imagines that I have close to 4000 weighings, and some series of weights over 24 hours, one can appreciate that alone I would have had great difficulty in accomplishing my work.

Bouchaud also measured the weights of the internal organs of the malnourished babies that died and found they had shrunk, some very markedly, such as the liver and muscle, each by a third, and adipose tissue four-and-a-half-fold. With several thousand weighings, Bouchaud was able to calculate how much human milk babies consumed and how well they grew, concluding that 'three big causes seem to me to act together to destroy the life of the newborn; they are: birth before term, insufficient or incorrect feeding, and in all vulnerable babies, a low temperature. Infections have their malign effect afterwards'. These findings, undertaken with scientific rigour, strengthened the prevailing view that human milk was the chief determinant of the viability of infants.

Bouchaud's doctoral thesis, *On the Death by Starvation and Experimental Studies on the Nutrition of the Newborn* (1864), echoes *Recherches Physiologiques sur la Vie et la Mort*, published more than sixty years earlier (1800), in which Bichat tried to explain the nature of life, concentrating on the function of the organs and the organisation of the body. Bouchaud's work was a product of an experimental method of research investigating the determinants of the viability and mortality of the newborn.

> One finds in several authors who are interested in the diseases of children, information indicating that this morbid state has been clearly perceived. I cite in particular Billard, who writing on what he observed, cannot let pass in silence this type of death; he says, apropos intestinal indigestions 'they suffer from

hunger, which is to say their stomach and intestinal tube does not digest the milk that they swallow and are given'.

Failure to digest milk increased their risk of mortality, and the construction of tables recording the rate at which babies put on weight was a useful tool to judge their viability. Bouchaud acknowledged that 'Quetelet was the first author who attempted to weigh the newborn. He reported the averages of only seven measurements and was content to say that the infant lost weight in the first days of life and did not regain it until the end of the first week.' The statistician, Adolphe Quetelet (1796–1874), had collected the weights of children in the foundling hospital in Brussels in the 1830s in order to define '*l'homme moyen*' (average man), saying: 'the study of diseases and of the deformities to which they give place, has shown the benefits derivable from corporeal measurements; but in order to recognise whatever is an anomaly, it is essentially necessary to have established the type constituting the normal or healthy condition'. Bouchaud could distinguish the progressive deviation of the abnormal from the normal using his tables of body weights from birth:

> Certainly any infant will not follow this development exactly, but if one compares their numbers with those of the table one sees that they are pretty comparable. What is more, if one regards the average weight of the infant at birth to be 3250g, and 9kg at twelve months, numbers which are very close to those given by Quetelet, one can be assured that one passes directly from the first to the second month, by adding the weight gains of the preceding month.

The form of 'human experimentation' adopted by Bouchaud conceived the living body in new ways, encompassing and integrating the models of his predecessors, Liebig and Lavoisier, Bichat and Boyle, Harvey and Helmont, back to the alchemists and the ancients. Bichat's physiology had seen the body as a collection of separate organs, independent, indivisible 'elements' in the way that the chemistry of Lavoisier saw matter as made up of distinct elements. Each organ played a critical role, particularly the vital triad – liver, heart and brain – long seen as the seats of natural, vital and animal spirits. The organs of the body were the 'little machines of the great machine'. Destruction of any of them led to death.

The mechanical, hydraulic and pneumatic machine of Boyle and Harvey, in which the organs were workshops linked together by fluid-carrying tubes, was a chemical factory and a heat machine, in which the organs together operated in an interdependent 'organised' way. Von Liebig had showed how food powered and nourished the body through the study of the overall balance of the bodily ingesta (food), excreta (faeces, urine and sweat) and respiratory gases (breath), and thereby conservation of matter, in accord with Lavoisier's teaching that 'All vital activity arises from the natural action of the oxygen of the atmosphere and the elements of the food.' The process of alchemical transmutation, or of chemical transformation, within the body he termed 'metabolism'.

The French experimentalist, Claude Bernard (1813–78), by analysing the blood entering the liver by the portal vein, showed it was the 'seat of an internal secretion that produced sugar at the expense of the blood passing though it'. The liver was a chemical factory, as the heart was a pump. The basis of life was to be found in the coordinated, interactive, cooperative functions of the organs and tissues: 'A complex organism

should be looked upon as an assemblage of small organisms which are the anatomical elements that live in the liquid *milieu intérieur* ... The phenomena of the living body are in such reciprocal harmony one with another that it seems impossible to separate any part without at once disturbing the whole organism,' argued Bernard, echoing the words of the naturalist, Georges Cuvier (1769–1832), that 'All parts of a living body are interrelated; they can act only in so far as they act all together; trying to separate one from the whole means transferring it to the realm of dead substances.'

These conceptions, which informed Bouchaud's studies of babies, where the assessment of infant milk intake was based on changes in body weight before and after a feed, helped to put infant feeding on a truly scientific basis. From serial measurements it was possible to estimate the volumes of milk required to achieve 'normal' growth. By combining the calorimetry of Lavoisier with the metabolic balance methods of Liebig, the German paediatrician, Otto Heubner (1843–1926), and physiologist, Max Rubner (1854–1932), calculated the caloric requirements of the healthy infant (100 kcal/kg/d) and of the 'atrophic' infant (130 kcal/kg/d), commenting that 'the successful and exact accomplishment of the experiment requires from four to six days; it is very difficult, and beside complicated pieces of apparatus numerous well-trained investigators have to be employed'.

These scientific achievements, by which the vitality and viability of the baby came to be understood in purely material and mathematical terms, were the fruits of 'well-trained investigators' within new scientific research institutes, many alongside university hospitals, collaborating internationally, particularly in Germany and France. In explaining how babies thrived, long gone were the 'faculties' of the ancients and the 'fermentations' of the alchemists which transmuted milk into flesh. Human milk, the source of vitality, nourishment and fuel, was made of nutrients – chemical substances which, with oxygen, supplied power and building materials, to warm, move, grow, maintain, repair and defend the infant body. It was in France, which had long regarded mother's milk as a symbol of its strength, benevolence and concern for the children of the Republic, that this knowledge of the nature and properties of human milk was to have the first and biggest impact on improving the health and fortunes of many infants.

FROM PUBLIC HEALTH AND WELFARE TO TECHNOLOGY AND BIOLOGY

Recovering from the shock and demoralising effects of the Franco-Prussian war of 1870–71, when France was overcome by superior German forces composed of physically fitter young



Honoré Daumier, *République*, 1848

men (ironically, breastfeeding rates rose and infant mortality fell during the siege of Paris, as cow's milk was scarce), concern for the health of babies became a pressing social and political – as well as medical and a public health – issue. It gave impetus to a pro-natalist movement, aimed at boosting the birth rate and improving maternal welfare.

With its long history and centralised regulation of wet nursing, starting with the establishment of the bureaux de nourrices in eighteenth-century Paris, initiatives fostered by the *Société des Crèches* in the 1840s, designed to provide places where mothers could leave their children during the working day, the *Société Protectrice de l'Enfance*, for the protection of infants, and the child-care centres of the *Sociétés de Charité Maternelle*, all focused national attention on mothers and babies.

