An introduction to the diseases of infancy / by J.W. Ballantyne.

AN INTRODUCTION

TO

THE DISEASES OF INFANCY.

BY

J. W. BALLANTYNE, M.D., F.R.C.P.E.,

LECTURER ON DISEASES OF INFANCY AND CHILDHOOD, EDINBURGH SCHOOL OF MEDICINE;
LECTURER ON MIDWIFERY AND GYNÆCOLOGY, MEDICAL COLLEGE FOR WOMEN, EDINBURGH;
PHYSICIAN FOR DISEASES OF CHILDREN, COWGATE DISPENSARY;
PHYSICIAN FOR DISEASES OF WOMEN, WESTERN DISPENSARY;
SECRETARY TO THE EDINBURGH OBSTETRICAL SOCIETY; AND
LATE SENIOR ASSISTANT TO THE PROFESSOR OF MIDWIFERY AND DISEASES OF WOMEN AND CHILDREN IN THE UNIVERSITY OF EDINBURGH.

WITH COLOURED AND OTHER ILLUSTRATIONS.

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TO

ALEXANDER RUSSELL SIMPSON,

M.D., F.R.C.P.E., F.R.S.E.,

PROFESSOR OF MIDWIFERY AND THE DISEASES OF WOMEN AND CHILDREN
IN THE UNIVERSITY OF EDINBURGH,

THIS WORK IS DEDICATED,

WITH AFFECTIONATE GRATITUDE AND ESTEEM BY HIS FORMER ASSISTANT,

THE AUTHOR.

In preparation, by the same Author, and uniform with the present Work.

THE DISEASES PECULIAR TO THE FŒTUS AND YOUNG INFANT.

PREFACE.

In this work the attempt has been made to found on the sure basis of Anatomy and Physiology a rational conception of the differences which exist between disease as it occurs in the infant and as it is met with in the adult. The anatomical and physiological peculiarities of the infant have been stated, and from them deductions have been drawn concerning the hygiene of early life and the symptomatology of disease in infancy.

The diseases which are truly peculiar to the infant are few in number; but the diseases which, occurring in infancy, are modified by the anatomical and physiological conditions then in existence, are very many. To repeat, therefore, in text-books devoted to pediatrics the full descriptions given of disease in the adult, noting here and there a difference in symptomatology and treatment, seems to me to be unnecessary; for the medical man who devotes himself to the study of the diseases of early life is already cognizant of the symptoms and therapeutics of adult maladies, and his immediate desire is to be able to apply his already acquired knowledge to the conditions met with in infancy.

The pediatric physician, it must never be forgotten, is a physician first, and a pediatrist afterwards. It has, therefore, been my object to gather together the scattered facts relating to the Anatomy and Physiology of infancy, to apply them to the elucidation of the phenomena of disease as they are met with in early life, and to found upon them the rules which ought to guide us in the feeding and rearing of infants. I hope in a future work to discuss the pathology and treatment of the diseases which may be said to be truly peculiar to infancy—those, for example, which are the result of abnormalities in the process of parturition, those which may be produced by irregularities in the circulatory and respiratory changes at birth and by the presence of the stump of the divided umbilical

cord, and those which can be directly traced to pathological intra-uterine conditions.

With regard to that part of this work which deals with the anatomy of infancy, it may be said that the statements therein met with are founded in the main upon special researches made by means of the frozen sectional method. These were described in a thesis, entitled "Certain Anatomical and Pathological Conditions in the Fœtus and New-born Infant in their relation to Obstetrics," which was presented for graduation in the Doctorate of Medicine at the University of Edinburgh in 1889. This thesis was awarded a gold medal and the Simpson-Gunning Victoria Jubilee Prize in Obstetrics. Certain papers embodying portions of these researches have appeared from time to time in the *Edinburgh Medical Journal*, and are now gathered together and placed alongside of the parts hitherto unpublished.

I have to acknowledge the valuable and valued advice, encouragement, and help I have at all times received from Professor A. Russell Simpson. I have also to thank Mr James A. Melville for much assistance in the revision of the proof sheets, and Mr William Cathie for the truthful manner in which he has drawn and coloured from Nature the plates illustrating the text. My thanks are also due to my publishers, Messrs Oliver & Boyd, and to the Manager of their printing department, Mr Hugh Cameron, for the great care they have exercised in the production of the work.

J. W. BALLANTYNE.

24 Melville Street,
Edinburgh, *May 15th*, 1891.

Note.—As these sheets have been passing through the press, Archbishop Magee, the champion of children in the matter of life insurance, to whom reference is made on page 5, has fallen a victim to influenza whilst in London working for this cherished cause.

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The medical examination of a sick infant by a physician is always a difficult matter, and requires thorough knowledge of infantile maladies and unbounded care and tact. Diagnosis in adults, or even in older children, is fairly easy to the man who is well versed in physical signs and their meaning; but the diagnosis of the diseases of the infant is surrounded on all sides by difficulties which fairly baffle the young practitioner, or, what is even worse, drive him along the royal road of diagnosis to the conclusion that all the maladies he meets with are due to dentition. In consequence of the great difficulty experienced in the clinical investigation of the diseases of infancy, it follows that in the hands of very many medical men the diagnosis of infantile maladies is often extremely vague and their treatment empiric and unsatisfactory. Difficulties in diagnosis are, no doubt, to a great degree accountable for much of the ignorance which surrounds this branch of medical study. Many of these difficulties, however, can be lessened; and some can be entirely overcome by tact, good common sense, and by the knowledge of the peculiarities of the organism of the infant. That these means are not more widely employed to remove the obstacles in

the way of the rational diagnosis and treatment of the diseases of early life is due to another cause.

This cause is found in the fact that students of medicine, as a general rule, neglect to acquaint themselves with a knowledge of the diagnosis and treatment of infantile diseases whilst they are pursuing their course of study at College or in the University; and as a result young graduates spend many anxious hours during the first few years of their professional life in endeavouring to treat successfully the maladies which are peculiar to infants and young children. It must not hastily be concluded that medical students are altogether to blame in this matter; for the fault lies rather with the Examining Bodies, who require no special evidence of the study of pediatrics from the candidates who apply for their degrees, and who do not make compulsory the examination of undergraduates in this branch of medical study. The fact that the Examining Bodies are wrong will not, however, shield the graduate from the indignation of parents whose children he has unsuccessfully treated; and the fact that pediatrics is not a compulsory subject of medical study does not in the slightest degree lessen the load of responsibility which falls upon the shoulders of the medical student who deliberately neglects to avail himself of the many facilities now afforded him for the acquisition of some special knowledge of the diseases of infancy. Dr Ryan, lecturing on this subject many years ago, said:—"I need scarcely observe that it would be no excuse to offer to an affectionate parent on the death of a favourite or only child were a medical practitioner to say, 'I am sincerely sorry for your affliction; diseases of children are not properly studied; in fact, the profession in general know nothing about them; in truth, there is no examination in them.' Well might a parent stare with astonishment on hearing such a declaration." To study specially the diseases of infancy is, therefore, in the first place, a duty physicians owe to society at large, and to their patients in particular; for there can be no reasonable doubt that the great mortality which at present exists amongst young children is in great part due to the lamentable ignorance upon the rearing of infants which exists in the popular mind, and to the fact that many medical men employ methods of treatment in the care of infantile maladies which are almost as empiric and irrational as those used by the laity. In the second place, the acquisition of a knowledge of diseases of infants and children is a duty which medical men owe to them-