The *Société d'Allaitement Maternelle* encouraged maternal nursing, but in Paris a private *bureau des nourrices* flourished,



M. Miranda, *A la Porte d'un Bureau de Nourrice Privé*, 1874

catering for the well-to-do who were able to afford live-in wet nurses, such as the *Mother in Luxembourg Gardens with her baby and wet nurse*, depicted by Albert Edelfelt (1854–1905). The novelist, Émile Zola (1840–1902), writing in *Fruitfulness* (1899), urged working mothers to nurse their own babies: 'There is no more glorious blossoming, no more sacred symbol of living eternity than an infant at its mother's breast ... It is a mother's duty to nurse her child and a mother represents the eternity of life. She deserves a social culture, she should be religiously venerated.'

In spite of this concerted national effort of legislative and philanthropic initiatives, which included combatting the



Albert Edelfelt, *Mother in Luxembourg Gardens with her Baby and Wet Nurse*, 1887

scandal of 'farmed-out' babies with Théophile Roussel's (1816–1903) law of 1874 requiring registration of wet nurses who took infants into their homes, with a persistently high infant mortality rate and declining birth rate, anxiety about 'physical degeneration' and 'national inefficiency', as well as 'depopulation' grew. Amongst those committed to the *Puériculture* movement and closely allied with the *Ligue Contre la Mortalité Infantile*, was a group of Paris obstetricians who took a special interest in the postnatal care of the babies born on their maternity wards.

8

Biology and Technology

BREAST AND BOTTLE

When I was chief of the maternity service at the Charité Hospital, I was very occupied with the care of the newborn. I was struck by a response that was given to me by women who had formerly been my patients on the maternity ward, when they came back. I asked them how their babies were getting on, and often they said to me: he is dead!

THIS SHOCKING RESPONSE of mothers recently discharged from the maternity wards of the Paris *Charité* hospital under the supervision of the professor of midwifery, Pierre Budin (1846–1907), highlights the gulf between the care provided to mothers by obstetricians in hospital and the fate of their newborn when they left. Budin was distressed to learn that many of the babies he had delivered safely had died not long after they had gone home. It was clear to him that poor infant feeding was to blame, and he established postnatal infant welfare clinics, which he called '*consultations des nourrissons*', where infants were weighed to measure their growth and breastfeeding supported, saying: 'We encourage breastfeeding with all our power ... in all we write we stress the importance of maternal nursing. The newborn must be put on the breast, it must be suckled by its mother.'

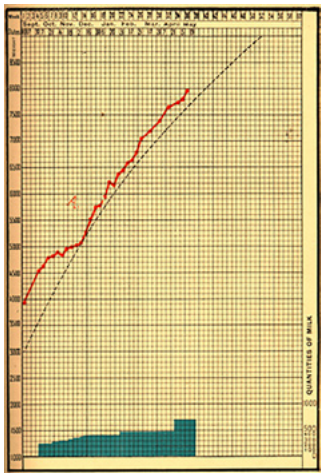


Albert Demarest, *Sortie de la Maternité*, c. 1900

The *consultations*, also called *'gouttes de lait'* by Leon Dufour (1856–1928), a physician who independently pioneered similar clinics in Fécamp in Normandy, were intended:

> to induce mothers by advice and by encouraging them in every possible way, to feed their babies at the breast. When it is impossible for the child to be wholly breastfed, the mother is urged not to abandon breastfeeding altogether, but to supplement her own milk with suitably prepared cow's milk, to ensure the child being, if not wholly, at least partially breastfed.

The primary principles of both institutions were 'to encourage and aid breastfeeding, to supply good quality sterilised milk if required, and to provide weekly infant care and



Infant growth chart used in the *consultations*, from Pierre Budin, 1905

supervision of infants during their first two years'. The clinics were swiftly established in many parts of Paris, and further afield in France.

A propaganda picture depicts the work of a *goutte de lait* at Belleville in Paris. The left panel of the triptych overleaf shows a baby being weighed, the weight recorded by a doctor. On the right a mother is receiving a bottle of sterilised modified cow's milk for her baby. The middle panel shows the paediatrician Gaston Variot (1855–1930), a colleague of Budin's, advising a mother about feeding her baby. The eye is led to the doctor, and his concern and interest in both, and to the breast – the subject of the painting – the *drop of milk*. Alongside, bathed in sunlight, stands another, smiling mother, beaming at her healthy child in arms, surrounded by sturdy toddlers and young children. The triptych celebrates the virtues of human milk.



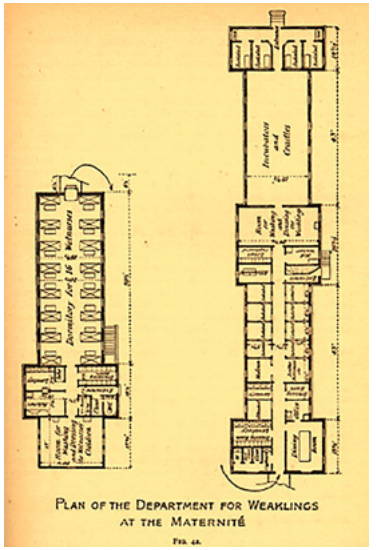
Jean Geoffroy, *L'Oeuvre de la Goutte de Lait*, 1903

The weighing balance was central to the 'weekly infant care and supervision'. Employed initially to weigh the baby to determine its viability, it became an instrument to assess its growth in relation to milk intakes. Budin constructed a chart of weights based on Bouchaud's measurements for use in the *Pavillon des Enfants Débiles* (neonatal nursery) for small and premature babies, and in his *consultations*. The weighing scale and growth chart joined the thermometer and temperature chart as tools for the care of the vulnerable newborn:

> When babies develop normally they put on weight regularly and of a quantity more or less according to their age – this is a general rule. When the curve of weight gain of an infant is good, one can conclude that it is in an excellent state of health, and is in no danger; if it is unwell one knows that the weight goes down.

Wet nurses were accommodated in the *Pavillon* to provide much-needed human milk for the vulnerable *enfants débiles* who had been born too early or too small. However, in the *consultations*, sterilised milk made up of simple mixtures of cow's milk and sugar diluted with water was supplied to mothers who could not nurse their young.

The success and effectiveness of the *consultations* and *gouttes de lait* inspired comparable initiatives in other European and North American countries, including Great Britain where the first 'infant milk depots', as they were called, were opened in Finsbury in London, St Helens in Lancashire and Glasgow in Scotland. Although modelled on the French *consultations*, they did not always stress breastfeeding, often advertising 'the supply of sterilised humanised milk for the



Pavillon des Enfants Débiles à la Maternité de Paris, from Pierre Budin, 1907

use of infants' rather than prioritising the support of maternal nursing. With the technology to pasteurise and bottle it, their purpose was to supply 'clean, harmless, palatable cow's milk' to mothers to feed their infants. A greater purpose of the milk depots was to address the high rates of infant mortality and their implications for the health of the nation.

INFANT MORTALITY: A POLITICAL AND ECONOMIC PROBLEM

The *consultations*, *gouttes de lait* and milk depots became components of an international maternal and child health movement which was informed by mortality statistics. While population death rates declined from 22.6 to 16.9 per 1,000

Infant Mortality in Second Half of Nineteenth Century

Years	Death-rate per 1,000 population	Deaths under one year per 1,000 births
1851-1855	22.6	156
1856-1860	21.8	151
1861-1865	22.5	151
1866-1870	22.4	156
1871-1875	21.9	153
1876-1880	20.8	144
1881-1885	19.4	138
1886-1890	18.8	145
1891-1895	18.7	150
1896-1900	17.6	156
1901	16.9	151

Population and infant mortality rates 1850–1900

during the second half of the nineteenth century, infant mortality remained stubbornly high, at around 150 per 1,000 live births, as high in 1900 as it was in 1851. The highest loss of life within infancy was the first three months which took the greatest toll. Moreover while population death rates overall were going down, birth rates were also declining.