selves. A very large number of the patients whom a general practitioner has to visit every day will of necessity be children; and in not a few instances medical men can state that the commencement of their success in practice dates back to the first sick child whose life they were fortunate enough to be able to save. If one can save the infant's life, one will in ninety-nine cases out of a hundred become the family medical attendant. But, in the third place, pediatrics is a branch of medical study which is difficult and also extremely interesting. It still offers a wide field for original investigation; and since the phenomena which are to be studied are simple compared with those seen in the adult organism, such investigations must necessarily have an important bearing upon the study of all the mental and physical processes which are met with in the full-grown man or woman. A well-known author has expressed his feelings upon this matter in the following sentences, which may suitably be quoted here:—"I possess," he says, "profound tenderness for infants. The passions are first observed in them, and it is in them that it is useful, as it is curious, to study their mystery and labyrinth. If we wish to know the medical condition of man in a savage state, it is in infants we find it. It is in them alone we can mark the anatomy of our faculties; these only demonstrate the origin and first essays of sentiment, and our first sensations. In these we see how gradually the wants, feeling, idea of existence, and sensations are developed, and we cannot know their origin unless we return to infancy. It is therefore the infant that enables man to know himself. Infancy is a mirror in which we can see ourselves at all times, great and small."

The reasons stated above are amply sufficient to prove that the study of the diseases of childhood is an essential and important part of the medical curriculum. Let us now look at the position which the subject of pediatrics has occupied in the history of medicine. Not more than forty years ago, throughout the whole of England and America, there was not one single hospital set apart for the treatment of diseases of children. "It was," as Dr Charles West said at the Medical Congress in 1881, "but rarely that one saw them, little waifs and strays, in the wards of our general hospitals, for the maxim 'De minimis non curat lex' held good in medicine as in law." France stood alone amongst the countries of the world as the land in which great attention was paid to the maladies of early life, and the best text-books upon diseases of children were all

written by Frenchmen practising in the Parisian hospitals. At the present time, to the credit of the medical profession and of the public generally be it said, a great change has taken place. Admirable hospitals for children, well manned by experienced physicians and surgeons, exist in most of the large towns of the world; reliable text-books upon pediatrics are constantly issuing from the press in Germany, France, America, and in our own land; journals specially devoted to the diseases of children appear weekly or monthly in many different languages; and medical students and young graduates are in increasing numbers applying themselves to the clinical investigation of the diseases peculiar to childhood. A great diminution in the mortality amongst children has already taken place, and with an advance in our knowledge of the physiological and pathological processes of infancy and childhood, with an improvement in the methods by which pediatrics is taught, and with an increase in the facilities granted to the student in order that he may satisfactorily study this subject, we may confidently look forward to a still greater reduction of the number of deaths and serious illnesses amongst children. It is, however, still matter for regret that the study of the diseases of *infancy* has not advanced *pari passu* with that of the maladies of *childhood*. Children under two years of age are not, as a rule, admitted to the hospital; they are seen, it is true, in the out-patient department, but there it is to be feared they are often somewhat imperfectly examined and not altogether satisfactorily treated. A thorough knowledge of the physiology of the first three years of life is still a desideratum, there is no reliable treatise upon that subject, and it is, therefore, scarcely matter for wonder that so little is known of infantile pathology. In consequence of these deficiencies the mortality during the first two or three years of life is enormous. Dr Eklung of Stockholm, who has studied most carefully the death rate amongst children in all parts of the world, finds as a result of his compilation that in Europe 25 per cent. of all deaths occur in children under one year of age. Another calculation reveals the startling fact that of all children born, 20 per cent. die before the first year of life is completed, 10 per cent. die in the first month, and 33 per cent. die before the fifth year is reached.

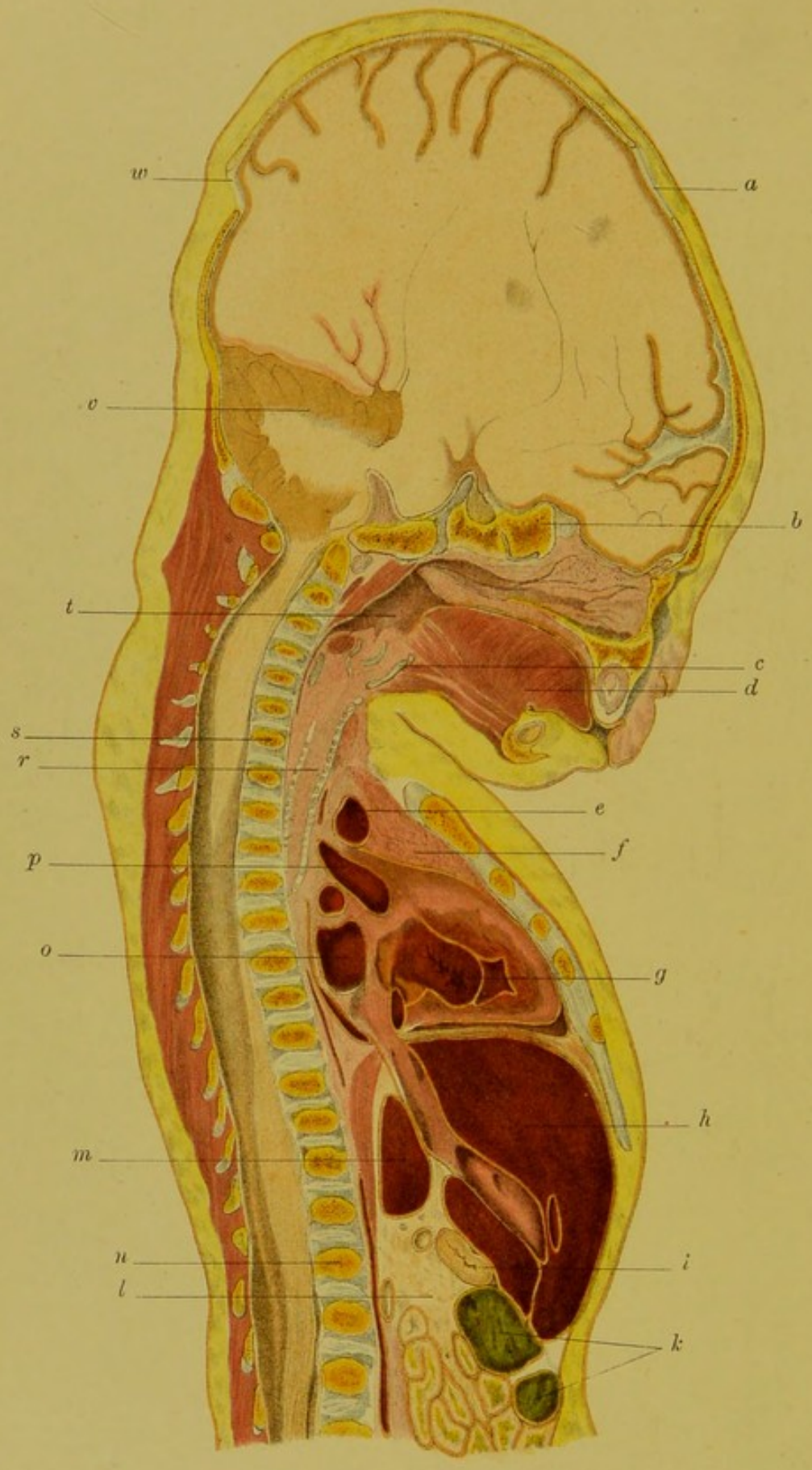
Whilst a knowledge of the diseases of *children* is most important, a proper conception of *infantile* maladies is absolutely essential if any diminution of this distressing mortality is to be brought about.