Babies were dying of malnutrition and marasmus, owing to poor feeding, accompanied by infectious diseases such as gastroenteritis, pneumonia and meningitis. Infant mortality was highest amongst the poorest families, often living in the overcrowded slums of burgeoning cities like Glasgow, where the death of children was commonplace, as recounted by the medical officer of heath, James Burn Russell (1837–1904):

> There they die, and their little bodies are laid on a table or on the dresser, so as to be somewhat out of the way of their brothers and sisters, who play and sleep and eat in their ghastly company. From beginning to rapid ending, the lives of these children are short parts in a continuous tragedy. A large proportion enter life by the side-door of illegitimacy. One in every five of all who are born there never see the end of their first year. Of those who so prematurely die, a third have never been seen in their sickness by any doctor.

Comparable figures were recorded throughout Europe and set alarm bells ringing in political circles. Persistently high infant mortality rates had dire implications for the armed forces dependent on a supply of fit young men. In France this had inspired 'pronatalism'. In Britain it generated worry about 'national efficiency', fuelled by the finding that, in the run up to the Second Boer War (1899–1902), one in three recruits was unfit for combat. Royal Commissions were established, parliamentary inquiries set up and the attention of medical officers of health concentrated on maternal health and infant nutrition.

This was the 'decade of welfare' (1900–10) in which infant feeding became a political question in many European countries and drew together politicians and public health professionals dedicated to fighting the threat of 'physical deterioration', 'degeneracy' and 'depopulation'. Fifty years after *The Lancet* had drawn attention to the problem, the *British Medical Journal* championed a new 'campaign for clean milk'.

> At present cow's milk is too often, when it reaches the houses of the poor, in a state which renders it dangerous to life. Can any reasonable mind be surprised at the great infant mortality and at the unfitness of the majority of the survivors? Without clean milk there will be continued death and

> unfitness; the moral is that every effort should be made to get clean milk ... Then and only then will this great national problem be satisfactorily solved.

Clean milk, both raw and modified, was of course critical, and with the discovery of the bacterial causes of diarrhoea, gastroenteritis and other childhood infectious diseases, the risks of dirty and contaminated cow's milk became starker but also amenable to practical public health interventions with the application of sterilisation and pasteurisation. The children's physician, George Carpenter (1859–1910), warned in his *Advice to Mothers* (1898) that cow's milk is too often:

> swarming with germs, and not only germs, but particles of manure, hair, dirt, hay, and so forth, and often contains boric acid or salicylic acid, added by the dealer to preserve it. There is further, the ever-possible invisible added danger that the milk may be contaminated by scarlet fever, typhoid fever, diphtheria, and by tubercle germs, not to mention many others.

Breastfeeding was still the most common way in which babies were fed, particularly amongst the poor. Surveys reported rates of around 80 per cent. After the First World War the availability of dried milk and relaxation of the medical supervision of infant feeding made artificial milks more widely used and bottle-feeding safer. Banana-shaped feeding bottles, which were easier to clean, replaced 'murder bottles' with their unhygienic tubes, so popular in Victorian Britain. Nevertheless, throughout Great Britain medical officers of health stressed the importance of human milk to infant health, and sought to

mobilise, in various ways, municipal, philanthropic, voluntary and commercial agencies towards that end. Lady health visitors were trained to contact mothers as soon as possible after a new birth, to 'support breastfeeding and give sensible advice about alternatives'. Paediatricians, such as Leonard Findlay (1878–1947), the professor of medical paediatrics in Glasgow, stressed the vital importance of human milk:

> Of the value of mother's milk as an infant food all physicians are agreed, and it therefore behoves us to encourage that method of feeding by every means that lies within our power. It is from health reasons incumbent alike on the rich and poor mother to perform this duty by her offspring, but from the economic standpoint, alone there seems to me no other method that can be adopted by the mother of the poor.

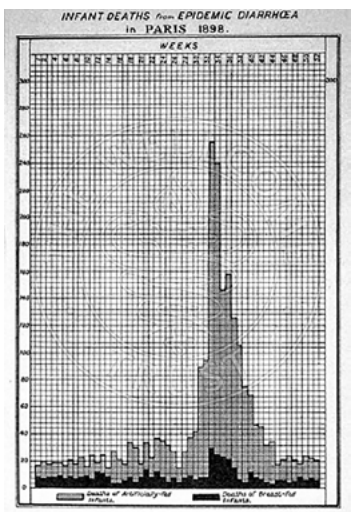
The 'economic standpoint' was relevant, not just to safeguard the future of the work force and armed forces, but also to protect the economy of poor households. Findlay had worked in Berlin before the First World War, investigating infant malnutrition and rickets for the International Red Cross, and warned that:

> It is one of the greatest calamities that can befall a newborn child to be deprived of its natural nourishment. We know nothing that can compensate for this loss, and the only consolation is the fact that the inability to suckle is much rarer among the mothers of the poor than among those of the rich. Breastfeeding is the salvation of the poor child, for it

is the only thing which gives it a chance in this life. It is the virtue of breastfeeding that the children of the poor have the resistance to withstand infection by disease with which they are invariably surrounded.

THE MEDICAL CONSEQUENCES OF ARTIFICIAL FEEDING

Textbooks of child health stressed the vital importance of breastfeeding, usually in the opening chapter about birth and infant care. Evidence for the beneficial effects of human milk and the dangers of alternatives were spelt out, and although formulas for the preparation of substitutes were included, many paediatricians expressed grave reservations about them, including Findlay, who wryly commented that 'One might as easily hope to convert St Paul's Cathedral into Westminster Abbey by



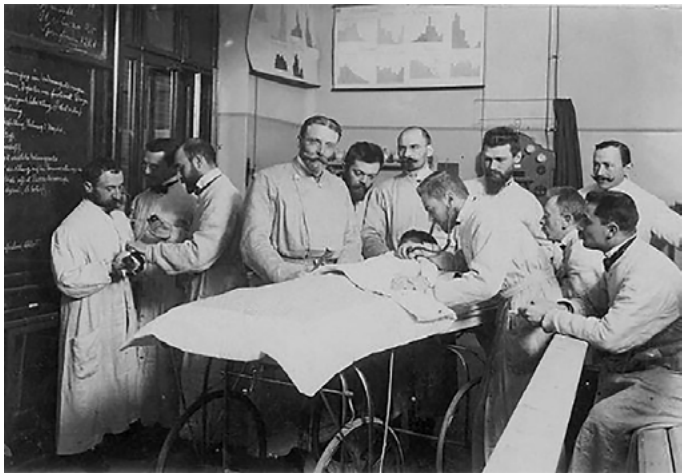
Summer diarrhoea deaths in Paris 1898, from Pierre Budin, 1907

altering the shape of the dome and steeples as to change the one milk to the other by simply varying the amounts of protein, fat and sugar.' Cow's milk-based alternatives, even if they were composed of the same amounts of these nutrients proved to be inadequate in unexpected ways. Curd obstruction owing to excess casein was well recognised, as was diarrhoea, and also rickets and scurvy, which afflicted bottle-fed babies.

In France the association between bottle-feeding and the early death of babies from gastroenteritis had been vividly depicted by Budin, who represented the much higher mortality of artificially-fed babies than those breastfed during an epidemic of summer diarrhoea, as an Eiffel Tower shaped histogram. The dangers of the use of unpasteurised unwholesome cow's milk to feed babies could not be more forcefully illustrated.

Budin's colleague Dufour reduced infant mortality from gastroenteritis six-fold, from 16 per cent to 3 per cent in his clinics in Fécamp. This was due largely to clean, sterile, pasteurised milk. Pasteur's demonstration of the fermentative effects of micro-organisms in spoiling wine and contaminating milk led to his demonstration that heating milk to 60 degrees destroyed pathogenic bacteria. His work set in motion an intense interest in the roles of micro-organisms in infectious diseases. Identification of the bacillus of tuberculosis in 1882 was followed soon after by the discovery of many other microbes to which babies were vulnerable, such as the bacterium, *Escherichia coli*, named after its discoverer, Theodor Escherich (1857–1911).

As professor of paediatrics in Graz in Austria, Escherich is clearly the 'chief' of a team of clinicians and scientists. On his left Meinhard von Pfaundler (1872–1947) listens to the heart of the child on the trolley, wielding the symbol of the modern



Theodor Escherich with his staff and students, 1902

clinician, the stethoscope. On his right stands Ernst Moro (1874–1951) in the act of injecting a rabbit held by a technician, representing 'medical experimentation'. The scene is set in a lecture theatre, symbolising the third element of the new scientific medicine – teaching. Three students, identifiable by their clean-shaven chins and restrained moustaches, aspire to be part of this triumphant scene: the integration of scientific research, medical care and clinical teaching.

The scene epitomises the state of paediatrics in German-speaking Europe in the early years of the twentieth century. It also illustrates how the new sciences of bacteriology and nutrition were promoting the status of paediatrics, and the importance of these two subjects to its coming of age. The link between 'improper feeding', gastroenteritis, malnutrition and failure to thrive led to the development for sick babies of specially manipulated feeds, such as *Eiweiß milch* (buttermilk), rich in cow's milk protein.

This special feed was developed by the German paediatrician, Heinrich Finkelstein (1865–1942) who proposed the concept of 'intestinal intoxication' or 'alimentary fever' as an explanation for the nutritional wasting (also termed atrophy, athrepsis and marasmus) that accompanied chronic diarrhoea. He postulated that 'wrong feeding' (*Fehlernährung*) lowered tolerance to food, which led to *Dekomposition* that could be treated effectively with such 'special feeds'. Finkelstein tackled the high death rate of children admitted to the infant wards of the *Charité* hospital in Berlin, and by means of isolation, an 'aseptic nursery' with attention to hygiene and proper feeding, including the use of *Eiweiß milch*, he reduced the infant mortality rate from 'hospitalism' from 50 per cent to 10 per cent within two years.

Facilities for the care of mothers and babies were extensive and highly organised in Berlin in ways that permitted clinical research. The Kaiserin-Auguste-Viktoria-Säuglingsheim was said to be the 'the most sumptuous hospital of its kind in the world', with one hundred beds for infants, and its milk kitchen was equipped 'with the most modern appliances for sterilizing, cooling and filling feeding bottles'. There was a farm attached to the hospital where 'cows were kept under hygienic conditions', chemical and pathological laboratories, and a 'residency for voluntary assistants who wished to study this branch of medicine'. The wards and clinic were organised to support the investigation of children's diseases. The German-speaking countries were leading the way in paediatrics and, in particular, the understanding and treatment of the digestive diseases of babies.

Rickets was another well-recognised disease of young children, which appeared to be due to 'improper feeding', but was resistant to special infant feeds. After the First World War

and the famine that followed in Eastern European countries, paediatricians were faced with the care of large numbers of malnourished children with rickets. The chemist, Harriette Chick (1875–1977), working in the wards of the Vienna University Kinderklinik in 1920, investigated babies with rickets, many as young as four or five months, and found that cod-liver oil prevented and cured the disease. The essential factor in the oil was later isolated and called vitamin D. This demonstration by Chick and her colleagues was extraordinary, and surprised even the chief paediatrician of the Kinderklinik, Professor Clemens von Pirquet (1874–1929), who exclaimed:

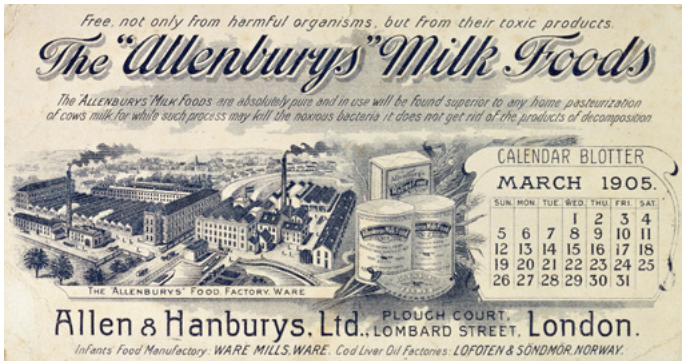
> I imagined rickets to be a disease comparable with tuberculosis. In our towns almost all children are infected by tuberculosis by the time they are fifteen years old, but the more severe symptoms of the disease are shown by those who become infected in the earliest years of life ... In the same way I believed that the more severe symptoms of rickets were shown first by children who became infected shortly after birth, that is to say, infants who, in overcrowded dwellings come into contact with other cases of rickets at an early age.

Rickets turned out to be caused by deficiency of an 'accessory food factor' not present in significant amounts in many foods, including cow's milk. The discovery of vitamins ('vital amines' as they were thought to be) not only revealed a hitherto unrecognised family of nutrients, vital for life in addition to carbohydrates, protein and fats, but also food deficiency diseases which could be cured only by diets containing the missing factor or the essential micro-nutrient itself. Human milk does not contain a lot of vitamin D and most is made in the skin as a result of exposure to sunlight, and the infantile rickets that Findlay and Chick saw was due to deprivation of both.

TECHNOLOGY AND COMMERCIALISATION OF INFANT FEEDING

The use of artificial baby milks grew rapidly after the First World War as a result of new technology and energetic marketing. Powdered, dried milk in packets and boxes, and evaporated or condensed liquid milk in tins and cans, were handy alternatives to fresh cow's milk and permitted large scale manufacture and distribution. There were many new brands of proprietary infant feeds available, advertised in the medical and nursing press and directly to the public in newspapers and women's magazines. The essential components of 'safe' infant feeds were defined, and handbooks of infant care contained chapters detailing their chemical compositions, recipes for preparing them and appropriate uses. The first edition of *Food and the Principles of Dietetics* (1906) by Robert Hutchison (1871–1960) listed no fewer than sixteen commercially available artificial baby foods. Advertisers of proprietary formulas frequently stressed that 'they caused no digestive disturbance'. Allenburys, for instance:

> The best food for the young infant is mother's milk or its equivalent. *Allenburys* closely resembles healthy human milk, in composition, nutritive value and digestibility, analysis proving it almost identical ... [It is] absolutely pure and will be found superior to home pasteurization of cow's milk, for while such process may kill noxious bacteria it does not get rid of the products of decomposition.