It has been customary to look upon pediatrics as a speciality; but it is far more than a speciality in the ordinary sense of the word, for it does not deal solely with one organ of the body, but with the whole organism at that time of life when the interesting changes incidental to development and growth are going on. It does not, like the special study of the eye, the ear, the throat, the skin, or the uterus, tend to a one-sided view of medicine; it rather leads to a more comprehensive knowledge of all the subjects of medical study than is possessed by many of the medical men of the day. One department of the subject, concerning which most inadequate, if not actually erroneous, ideas prevail, both in the profession and amongst the laity, is that of infantile hygiene. I can scarcely find language strong enough to characterise the practice of the great majority of the people of vaunted civilized lands in the matter of the physical education and rearing of their progeny. An old writer says:—"Persons often take great interest in rearing domestic animals, but if we speak to a father on the physical education of his infant he almost feels offended; but ask him about his dogs and horses, and he is ready to give his views on rearing them."

I do not now specially refer to those grosser evils which require the institution of Societies for the Prevention of Cruelty to Children and the passing of Bills in Parliament for the regulation of child labour, nor to the shameful practices connected with infant life assurance, concerning which the Archbishop of York recently said that "he thought that the person who, in a fit of passion, suddenly and swiftly terminated a child's life was innocent compared with one who let it waste away day by day until its miserable life was ended," and all for the sake of insurance money more often spent in drink than on the funeral. No, I rather allude in this relation to the hygienic mistakes made in the feeding, clothing, and education of children, which are so prevalent at the present time. If the laws of hygiene were widely known and extensively acted upon, the distressing mortality in early childhood would assuredly be brought to a minimum, and children would grow up into men and women in all respects better fitted for the duties of life and for the never ceasing struggle against sickness and death.

It will, no doubt, be conceded by all medical men as imperative that the hygiene and the diseases of infants be studied by all who would become successful practitioners of the art of healing and of keeping in health; and a return may now, therefore, be made to the

consideration of some of the special difficulties which surround the study of pediatrics. But in the following pages use will have constantly to be made of the terms "new-born" and "infant;" and it may, therefore, be well here to define exactly what is understood by these expressions. The term "new-born" is that which is applied to the infant during that period of his existence which may be called the time of transition or metamorphosis. During this period, which may be said to correspond to the first month of life, there are great changes taking place in the anatomy and physiology of the infant. Organs that have during intra-uterine life had no call put upon them are suddenly brought into functional activity, whilst the structures which have been physiologically active during fœtal life now begin to atrophy from disuse. Thus the lungs, which during intra-uterine life are quiescent, are called into functional activity as soon as the infant makes his first inspiration of the atmospheric air, whilst the organs of digestion begin their work with the ingestion of the first mouthful of nourishment. On the other hand, the vessels which have during fœtal life brought the blood of the infant into close relation with that of the mother rapidly atrophy when the changes in the circulatory system which occur at the time of birth are established. As Lorrain has put it, it is during this period that the new functions are perfected and that the old organs disappear: the umbilical cord separates, and the navel becomes cicatrised; the epidermis cracks and falls off; the hair is renewed; the meconium is expelled; the umbilical arteries and vein are obliterated; and the foramen ovale is closed. It is during the first month of life that these changes occur, and the term "new-born" is therefore applied to the infant during this period of its existence. "Infancy" is a term which cannot be so rigidly defined. Infancy has been by many divided into two epochs: the first (*première enfance* of the French, *Sauglingsperiode* of the German physicians) has been held as extending from birth to the appearance of the milk teeth at the seventh or eighth month; the second epoch (*seconde enfance*, *Kindersalter*) has been defined as that intervening between the appearance of the milk teeth and that of the permanent or second teeth, ending, therefore, at the sixth or seventh year of life. In this work, however, the term "infancy" is understood as applying to the first three years of life; at the end of the third year indications of all the chief mental processes are to be found in the infant, and all the bodily functions, with the



Mesial Sagittal Section of New-born Infant (§ *Natural Size*).

Wm CATHIE, DEL ET LITH.

PLATE I.

Mesial Sagittal Section of New-born Infant. In the upper part of the region of the Head the section has passed slightly to the right of the middle line, leaving the falx cerebri unexposed.

a. Anterior Fontanelle.
b. Presphenoid.
c. Thyroid Cartilage of Larynx.
d. Tongue.
e. Left Innominate Vein.
f. Thymus Gland.
g. Tricuspid Opening in the Heart.
h. The Liver.
i. The Pylorus.
k. Transverse Colon.
l. The Pancreas.
m. Lobus Spigelii of Liver.
n. First Lumbar Vertebra.
o. Left Auricle.
p. Aorta.
r. Trachea.
s. Seventh Cervical Vertebra.
t. The Pharynx.
v. Cerebellum.
w. Posterior Fontanelle.

exception of the sexual and reproductive, are in operation; but at the same time it must be conceded that it is not desirable rigidly to limit the terms infancy, childhood, babyhood, or youth, to any definite number of years—the words are to a large extent interchangeable, and will always remain so.

Difficulties in the Clinical Investigation of Infantile Diseases.

a. The difficulties which surround diagnosis of disease in infancy are, in the first place, due to the existence of Anatomical Peculiarities in the organism of the infant which influence the physical signs elicited by the medical man. If these anatomical characters be well known and be kept clearly in mind, this source of difficulty to a great extent vanishes; but, unfortunately, anatomical teachers and text-books say but little of the anatomy of the first years of life, and not one medical student in a hundred ever has an opportunity of dissecting an infant, and therefore it results that medical men have often vague ideas of the position and relations of the viscera in the infant. There are, it is true, most valuable treatises upon the anatomy of early life, of which the *Atlas of the Topographical Anatomy of the Child*, by Symington, is a brilliant example; but such works are not readily accessible to the student and to the busy practitioner, and, further, the information contained in them is treated rather from the purely anatomical than from the clinical standpoint. In this work, therefore, it will be found that a large place (some may say too large a place) is given to the consideration of the anatomy of the infant. As examples of the peculiarities in the anatomical constitution of the infant, it is only necessary to mention the presence of the large thymus gland in the thorax, the large size of the liver, and the existence of fontanelles in the cranial vault, in order to make it clear how essential it is that the medical man should be conversant with these details in order that he may avoid mistakes in the diagnosis of infantile maladies.

b. The Physiology also of the infant presents differences of considerable importance when compared with that of the adult. There is a real want of reliable information regarding the physiology of early life, which at the present time forms a considerable obstacle to progress in the rational treatment of the diseases of infancy, and in the application of the laws of health at that time of life; and what little is definitely known about this subject is not usually

found in text-books upon infantile maladies, neither is it possessed by the great majority of medical men. It need only be said that with regard to the functions of nervous action, digestion, excretion, blood-formation, and even those of circulation and respiration, so little is definitely known that it is a matter for congratulation that infantile diagnosis and treatment are so far advanced as they are.

In the second part of this work, therefore, what is known of the physiology of infancy is stated and applied as far as is possible to the elucidation of the laws of infantile hygiene, and to the explanation of the peculiarities of the symptomatology of diseases in early life.

c. The third cause of difficulty in infantile diagnosis and treatment is the result of this absence of a general knowledge of the physiology of early life, and it consists in the WANT OF SATISFACTORY EXPLANATIONS OF THE PATHOLOGY AND PATHOGENESIS OF MANY DISEASES PECULIAR TO INFANTS; for it follows that until the physiology is thoroughly known no great advances can be made in pathology. It is only necessary, in order to illustrate this contention, to point to the diverse opinions held as regards the pathology of such diseases as rickets, icterus neonatorum, congenital defects and malformations, sclerema neonatorum, trismus neonatorum, and infantile convulsions. More light is anxiously awaited in this department of general pathology.

d. SYMPTOMATOLOGY OF INFANTILE DISEASE.—The difficulties which have been enumerated can only, in the present state of our knowledge, be partially overcome; but it is possible much more completely to get rid of some other impediments which stand in the way of rational progress in pediatrics. Allusion is here made to the fact, which has indeed been already hinted at, that the symptoms of disease in infants differ in many instances from those seen in adult life, or have at any rate a different significance. There is, to a certain extent, a special symptomatology of infants' diseases, and this proceeds also, in great measure, from the differences in physiology. As examples of the difference in value of symptoms in early as compared with adult life, there may be cited the frequent absence of expectoration in respiratory diseases, the absence of a distinct rigor in fevers, the unreliable indications afforded by the state of the tongue, and the fact that a high temperature and a quick pulse may, in an infant, point to causes only trivial and evanescent.

Many of these symptomatic peculiarities will be referred to in connexion with the study of infantile physiology; but they do not form formidable obstacles in the way of the physician who possesses the power of observation and some degree of experience.

e. Fifthly, there are some purely TECHNICAL DIFFICULTIES connected with the clinical investigation of the diseases of infants. The obstacles of this kind met with consist chiefly in the impossibility of obtaining information from the little patient, and in the interference with the examination caused by the struggling and crying of the child. These impediments in the way of a thorough investigation of the case have been well summarized by Dr West, as follow:—"You cannot question your patient, or if old enough to speak, still, through fear, or from comprehending you but imperfectly, he will probably give you an incorrect reply. You try to gather information from the expression of his countenance, but the child is fretful, and will not bear to be looked at; you endeavour to feel his pulse, he struggles in alarm; you try to auscultate his chest, and he breaks out into a violent fit of crying." The full force of Dr West's words has probably been practically proved by every physician who has had to treat little children. These technical difficulties are, however, in great measure removable, and most medical men soon learn that by the use of tact, and by experience, it is possible to examine thoroughly a sick infant without what may well be termed a "scene." The difficulty which arises from the fact that the little patient has not the power of speech may be greatly lessened by attention to the cry, physiognomy, gestures, and attitude of the infant, and by paying due heed to the history of the illness which the mother or nurse is able to supply. The difficulties due to crying and struggling of the infant may be avoided altogether by seeing the child when he is sleeping, and mothers are coming to realize that it is not advisable "to wake up the baby to see the doctor." With care a fairly thorough examination of the sleeping infant may often be made: the pulse and respiration rates may be counted, the expression of the face may be noted, and to some extent palpation and auscultation may be accomplished without waking the child. The procedures to which children object, such as the examination of the mouth and throat, should be left to the last. Other hints as to the investigation of infantile signs and symptoms will be found under the heading of, "General Rules for the Clinical Investigation of Diseases of Infants" (p. 10).

It must not be thought that there are no factors which render the investigation of infantile maladies easy, and so in some degree counterbalance the difficulties of which mention has just been made. The want of verbal information from the infant must have set against it the fact that statements of symptoms made with the purpose of deceiving the medical man are altogether absent; the difficulties due to the struggling and screaming of the child are in great measure counterbalanced by the ease with which the whole body of an infant may be inspected and palpated; and the peculiarities of infantile symptomatology are rendered less disconcerting by the absence of the results of former illness or of vicious habits, and by the fact that disease in early life is usually uncomplicated. Notwithstanding the presence of the above mentioned characteristics which facilitate clinical investigations, the study of diseases of infancy still remains for some practitioners a sealed book, and many medical men feel at all times comparatively helpless in the presence of a sick infant. It is, therefore, very important to keep in mind certain general rules in the diagnosis of infantile maladies.

General Rules for the Clinical Investigation of the Diseases of Infants.

The medical man who wishes to excel in this branch of practice must possess a large amount of patience, gentleness, and tact, for, without these qualities, he will never succeed in making friends with his little patients, and, therefore, his diagnosis will be very frequently incomplete or erroneous, and his treatment futile.

On arriving at the house the doctor, before examining the infant, ought to learn as much as he can concerning the symptoms of the illness from the mother or from the nurse in attendance. He ought to listen patiently to the long rigmarole of irrelevant information which the mother often gives, and should only, by an occasional question, guide the conversation in the direction of important details. He must keep in mind that the mother is probably nervous in the extreme about her infant, and that, moreover, she has not had an education to fit her to differentiate important from trivial details in the formation of a diagnosis. Considerable attention ought always to be paid to the statements made by the mother, for her conclusions are generally correct, although the facts upon which she bases these

conclusions may seem trivial. When a mother assures the medical man that her baby is no better or is worse than before, it is well for him to give all credence to her statement, for in ninety-nine cases out of the hundred it is correct, although the doctor himself may not be able to appreciate the apparently trifling changes upon which the mother forms her opinion. The men who are most skilled in pediatrics are usually found to be those who pay most deference to the mother's opinions. As Finlayson says:—"While lightly estimating all their theoretical views, we should weigh most seriously all their statements and opinions as to the actual facts of the illness, and especially as to the general conditions." *

The preliminary information which the medical man obtains from the mother or nurse ought to put him in possession of many important facts, of which the following may be mentioned. He learns, in the first place, the name and sex of the infant, and let him not forget in future that he has been made acquainted with the latter fact. The remarks of the talented author of *The Idle Thoughts of an Idle Fellow*, although addressed to the laity, may in reference to this matter be taken to heart by the profession also. He says:—"It would be of great convenience if some fashion were adopted, enabling you to tell a boy from a girl. At present it is most awkward. Neither hair, dress, nor conversation affords the slightest clue, and you are left to guess. By some mysterious law of Nature you invariably guess wrong, and are thereupon regarded by all the relatives and friends as a mixture of fool and knave, the enormity of alluding to a male babe as 'she' being only equalled by the atrocity of referring to a female infant as 'he.' Whichever sex the particular child in question happens *not* to belong to is considered as beneath contempt, and any mention of it is taken as a personal insult to the family. And as you value your fair name, do not attempt to get out of the difficulty by talking of 'it.' If you desire to drain to the dregs the fullest cup of scorn and hatred that a fellow human creature can pour out for you, let a young mother hear you call dear baby 'it.'"

A *general* idea of the age of the infant may be obtained from his size and appearance; but it is well to know the *exact* age, for this knowledge is of great importance in relation to dentition, and is also valuable in estimating any interference with the regular and normal increase in body-weight. Further, certain diseases are

* Finlayson in Keating's *Cyclop. of Dis. of Children*, vol. i. p. 80.

almost peculiar to certain ages: thus there is the group of diseases characteristic of the first month of life, such as trismus, sclerema, ophthalmia, and the affections of the umbilicus; and, again, there are the morbid conditions which so often occur at the time of teething. It is well in the case of young infants, therefore, to ascertain the age in months, weeks, and even in days.

The place of residence of the patient has no doubt been already noted, and this fact is of importance, for sometimes the knowledge of the locality in which the child lives may aid diagnosis, as in the case of an epidemic of scarlet fever or measles in a definite part of a town or city, or in some district of the country. In the case of infants seen in hospital, the address of the parents is always necessary for future reference if it be desired to follow up the history of the illness.