Advertisement for Allenburys Milk Foods, 1905

Nestlé and Glaxo followed suit, comparing their products favourably, as: 'very similar to breastmilk', prepared to 'normal breastmilk standard' and 'practically identical' to human milk (Nestlé); in 'complete agreement with breastmilk' and with 'close approximation to mother's milk' (Glaxo). Human milk was the standard, and in many towns and cities entrepreneurial doctors or nurses, in partnership with local dairies, developed and promoted their own brands of baby milks. For instance, Laura Smith (1866–1934), formerly the matron of the children's dispensary in Glasgow, all too familiar with the plight of poor babies of the city, exploited the clinical expertise of her medical colleagues and her knowledge of the big national brands, writing:

> There is no substitute for healthy mother's milk, so I devoted my energy to finding means of making undiluted cow's milk easily digested by the youngest and weakest children without digestive disturbance. Dilution with water is obviously wrong because it seriously decreases the nutritive value and does not increase the digestibility of casein. My long experience showed that specially prepared wheat added in regulated quantity to undiluted fresh milk breaks up the casein rendering it to a fine flocculent curd easily digested by the weakest children from birth, thereby reaping the full benefit of the whole milk and all the nourishment milk alone can give.

Sister Laura was aware of the objections to artificial feeding, such as the tendency of cow's milk to curdle and become indigestible. She also exploited the 'war effort' by depicting an idealised image of herself penning her message, above a frieze showing a vulnerable baby in a pram growing up to be a healthy child who advances to join the fit young men that are to defend the country and safeguard its greatness, chiming with



Sister Laura's baby food and message, 1919

the prime minister, David Lloyd George's (1863–1945) message of a 'fit country for heroes to live in'.

Some paediatricians favoured patent foods based on predigested cereals made up with milk. Others argued that so long as cow's milk was clean and sterilised, dilution with water was all that was necessary. Still others, influenced by American teaching, recommended complex mixtures of cow's milk, cream, sugar, salts and water in carefully calculated proportions to mimic the equivalent composition of human milk, to be prescribed according to medical advice. The professor of paediatrics at Harvard, Thomas Rotch (1849–1914), was the arch-exponent of this mathematic approach. In partnership with the Walker-Gordon Laboratories he concocted recipes for infant milks according to precise formulae:

> The amount to be given at each feeding must be carefully regulated according to the gastric [stomach] capacity ... I have arranged some tables to show how the intervals of feeding and the amount of food to be given should correspond to the gastric capacity at different periods of the first year.

The gastric capacities of babies were calculated by weighing them before and after a feed, and assuming that the full feed remained in the stomach. Pages of his textbook, *Pediatrics* (1896), were devoted to illustrations of the stomachs of babies. His artificial feeds had evolved from simple mixtures that resembled human milk made up of household milk, sugar and cream into laboratory-prepared prescriptions tailored to the exact nutritional requirements of the individual baby. Rotch's teachings and mathematical milk formulas were adopted widely, including in Great Britain.

The so-called 'percentage feeding method' fell out of fashion, eclipsed by the growing availability of easier-to-prepare products based on evaporated or dried cow's milk. Undermined by doctors who complained that his system 'required the equivalent of an advanced degree in higher mathematics', it was ridiculed by his Harvard colleague, Oliver Wendell Holmes (1809–94), who quipped that 'a pair of substantial mammary glands has the advantage over the two hemispheres of the most learned professor's brain in the art of compounding a nutritious fluid for infants'. Rotch's successor, McKim Marriott (1885–1936), took a more pragmatic view, saying: 'There is no reason to resort to the use of complicated formulas or expensive proprietary preparations when the particular requirements in the individual case may be fully met by simper means.'

> There is nothing mysterious and sacred about breastmilk, it is just food. It is perfectly possible to prepare an artificial formula which meets nutritional requirements. There are numerous ways in which infants may be fed successfully, and there is no one method of feeding or type of food which is to be recommended to the exclusion of others; on the other hand, there is no reason to resort to the use of complicated formulas or expensive proprietary preparations when the particular requirements in the individual case may be fully met by simpler means.

The sacred duty of the mother to nurse her baby with nature's perfect food was no longer incontrovertible. Infants appeared to thrive on artificial milks. Even Variot, depicted as the great defender of breastfeeding, accepted the equality of alternatives. Questioning the prevailing opinion that the

growth and development of artificially fed babies was generally inferior to that of breastfed, he showed that the bottle-fed did almost as well as the breastfed, particularly in the second half of the year. His measurements reinforced the credibility of infant milk formulas, and the value of growth charts.

Paediatricians who had promoted breastfeeding for unequivocal and laudable reasons because of its manifold benefits now had to accept that alternatives might be just as good. It was a delicate balancing act. Frederic Truby King (1858–1938) for instance, who founded the Plunket Society in New Zealand to train nurses to advise mothers on infant care and promote breastfeeding argued that: 'It may be laid down as an axiom that every mother can nourish her offspring in the natural way. The exceptions are so rare and so striking as merely to prove the rule that, practically speaking, the breastfeeding of babies should be and could be universal.' However, despite his belief that all women could nurse their babies, King argued for the very best artificial feeding to 'stem that progressive nutritional failure from generation to generation'. Believing that the well-fed, well-nourished bottle-fed baby girl would grow up to be able to breastfeed her own children, he set up his own factory to produce 'humanised milk', to be dispensed at Plunket clinics. Karilac consisted of sugar of milk (lactose), dextrose sugar and gelatine, added to fresh cow's milk and water.

DECLINE OF BREASTFEEDING AND RISE IN FORMULA FEEDING

By the 1920s infant feeding had ceased to be a pressing political issue. Paediatrics had come of age, artificial infant feeds were widely available and infant mortality was declining. The infant food industry was not slow to take the credit, such as Glaxo, which claimed:

> Many factors have combined to bring about the remarkable decline in infant mortality during recent years, but there must be few who will not concede that the replacement of farinaceous foods and infective raw milk by properly prepared, standardised dry milk has been a factor of some importance.

With the advertising of 'humanised' cow's milk directly to the public, the mass production of feeding bottles and its acceptance by many of the medical profession, the artificial feeding of infants became increasingly popular. It was becoming a matter of maternal choice, sanctioned – even blessed



Advertisement for Glaxo infant feeds, 1921

– by the medical profession. Nature was no longer the supreme guide to how to feed babies. Science and technology had eclipsed her and doctors who urged mothers to nurse their own children were now becoming allies, if not spokesmen, for an industry undermining that advice.

There was also a view that 'the function of maternity [lactation] is being atrophied in modern women; and the higher their civilisation the less able they are to suckle their infants'. However, many mothers welcomed this change and choice. Artificial feeding offered them emancipation from the nursery, along with wider social and sexual opportunities. The flappers of the 1920s epitomised new female freedoms: cigarette smoking, hair bobbing, contraceptive using and bottle-feeding were symbols of liberation. It was a confusing time for doctors, such as Donald Paterson (1890–1969) and J. Forest Smith (1893–1973), authors of *Modern Methods of Feeding in Infancy and Childhood* (1939):

> The attitude of medical men towards the subject of artificial feeding varies. In some there is complete indifference, the subject too trifling to bother about, and the feeding of the infant is left to the mother or nurse to manage, or perhaps advice is given to use patent foods and to follow the directions on the tin. Others [medical men], confused by the various systems advocated for feeding the baby artificially, and finding that no method will give universally good results, think the subject too difficult, and when the need arises refer the 'feeding case' to the specialist.