From the mother or nurse the medical man hears what it is that the infant suffers from, and how long he has so suffered. The complaint is usually stated in popular phraseology as "the hives," "water on the brain," "worms," "tooth rashes," and the like; and the physician who desires to excel in the treatment of infantile maladies ought to make himself familiar with the terms in use among the laity to describe the diseases of infancy, and especially the terms employed in the district of the country in which his practice lies. The popular terminology used by mothers in the South of England is ingeniously put into rhyme in the following lines which appeared some years ago in the *British Medical Journal:*—

"'E's cutting 'is teeth across the loins with a wheezling on the chest;
We always thinks for this complaint Roosian taller plaisters is the best."
"'E's come out all into a rash; I am sure 'e 'as the measles;
'E's worked up'ards and down'ards, and 'is milk comes up in curdles."
"'E's a-wasting to a shadder; I am sure everythink I've tried;
I gives 'im boiled bread and arrowroot, yet 'e's never satisfied."
"'E's got the thrush which is a-going through 'im,
So I give 'im a cooling powder, which give 'im rather a doing."
"'E's cutting 'is teeth crossways; they ain't quite through yet.
'Is little 'ed sweats so at night, it makes the piller soaking wet."
"'E's inwardly convulsed; 'is little eyes roll so in 'is 'ed;
'E's like a burning coal at night; I can't abide 'im in the bed."
"'E's collecting water in 'is 'ed whilst cutting 'is back teeth;
'E's got the eating diabetes, for 'e does nothink else but eat."
"Every time 'e draws 'is breath it comes right from 'is little stummick;
'E's got the red-gum all over 'im; 's teeth it is what's done it."
"When 'e waked the water stood upon 'is 'ed in drops, and reg'lar smoked;
'Is breathing was that 'ard at night, I thought 'e must 'ave choked."

The medical man ought also to question the mother as to the duration of the child's illness, so that he may get some idea of the acute or chronic nature of the disease, and also in order that he may judge correctly with regard to the prognosis he should give. It is also well to ascertain whether or not the disease were present at birth. The history of the present illness must then be inquired into in detail. The medical man will hear from the mother whether its commencement was sudden, as in croup; or gradual, as in hydrocephalus; whether the progress has been rapid or slow; and what circumstance is alleged as a cause. The mother may, and commonly does, adduce teething as a cause, and this should be noted, we bearing in mind, however, that the influence of dentition as an etiological factor has been much exaggerated. It is also necessary to inquire whether or not any treatment has been adopted by the mother, and if remedies have been used what their nature was. The history of the previous health of the infant, although not of great value at this early time in life, should be inquired into; and in the case of young infants much light may be thrown upon the character of the disease by the investigation of the history of the mother's confinement. Certain of the diseases of the new-born infant are directly referable either to the labour itself, or to some operative or manipulative interference which may have been necessary. Thus, facial paralysis may follow an instrumental labour or a labour in a deformed pelvis; and fractures, wounds, and dislocations may be due to interference with fingers, hooks, etc. Trismus neonatorum has been ascribed to rough usage of the umbilical cord, and in cases of this disease the method in which the cord has been treated should be investigated.

The medical history of the mother and also of the father is also extremely important in many cases of infantile disease, and in some cases it may be necessary to inquire into the history of brothers and sisters, and even of grandparents and cousins. It is well known that many diseases have a hereditary tendency, being transmitted from parents to children, or sometimes, as in the curious cases of atavism, from the grandparents. As examples of the former class may be mentioned syphilis and cancer; and of the latter class, tubercular disease and hæmophilia, which last named disease seems to affect the males, but appears to be transmitted through the females who remain themselves unaffected. The medical history has often to be obtained with some degree of cunning,

for parents will often adduce many circumstances, such as maternal impressions, rather than admit the existence of hereditary bad tendencies in their family. It has been shrewdly pointed out that weak points in the mother's family history are often most readily obtained from the father of the child or from his sisters, and the same remark may be applied to disease on the father's side. It is also advisable to avoid as much as possible direct references to consumption, cancer, or scrofula, and to use rather such terms as "decline," "swellings in the neck," "tumours," etc. (Finlayson.) The combination of different diseased tendencies in the parents may determine peculiarities in the infant which differ from both. Sometimes a morbid tendency, such as that of tuberculosis, may manifest itself in different forms in the children of the same parents. Thus one child may have tabes mesenterica, another hip-joint disease, and a third tubercular meningitis; whilst in a rheumatic family one child may have rheumatism, another chorea, another heart disease, and a fourth simply "growing pains." In some families a tendency to acute attacks of disease can be traced, and a special liability to certain of the exanthemata is found; whilst in other families there seems to be some immunity from fevers, or at least from serious attacks. A lady with whom I am acquainted has had measles three times, and her boy has had the disease twice; a medical friend has had scarlet fever thrice. All these and many other points must be kept in mind by the physician as he inquires into the heredity of any given disease.

The mother ought also to be questioned as to the food which has been supplied to the infant, and as to the general hygienic surroundings. It is always most important to find out whether the mother is suckling her child or bringing him up on the bottle. The diseases due to diet are very common in infancy; diarrhœa, rickets, thrush, are some examples of this, and many others might be named. Bad hygienic conditions, such as bad ventilation, dirty habits, and the like, are also powerful causal factors in the production of disease in early life.

Whilst the physician has been obtaining information on the above mentioned subjects from the mother or nurse, he has no doubt been told the symptoms from which the infant has been suffering, and he has been enabled roughly to form an opinion as to the system of the body most affected. He may have learnt that the infant has been suffering from vomiting, flatulence, diarrhœa, or constipation, or he may have heard that the child habitually cries after taking food, or has symptoms which the mother thinks point to the presence of "worms."

Again, he may have elicited a history of cyanotic attacks, fits of blueness, or of flushings or hæmorrhage. Yet again, the symptoms may have pointed to disease of the respiratory system, and may have consisted of attacks of coughing, snuffling, or suffocative seizures. The symptoms narrated by the mother may lead him to look for skin disease, or they may have suggested to him genito-urinary troubles. Finally, his questions may have occasioned answers which have led him to look for disease of the nervous system; there may have been, for example, convulsions or paralytic symptoms, or attacks of pain in the head in the infant.