The social changes that helped to transform the attitudes of mothers to infant feeding were also domestic, such as

improved hygiene in the home, refrigeration, piped water and sanitation, as well as pasteurisation. Cow's milk was no longer a dangerous substance, a poison unfit for consumption, but available not just raw in bottles but also in tins, evaporated, dried, condensed and sweetened. The British Milk Marketing Board promoted cow's milk under the slogan 'Full of Natural Goodness', and anticipating the welfare state, the prime minister, Winston Churchill (1874–1965), proclaimed: 'There is no finer investment for any community than putting milk into babies,' words that reinforced the view that feeding babies properly must be a good thing, not just for their own health but also for the country as a whole. Intended 'to safeguard the nutritional status of expectant mothers and young children', a welfare food scheme was established under wartime emergency legislation in 1940 to provide free milk to both mothers and babies.

The rise in artificial feeding was, of course, paralleled by a decline in breastfeeding. After the Second World War, smaller, mobile, nuclear families became used to processed food in tins and packets, and the home as a place with an indoor toilet, tiled bathroom and a kitchen with a fridge in which mothers could store bottles of made-up artificial feeds. They could store expressed breastmilk too, if they wished, but breastfeeding, regarded as messy and unclean, did not fit easily into modern domestic life and was even viewed in some specious way as primitive and unseemly, to be done in private, if at all.

The paediatricians, Philip Evans (1910–90) and Ronald MacKeith (1908–77), in *Infant Feeding and its Difficulties* (1951), opened their discussion of milk with the words: 'The basic material of the infant's diet is milk. It may be human or bovine, fresh or preserved by canning or drying; fat or protein may be removed from it; water, protein, amino acids, sugar, starch, salts, acid or vitamins may be added to it.' They took it for

granted that any feed composed of the right essential nutrients was equally nutritious, entirely adequate and free of risks of 'gastrointestinal disturbance'. Now that artificial milks were accepted as safe, the manufacturers stressed new reasons why they should be used, for 'one or both of the following: baby is not gaining in weight or baby always seems hungry', suggested Glaxo in its *Ostermilk Book* (1951).

The popular paediatrician, Benjamin Spock (1903–68), advised the use of something little different to the mixtures recommended by Budin half a century earlier. Writing in *Baby and Child Care* (1955), he blithely explained to mothers that 'There is nothing mysterious about a formula. It is a mixture of cow's milk, water, and sugar.'

> The water and sugar are put in to make the mixture more like mother's milk in composition. The cow's milk that you use may be pasteurized whole milk, powdered milk or possibly, evaporated milk. Each has its special advantages. A variety of sugars are used. The commonest are granulated sugar, brown sugar, and mixtures of dextrins and maltose.

The distinguished nutritional scientist, David Bender (b. 1946), went further, saying: 'breastmilk, cow's milk – spray dried, roller dried or concentrated – half cream and full cream, with early or late weaners, all these methods seem to result in equally healthy babies'. The primacy of human milk was no longer absolute, as the leading paediatrician, Hugh Jolly (1918–86), confessed in his *Diseases of Children* (1964):

> The obvious reason for advocating breastfeeding as opposed to artificial feeding is that breastmilk is the ideal food for human babies. But many mothers when given this reason will quite reasonably say they have seen many extremely healthy babies brought up entirely on cow's milk. The emphasis in the arguments in favour of breastfeeding should be differently placed according to the mother with whom one is dealing.

Human milk might be equalled nutritionally by cow's milk, but was better psychologically.

> In Western communities, where the risk of gastroenteritis is now small, the emphasis should be placed on the close relationship between infant and mother achieved by breastfeeding, whereby the mother feels a satisfaction which she never knows if the baby is bottle fed. In developing countries, this close relationship is to a large extent obtained by having the baby on the mother's back all day and the emphasis to these mothers should be on the grave risks of gastroenteritis.

BREAST VS BOTTLE IN THE DEVELOPING AND DEVELOPED WORLDS

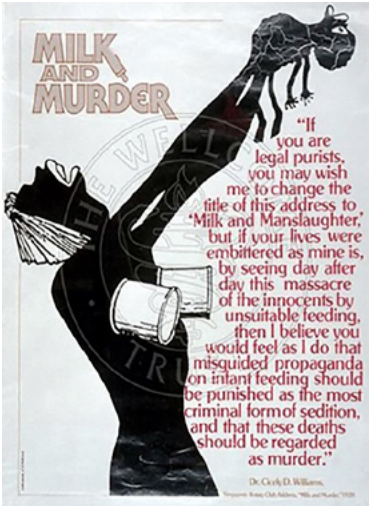
In the developing world the story was indeed very different. The promotion of artificial infant milks outside Europe and North America, with the creation of international markets, had disastrous effects on child health. In traditional and illiterate societies, where clean water was not always available, alternatives to human milk often proved fatal. Condensed cow's milk, available from the turn of the nineteenth century as a

by-product of butter, with sucrose added as a preservative, was purveyed in tins. It was sterile until opened but contained little fat or protein and was easily contaminated because of its sweetness, especially in the summer and hot climates. it was not suitable for infants.

In Malaya (now Malaysia), the paediatrician and campaigner, Cicely Williams (1893–1992), worried that mothers all too often abandon breastfeeding, because 'she feels weak; she has no milk; the baby will not suck; she has to go out to work; grandmother wishes to take control of the baby; mother does not feel it smart to feed her baby; someone advises her to give sweetened condensed milk'. Williams recounted the way the 'baby is given this out of a dirty bottle. It is rarely out in the sunlight, it gets a fever, develops boils and when the parents think the child is going to die they bring it to hospital, where it is found to have malnutrition, rickets, anaemia, beri-beri [thiamine deficiency] and bronchitis.' Too often the baby does die.

This was a situation not far akin to the plight of many European babies a century before. Not yet famous when she spoke these words in a provocative speech about 'bottle baby sickness', caused by the use of sweetened condensed milk in the place of human milk, Williams called this manslaughter:

> As everyone knows, milk is a specialized secretion from certain glands in females of the mammalian species. Murder is the death of some individual which has been brought about intentionally. Legally speaking you must prove the intention of procuring death with malice. But colloquially you talk about 'sheer murder' when someone performs an ill-considered act which is likely to result in death.



Cicely Williams, *Milk and Murder*, 1939

This was strong stuff, but Williams felt justified in not mincing her words.

> How are these things connected, milk and murder? Human babies are appallingly at the mercy of their surroundings. They are exceedingly liable to die of digestive diseases and from unsuitable food. Human milk is about the only food that they can live on. Anyone who, ignorantly or lightly, causes a baby to be fed on unsuitable milk, may be guilty of that child's death.

Williams was well aware of her predecessors who had argued so strongly about the virtues of human milk, pointing out that: 'nothing has yet been invented that provides a satisfactory substitute. Statistics have been collected to show that

the death rate among artificially fed babies is much greater than that among breastfed babies', and using the same language as *The Lancet* a century before under the provocative title 'Murder of the Innocents', she railed that it should be called manslaughter at the very least.

In many other parts of the developing world infant malnutrition, in the form of kwashiorkor and marasmus, or protein-calorie malnutrition, growth faltering, diarrhoea, with micronutrient deficiencies, particularly scurvy (vitamin C), rickets (vitamin D) and keratomalacia (vitamin A) were widespread. Infant malnutrition was noted to be most marked around weaning, when babies were first introduced to non-milk foods and/or breastfeeding declined, leading to the 'weanling's dilemma', outlined in Chapter 1.

The essential role of human milk within infant health and rearing was starkly obvious. International child health



Infant with marasmus

initiatives, adopted by the WHO and UNICEF, promoted the International Code of Marketing of Breastmilk Substitutes (1981), laying down rules aimed to prevent the misuse of commercial baby milks formulas, 'GOBI' (1982) – Growth monitoring, Oral rehydration, Breastfeeding and Immunisation – aimed at 'saving the lives of 20,000 children each day', and the Innocenti Declaration (1990) asserting the fundamental importance of breastfeeding for child health. The UNICEF Baby Friendly Initiative, designed to promote breastfeeding in maternity hospitals and adopted in many developing countries, extended its influence to the developed world. Based on 'extensive and resounding evidence that breastfeeding saves lives', it was responsible for doing exactly that. However, manufacturers continued to develop new infant milk formulas more and more closely resembling human milk and to promote and market them throughout the world, especially in countries undergoing a rapid demographic transition towards European and North American values and lifestyles.

In the 'developed world', the acceptance of bottle-feeding was reinforced by its adoption in maternity hospitals and lying-in wards. Long gone was the obstetrician with a list of wet nurses; in his place was a milk kitchen where artificial feeds were made up. Bottle-feeding was not only provided but also recommended and taught to mothers so that they went home trained to make up artificial feeds correctly and hygienically. Formula milk advertising intruded into the nursery and free cans of baby milk powder, and later liquid ready-to-feed milk in disposable bottles with teats, made artificial feeding simple and convenient.

Childbirth had become medicalised, with readier use of surgical procedures, such as Caesarean sections and forceps deliveries, and institutionalised, with the exclusion of family

and other attendants, but scant privacy for mothers. There was little resistance to these revolutionary changes in childbirth and infant feeding. They fitted into the busy working lives of many mothers and were deemed safer than home births and breastfeeding. There were small, heroic efforts by a few obstetricians to resist universal hospitalised maternity care and preserve home deliveries, with the 'naturalisation of child birth', along with the promotion of breastfeeding. They were attended by ever more determined efforts on the part of infant food manufacturers to improve and refine their products to more perfectly resemble human milk.

Scientific discoveries concerning the composition of human milk, both chemically and biologically, informed and fuelled these efforts, which involved the addition, subtraction and manipulation of the constituents of artificial formulas. The protein, fat and carbohydrate contents were chemically changed, with alterations to whey:casein ratios, modification of fatty acid profiles with 'structured lipids', and inclusion of complex carbohydrates, such as dextrins. These experiments in creating humanised formulas were attended by unexpected adverse effects on babies, such as anaemia (not enough iron), hypernatraemia (too much sodium from over-concentrated feeds), hyperphosphataemia (too much phosphate and not enough calcium) and hypercalcaemia (too much vitamin D), resulting in further chemical modifications to rectify them. Each 'problem' was dealt with by an alteration of the relevant chemical constituent, and through a process of trial and error bottle-feeding became safer.

Donald Paterson and George Newns (1908–85) pointed out in *Modern Methods of Feeding in Infancy and Childhood* (1955) that 'the advantages of feeding a baby on the breast are so numerous that it should not be necessary to stress them' and

referred to the discovery of 'a specific growth factor in human milk', a strain of the bacillus *Lactobacillus bifidus*. This heralded the discovery of living components within human milk. With the identification of more bioactive and live substances efforts were made to add these non-nutritional components to formulas to make them even more like human milk.

Scientists from the leading infant milk company, Nutricia, reviewed 'the composition of human milk as a model for the design of infant formulas' in 1994, concluding that 'there is little doubt that human milk serves a role in infant physiology greater than being a supply of energy and nutrients [alone]' and that 'the biological properties of human milk are uniquely suited to the human infant'. They regarded themselves as belonging to a long line of researchers extending back to antiquity, or earlier, observing:

> The search for human milk substitutes has been conducted since the Stone Age, but it was not until sanitation practices developed in the late nineteenth century that feeding these substitutes, mostly based on cows' milk, to infants could be safely accomplished. Since then there have been progressive attempts to bring the composition of these formulations closer to human milk.

They were probably right that sanitation, sterilisation and pasteurisation opened the door to safe substitutes, and now the quest was for a perfect synthetic replica of human milk: 'As knowledge has accumulated about the effects and action of different substances in human milk which serve other than nutritional roles, some of them have already been incorporated into infant formulas.' These included minerals and trace

elements, vitamins and 'conditionally essential substances', such as nucleotides, and were followed by the incorporation of prebiotics (oligosaccharides), probiotics (*lactobacilli GG*) and biosynthesised long-chain-PUFAs, like linolenic acid, arachidonic acid and DHA, as well as many other 'non-nutritional' substances listed in Chapter 1.

This process of widening and refining the composition of milk formulas for babies has become attended by rigorous research and regulation, with clinical trials of their safety and effectiveness conducted like the pharmaceutical testing of drugs. It has extended to the care of babies with special medical needs, such as those born very preterm, for whom nutritional 'fortification' of expressed breastmilk has been employed. For neonates with diseases that make breastfeeding impossible or whose mothers have infections that are transmittable in their milk, special 'milk' formulas can be life-saving. For babies of every shape and size, gestational and postnatal age, clinical need and developmental stage and disorder there is now an appropriate milk formula. The NHS lists eleven types of formula milks 'available in pharmacies and shops': first infant formula, goat's milk formula, hungrier baby formula, anti-reflux formula, comfort formula, lactose-free formula, hypoallergenic formula, follow-on formula, good night milk, soya formula and growing-up milk. Feeding babies has become fully medicalised and food technology has made this possible.

BACK TO THE FUTURE – THE CHILD IS FATHER OF THE MAN

The widespread use of alternatives to human milk in the last century has been an unprecedented historical development reflecting the techno-biological approach to human reproduction and infant nutrition that characterises modern times. The capacity of humans to shape their environment has been magnified by modern technology, which now affects almost every sphere of human life from farming and agriculture to diet and nutrition, to energy use and transport, to sport and medicine. Humans have become taller, heavier and live longer and healthier than ever before, write the economic historians, Roderick Floud and his colleagues in *The Changing Body* (2011):

> Changes in the size, shape and capacity of the human body since the beginning of the eighteenth century reflect and illustrate economic and demographic change over those three centuries [whereby through better hygiene and food] the health and nutrition of one generation contributes, by mothers and through infant and childhood experience, to the strength and longevity of the next generation, and so on.

The rates of growth of the fetus, the baby and its brain are all affected by maternal health and nutrition. There has generally been a secular increase in the size of infants, but for babies born small, because of poor nourishment in the womb, there may be penalties.

In the 1980s the epidemiologist, David Barker (1938–2013) reported that of men born just before, during and after the First World War, those with the lowest weights at birth and at one year of age were more likely to have, as adults, coronary artery disease, hypertension (high blood pressure), stroke and diabetes. Barker and colleagues proposed that reduced fetal growth from undernutrition programmed the metabolism of

the baby to make super-efficient use of sparse energy resources, which in later life resulted, through excessive intake of calories from obesogenic foods, to this constellation of chronic diseases. Moreover, in the low birthweight baby, accustomed as a fetus to restriction of nutrient supply in the womb, there could be harmful consequences of rapid postnatal catch-up growth induced by energy-rich milk feeds.