The physician has thus far been investigating the symptoms of the disease which affects his little patient, he is now in a position to examine clinically the physical signs of the infant's malady. His conversation with the mother may have been carried on in the room in which the child is or in another apartment, at any rate, if he now for the first time enter the room occupied by the child, he must not, unless the child be asleep, commence his clinical examination at once. If the infant be sleeping, the medical man should seize the opportunity of examining him as he lies in his cot or on his mother's knee. He may count the respirations, he may note the expression of the face, the attitude of the limbs, and the general development of the body, and he may to some extent palpate and auscultate the chest. Sometimes the mother has already taken the child's temperature; but if she has not, the doctor ought now to do so if possible without awakening the infant. If, on the other hand, the child be awake when the medical man enters the room, the examination cannot be so rapidly commenced. He will not proceed at once to the child's bedside, but will spend a few moments in talking to the mother or nurse so as to allow the little patient to become accustomed to his presence. If the infant be under the age of five or six months he will not, as a rule, resent the clinical examination to which he is subjected; but if he be older, screaming and struggling may be looked for. No very definite rules for conduct can be given to guide the physician in his efforts to examine the child; but it may be stated generally that he ought by every means in his power to endeavour to ingratiate himself with his little patient. He ought with a winning smile and in a pleasant, gentle voice to begin his conversation with the child. He may talk to him about his toys, or picture-books, or games, and he ought all the time to be watching for peculiarities in voice or expression. The

physician ought not to be above admiring the child's toys, or giving him his stethoscope to make a trumpet of, or even making chuckling noises in his throat for the baby's amusement. In a word, he must gain the confidence of and make friends with the little child. It is upon the mastering of seemingly trifling details such as these mentioned, that the great part of the secret of success with children depends, and if the intelligent medical man can succeed in making friends with his patient, there are few diagnostic methods that he will be unable to employ. Whilst gentleness is emphasized, firmness must not be forgotten. Many children are pampered, petted, and badly brought up, and with such children the medical man must be firm; for example, he must never, after commencing an examination of any part of the body, relinquish his efforts until the examination has been completed. If he gives up the attempt on account of the child's cries, his future influence with the infant will be nil; but if, on the other hand, he persevere and succeed, he will probably gain more power over him than anyone else possesses.

As to the actual method of examination no hard and fast rules can be laid down. The medical man must be prepared to vary at a moment's notice his mode of procedure, and to seize the fitting moment for the examination of any particular system or organ. As a general rule inspection and palpation of the head, chest, and abdomen may be carried out first, and the chest may be auscultated, and preferably from the back, so as to prevent the child's seeing what is going on, and then if necessary, percussion may be employed in order to clear up any obscure point. The auscultation of the chest posteriorly, either directly with the ear or by means of the stethoscope, will yield information by no means small in amount or poor in quality; and the procedure may be carried out almost without the child's being conscious of it. Percussion usually frightens the child very much; but, fortunately, it is not such an important diagnostic aid in early as in later life: it ought to be performed gently in all cases. Even the use of the stethoscope may terrify the child, and in the case of one little girl known to the author, the idea that the doctor was going "to bore a hole" so took possession of her, that she had a violent attack of palpitation which rendered the auscultation useless. The examination of the mouth and throat is usually the most difficult procedure to carry out in the case of an infant, and it ought to be left to the last: it will often in the best hands have to be done forcibly.

Such are some of the general rules which ought to guide the physician in his examination of an infant; many others will no doubt occur to the medical man in the prosecution of his investigations; but these and the hundred and one little practical aids to diagnosis in early life can only be expected to come with experience.

The characteristics of the physical signs of disease in infants fall to be described in connexion with the anatomy and physiology of the various organs and systems.

CHAPTER II.

THE ANATOMY OF INFANCY.

INTRODUCTION—METHODS OF STUDY—SECTIONAL METHOD—THE REGION OF THE HEAD.

In certain important anatomical characteristics the body of the infant differs from that of the adult, and with these peculiarities it is essential that the pediatric physician make himself acquainted if he would correctly diagnose and rationally treat the diseases of infancy. Were the body of the infant simply the body of the man in miniature, did the organs of the infant differ only in absolute size from those of the adult, then to a great extent the necessity for the special study of the anatomy of the early years of life would be absent; but, as it is, the infant's body is not only a small body, it is also an undeveloped body. Its organs, when compared with those of the full-grown organism, differ in relative size and importance as well as in absolute bulk. Some viscera are relatively large and have special functions in the infant, and some are relatively small and of apparently slight physiological value; therefore it is in the highest degree important that the physician or surgeon who devotes himself to the treatment of the maladies of early life should possess a very clear conception of what these differences in structure and function are. The study of the functional differences constitutes the physiology of infancy, a subject so important as to require separate consideration. The investigation of anatomical peculiarities naturally precedes the inquiry into physiological characters, and forms, therefore, the subject matter of the present section.

The anatomy of infancy, like that of adult life, may be studied systematically or topographically; but the latter method has in this work been adopted, as it facilitates the application of the anatomical details of early life to the principles and practice of the medicine and surgery of the pediatric practitioner. Further, the regional or topographical anatomy of the infant has been investigated by the sectional as well as by the dissectional method; in other words, the

study of frozen sections of the body, made in various planes, has been added to the ordinary means of simple dissection by the scalpel and forceps. The sectional method, after freezing, has been employed for the following reasons:—First, because it gives a picture of the relations of the parts much more accurate than that which it is possible to obtain by dissection alone; second, because by this method the surface landmarks are not removed; and, third, because in some cases—those, for example, in which there were fluid effusions—no mere dissection could have given an adequate idea of the relations of the organs and structures. Eight infants in all were studied by the sectional method, and in each case numerous vertical sagittal and coronal as well as horizontal sections were made. Many other infants were examined by simple dissection; and even in the case of those of which sections were made after freezing, the dissectional method was also employed to clear up obscure details and to confirm the observations made.

The method of preparing the frozen sections employed essentially agrees with that introduced by Pirogoff, and carried out also by Braune, Luschka, Henle, Hart, Barbour, Symington, and many others; but it differed in some of the details, more especially in those concerned with the accurate reproduction of the appearances seen immediately after the cutting of the sections. The process, which is now generally known and practised in most anatomical schools, need not here be described, and the consideration of the region of the head may be at once proceeded with.

The Region of the Head.

From the point of view of the obstetrician, the most important part of the infant's body is the head. The great importance of this region of the child's body is due, in the first place, to the circumstance that in the great majority of confinements (95 per cent.) the child comes through the maternal passages head first; in the second place, for the reason that the head is the largest and most solid part of the body of the infant; and in the third place, from the fact that any abnormality in the size, form, position, or ossification of the head will immediately introduce the elements of delay and danger into the process of parturition.

It is essential, therefore, that the obstetrician have an intimate acquaintance with the anatomy of this region of the infant's body, but it is not less necessary that the pediatric physician also

have an accurate knowledge of the structural peculiarities of the head of the infant, for in such peculiarities is found the explanation of some of the characters of disease and of many of the rules of hygiene in early life. The form of the infant's head is found to be far from normal in such diseases as rickets and syphilis; and any abnormality in the ossification of the cranial bones, whether that abnormality be in the direction of delay in bone-formation, or in that of prematurity of osseous deposition and union, has a far-reaching effect upon the mental health of the child and upon the normal development of the functions of the cerebrum and cerebellum. It is, therefore, evident that a knowledge of the healthy form and the natural characters of the head in the infant is absolutely essential for the physician who devotes himself to the treatment of the diseases of infancy. A correct conception of the normal makes possible the diagnosis of the abnormal, and opens up the way for rational treatment of disease.

The head consists of two parts, which differ from one another in size and importance. These parts are the cranium and the face. In the infant the cranium is relatively much larger than the face, and this disproportion is due to the small degree of development of the latter region. The relatively small size of the face is very evident when the head is seen in sagittal section (Plates I. and V.).

The cranium is made up of eight bones, two pairs and four single, which are in the infant loosely held together by membrane, and which are capable of a large amount of displacement upon each other. The cranium is clearly divided into two parts—the vault and the base. The vault is constituted by the two halves of the frontal bone, by the two parietal bones, and by that portion of the occipital bone which lies above the foramen magnum; at the sides also the squamous part of each temporal bone completes the framework of this part of the head. The base of the cranium is composed of the basi-occiput, the sphenoid, the ethmoid, and the petrous part of the temporal bones. The bones which make up the vault differ from those that form the base, in being thinner and more loosely joined together; thus when pressure is brought to bear upon the vault the bones are displaced, and a change in the form of the head is the result; on the other hand, pressure does not affect to any appreciable degree the base of the cranium.

The bones of the cranium are joined together by sutures; and

those which are of most importance are the sagittal, the frontal, the coronal, and the lambdoidal.

The presence of fontanelles, or "openings in the head," is one of the most important characters of the infant's cranium. These membranous spaces are six in number, two being placed in the middle line of the vault, and four being situated laterally. Their general characters are well known, but it is not so generally recognised that their size varies considerably even in normal heads. I have measured the anterior fontanelle in a large number of cases, and have found its average length at birth to be 2·7 ctms., and its average transverse diameter to be 2 ctms. In one case, where the ossification of the head was well advanced, both the antero-posterior diameter and the transverse measured 1·5 ctms.; whilst in a case where the bones of the head were widely separated, without there being any hydrocephalus, the anterior fontanelle measured 3 ctms. both antero-posteriorly and transversely. The variation in size of the anterior fontanelle must influence, to a very considerable extent, the degree of head-moulding. With regard to the posterior or occipital fontanelle, it should be noted that if the ossification of the head be at all far advanced, there is at this spot no distinct membranous space, the tip of the supra-occiput fitting in between the parietal bones. In many cases, however, there exists a space which is then triangular in shape, and is always much smaller than the anterior fontanelle. I have found the average antero-posterior measurement of the fontanelle to be 8 mms., whilst the base of the triangular space had a length of from 7 mms. to 1 ctm. In one or two cases I have seen the space entirely filled up by a Wormian bone of triangular form.

In connexion with the sutures and fontanelles of the infant's head, may be considered the fibro-cartilaginous hinge of the occiput. Budin, in his work upon the head of the infant (*De la tête du fœtus au point de vue de l'obstétrique*, 1876), lays special stress upon the existence of this hinge ("charnière cartilagineuse et fibreuse"), and points out its great importance as a factor in head moulding. It is formed by a band of tissue partly cartilaginous, partly fibrous, which extends from the posterior end of the foramen magnum outwards on each side to the postero-lateral fontanelle. This cartilaginous hinge, it may be pointed out, has an interest also when looked at from the developmental standpoint, for it marks posteriorly the line which separates the bones of the cranial

vault from those of the base. The bones of the vault are developed from the membranous capsule surrounding the encephalon, which in its turn is derived from the second ring of the protovertebral mass; whilst the bones of the base are developed from the first ring of this protovertebral mass, and pass through an intermediate cartilaginous stage before becoming ossified. The supra-occiput is thus divided developmentally from the basilar and ex-occipital portions of the bone. It is possible, also, that pressure upon the occiput after birth may cause a certain degree of displacement which may be an etiological factor in the development of certain nervous conditions sometimes met with in new-born infants, and of which tetanus neonatorum and infantile convulsions are examples. Marion Sims has founded upon this hypothesis his postural treatment of trismus.

The form of the head of the infant may now be considered. The normal size and form of the head before the commencement of labour is not yet clearly ascertained. This is due to the fact that from the passage of the head through the pelvis changes occur in its form, and these changes have not yet been fully worked out; hence, until the details of the measurements of heads of infants which have been removed by the Cæsarean section have been noted in a large number of cases, the exact form of the infant's head immediately before labour sets in cannot be definitely stated. Further, needless confusion and difficulty have been introduced into the study of this subject from the fact that different observers have taken different points on the head as their landmarks in measuring the various diameters. This difficulty may now be overcome by the universal adoption by obstetric writers of the definitions of the various diameters laid down at the Washington Congress in 1887. There are three antero-posterior diameters:—

(*a.*) From the tip of the occipital bone to the lower margin of the chin = diameter occipito-mentalis, O.M.

(*b.*) From the occipital protuberance to the root of the nose = diameter occipito-frontalis, O.F.

(*c.*) From the point of union of the neck and the occiput to the centre of the anterior fontanelle = diameter sub-occipital bregmatica, s.O.B.

The definitions of the occipito-mental and occipito-frontal diameters given above agree with those found in the majority of

text-books; but with regard to the sub-occipito-bregmatic diameter, some writers have placed its anterior starting-point at the posterior end of the bregma, others at the anterior end of the bregma, and still others at its centre. The definition as given by these last authors is, as will be seen, the one adopted by the Congress. In addition to the three diameters above mentioned, Budin describes a fourth antero-posterior diameter, which he terms the supra-occipito-mental or maximum diameter. According to this observer the occipito-mental diameter, although generally supposed to be the longest, is not really so, and this observation is perfectly correct if the definition of the occipito-mental as given by the Congress is accepted. Budin states that the maximum antero-posterior diameter is one which extends from the chin to the sagittal suture, terminating at a point in the suture which lies between the tip of the occiput and the anterior fontanelle, and which varies in different cases. This observation I have confirmed in many instances. Thus, in one case, the O.M. measured 10·5 ctms., whilst the maximum measured 11 ctms.; and in this instance the starting-point of the maximum diameter posteriorly lay nearly midway between the posterior fontanelle and the posterior end of the anterior fontanelle. In another case the O.M. measured 12·5 ctms., and the maximum measured 14·5 ctms.; whilst even in the normal or antepartum head the maximum diameter exceeds the occipito-mental by from 5 mms. to 1 ctm. The maximum diameter of Budin, which it may be noted corresponds to the occipito-mental as defined by Schroeder, is important as being the longest diameter of the head, and the only diameter which is always increased during the progress of the head through the pelvis in normal labour.

With regard to the transverse diameters of the head, comparatively little confusion exists. Two are usually defined:—

(*a.*) Between the two parietal protuberances = diameter bi-parietalis, Bi-P.

(*b.*) Between the two lower extremities of the coronal suture = diameter bi-temporalis, Bi-T.

A bi-mastoid diameter is sometimes measured.

The vertical diameters of the head are somewhat vaguely defined; thus the fronto-mental passes from the highest point of the forehead to the chin, and the cervico- or laryngo-bregmatic passes from the middle of the anterior fontanelle to the upper and anterior part of the neck in the neighbourhood of the larynx.

In relation to each antero-posterior diameter of the head there is a circumference, and the one corresponding to the maximum diameter is the greatest, whilst that corresponding to the sub-occipito-bregmatic diameter is the minimum circumference.

Form of the Head before Birth: The Normal Head.—It is impossible that such terms as ovoid, wedge-shaped, and the like, can convey an adequate idea of the form of the head, and it is necessary that the form be expressed in the terms of the three measurements represented by the antero-posterior, transverse, and vertical diameters.