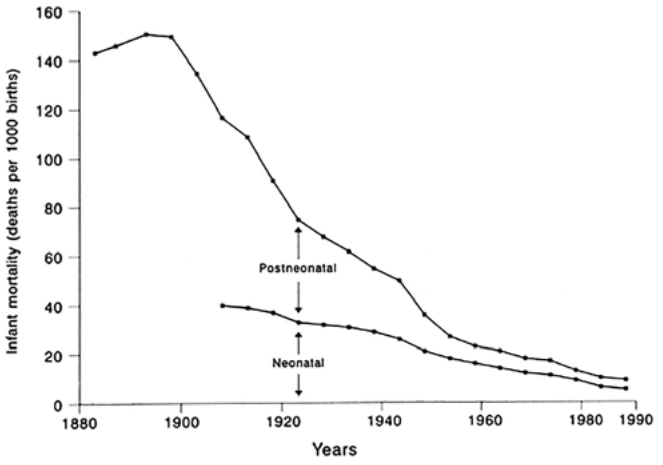
The faster postnatal growth in weight of babies reared on some artificial milk formulas is associated with childhood obesity, and quite possibly adult obesity and the chronic diseases associated with it. The lower plane of nutrition of the breastfed baby, defined by the 'slower' rate of infant growth of the modern WHO growth standards (2006) compared with that of earlier, twentieth-century charts, is likely to protect against childhood obesity. All these findings indicate that not only is intrauterine and postnatal life a critical period which has implications for later health, but also adds strength to the conviction that breastfeeding is the optimal way of feeding babies, for at least the first six months and, ideally, with appropriate complementary foods into the second year or longer.

There are two parts to human reproduction: gestation and lactation. From conception to weaning, technological ways of intervening in both biological processes have been adopted. Contraception, artificial insemination, *in vitro* fertilisation, genetic manipulation, amniocentesis, abortion, fetal surgery and Caesarean section are all artificial means of altering the natural course of reproduction. The use of the breast pump to express human milk is, perhaps, too. Lactation has become detachable from human reproduction, and it is now all too easy to replace it by a bottle that delivers a synthetic food. The choice between breast or bottle is regarded by many as a choice between equally safe and effective alternatives.

This choice can now be exercised at any time from birth to weaning and beyond. Infant feeding is now a matter of maternal preference, especially in the westernised, developed world, where many babies are reared on bottled feeds from birth. However breastfeeding can be life-saving. For the vast majority of the world's children, more than four-fifths of whom are born in the developing world, UNICEF has estimated that the universal practice of breastfeeding for at least six months could save some 1.5 million young lives each year.

How babies have been fed from antiquity to modern times clearly matters now, and has clearly mattered throughout history. Until the nineteenth century the voices of almost all who wrote about these matters, in whatever age and of whatever gender, class, profession or background, argued that human milk was indubitably the best food for babies. The humanisation of cow's milk to feed babies not nursed on the breast grew from simple home modification in the kitchen, expanded into local provision by the *consultations* and infant milk depots, was developed according to precise formulas in 'milk laboratories', and through industrial manufacture by national and international companies, breastmilk substitutes became available in maternity hospitals, and now in chemists, supermarkets and corner shops.

These developments in food technology have affected not just the fate of infants themselves but also the fortunes of mothers and families, and extended to abandoned infants such as foundlings, to social groups such as working women, to those who wet-nursed their young, to military recruits unfit to fight and to the health of nations throughout the world. History and geography tell the same story about the vitality of human milk, confirmed by modern WHO growth standards which represent a measure of optimal growth and health referable to all



Infant mortality rates from 1880 to 1990

children everywhere. Infant feeding has become a subject of international importance. From around 1900 there has been a continuous and steady decline in infant mortality throughout much of the developed world, coinciding with the economic and social changes documented by Floud, and others – better nutrition, sanitation and domestic housing, along with immunisation and welfare services for mothers and babies. Ironically, this decline has coincided with the switch from breast- to bottle-feeding.

We now expect most pregnancies will bear normal babies who will grow up to be healthy adults: a healthy start to life sets the child on a trajectory for a life free of chronic disease. Infant mortality rate is no longer a sensitive index of child health in the developed world (although it remains one of the best overall public health indices of a nation's health globally), and might perhaps be replaced by infant growth rate: grams of weight gained per month, rather than deaths per thousand live births.

Human milk feeding has an evolutionary history rooted in mammalian reproduction, hominid evolution and cultural pre-history. The biology of lactation may not have changed over the last two millennia, nor the essential composition of human milk, but the ways in which both have been conceived and understood have. So too has the practice of infant feeding, embracing breastfeeding and wet nursing, and now bottle-feeding, brought about by changing social customs, personal preferences, scientific recommendations and commercial pressures.

The changing conceptions of the nature and properties of human milk are best understood within the frames of thought of ages past. From a humoral to an alchemical, to a corpuscular to a natural, to a chemical to a biological fluid, human milk has been regarded as a vital substance which plays a critical role in human reproduction and infant nutrition and development. Since the Renaissance the body has come to be seen as a machine – a mechanical, hydraulic and pneumatic machine, a heat machine, a chemical factory, and now as a multicellular organism composed of tissues, organs, fluids and other extracellular substances in which chemical processes mediate molecular transformations to build, nourish, defend, repair and power it.

The aspiration of the bio-technology company, Biomilq, 'to replicate the nutritional profile of human milk using cultured human mammary epithelial cells' is the latest step in the technological quest for the perfect substitute. Claiming that it will be 'more nutritious than formula', and environmentally friendly because dairy cattle are a major source of greenhouse gases and around 10 per cent of the world's cow's milk go into making baby milks, this synthetic substance offers another technological solution to two man-made problems. Back to the



Mother and baby, breast and gut

future: the search for the perfect alternative to human milk, like the search for the Philosopher's Stone, is a quest for the Holy Grail, of the perfect formula that most perfectly resembles human milk – a futile search for something that already exists.

Human milk is much more than simply a secretion of disembodied epithelial cells. It is a miraculous, nourishing fluid containing numerous ingredients which are derived from mother's blood, body nutrient stores, metabolism and diet, that have all the vital properties described at the start of this book. The richness and perfection of human milk to meet the unique needs of the baby, and the elegant, finely tuned and harmonious physiological mechanisms and emotional responses which balance supply and demand, via breast and gut, are the consequence of the intimate, natural and symbiotic relationship between mother and baby. The volume of milk consumed is largely controlled by the sucking infant, and its composition tailored in many minute and vital ways through mother's nutritional status, health and care. Human milk is an integral part of nature and nurture. 'Choose your parents wisely,' advised the philosopher Bertrand Russell (1872–1970), not just for the genes they endow, but also for the care and feeding they provide.

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I have divided the sources listed in the bibliography below into primary and secondary publications. The former are works published before 1967 (when I was first a medical student) and the latter are more recent publications, including a number written by me, and colleagues, upon which I have drawn, especially for Chapters 1, 6, 7 and 8. They contain references to publications not listed below which may be helpful to readers who want more detailed information. Chapters 2 to 5 were drafted during a term in Oxford as a visiting fellow of Exeter College, and I thank the rector, Rick Trainor, Marguerite Dupree and the fellows for their kindness and hospitality. Ian Strathcarron, Lucy Duckworth, Stephen Kelman, Ramona Lamport and Matthew Gale transformed my typescript into this elegant book, my sister Rachel Munn kindly produced the artwork in Chapters 1 and 2, and my wife, Camilla, and children, Robin and Marion, put up with husband and dad droning on about human milk for three years. I thank you all.

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