In a case reported by Budin, the mother died of pulmonary hæmorrhage, and the child was removed by Cæsarean section. Labour had not commenced. The following were the measurements of the head of the infant:—Maximum = 12·9 ctms.; O.M. = 12·4 ctms.; O.F. = 11·8 ctms.; s.O.B. = 10·3 ctms.; Bi-P. = 10 ctms.; Bi-T. = 8·7 ctms. The maximum circumference was 37·6 ctms., and the minimum 33·5 ctms. The total length of the child was 51 ctms. I have not had the opportunity of measuring the head of a full-time child removed by Cæsarean section; but in a case where the mother died of pneumonia between the seventh and eighth months of her pregnancy, I was able to measure the infant's head. Labour had not commenced in this case, and the measurements were:—Maximum = 10·5 ctms.; O.M. = 10 ctms.; O.F = 8·9 ctms.; s.O.B = 7·5 ctms.; Bi-P. = 5·9 ctms.; Bi-T. = 5·1 ctms. The total length of the child was 30 ctms. In one of Freeland Barbour's cases, where frozen sections were made of the pregnant woman, the measurements of the head in utero were:—O.M. = 12·7 ctms.; O F. = 10·4 ctms.; s.O.B. = 10·8 ctms. In this case the patient died before labour set in, but the head of the child was in the pelvic cavity. In addition to these three cases where measurements were made of the head unmoulded by labour, there may be mentioned one out of many cases in which the head was measured six days after the confinement. The measurements in this case were as follows:—Maximum = 13 ctms.; O.M. = 12·5 ctms.; O.F. = 11·3 ctms.; s.O.B. = 10 ctms.; Bi-P. = 9·7 ctms.; Bi-T. = 8·3 ctms. The circumference in the O.M. plane was 35·5 ctms., and in the s.O.B. plane 29·2 ctms. The total length of the child was 48·1 ctms. In one case in which labour was precipitate the measurements of the head very closely resembled those given above. From a study of the figures thus obtained, an idea of the normal

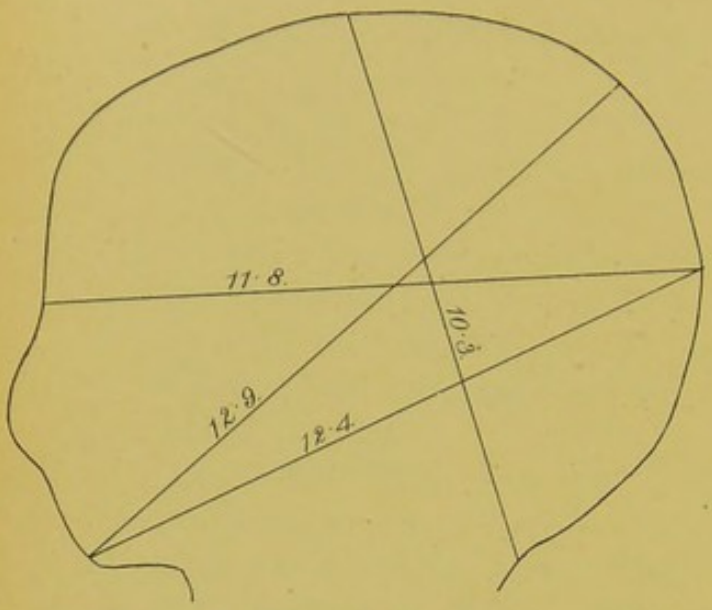


Fig 1.

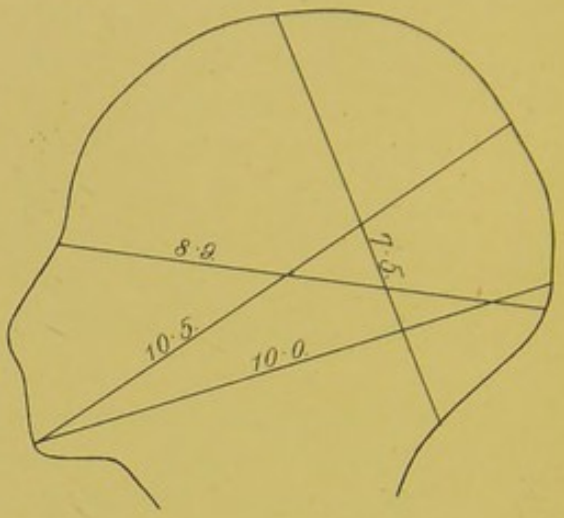


Fig. 2.

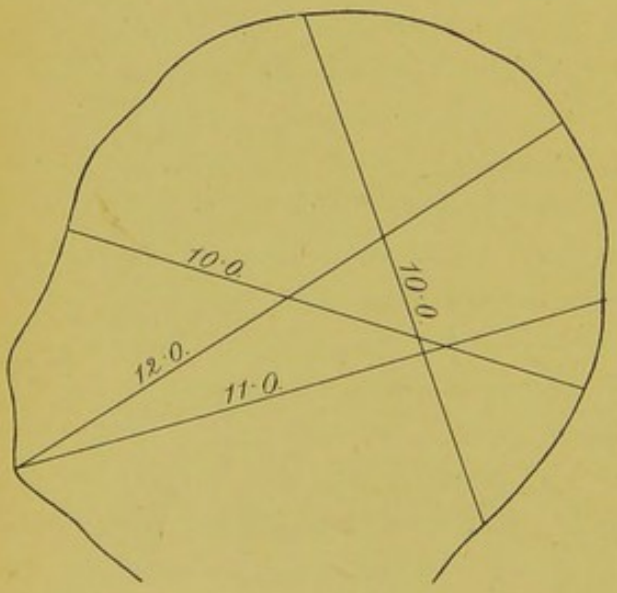


Fig. 3.

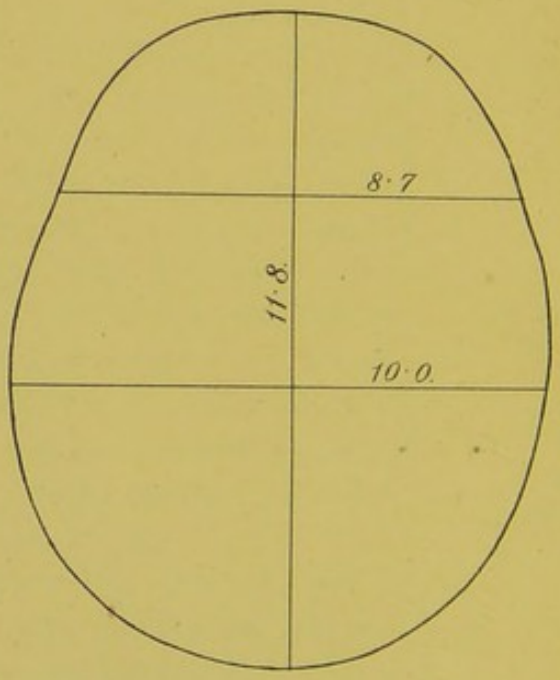


Fig 4.

Wm CATHIE, LITH.

PLATE II.

Outline Sketches of the Head, showing the various Diameters.

FIG. 1.—Sagittal Section of "normal Head" (after Budin), half natural size.

FIG. 2.—Sagittal Section of normal Head of $7\frac{1}{2}$ months' fœtus, half natural size.

FIG. 3.—Sagittal Section of Head immediately after normal easy labour, half natural size.

FIG. 4.—Normal Head as seen from above (after Budin), half natural size.

form and size of the head before the onset of labour may be obtained. The measurements may be placed in tabular form for the sake of comparison:—

	Budin's Case, full-time Infant, Cæsarean Section.	Barbour's Case, full-time Infant, in Frozen Section.	Ballantyne's Case, 7½ months' Infant, removed post-mortem.	Ballantyne's Case, 6 days old Infant.
Max.	12·9 ctms.		10·5 ctms.	13·0 ctms.
O.M.	12·4 ,,	12·7 ctms.	10·0 ,,	12·5 ,,
O.F.	11·8 ,,	10·4 ,,	8·9 ,,	11·5 ,,
s.O.B.	10·3 ,,	10·8 ,,	7·5 ,,	10·3 ,,
Bi-P.	10·0 ,,		5·9 ,,	9·7 ,,
Bi-T.	8·7 ,,		5·1 ,,	8·3 ,,

A glance at the accompanying drawings (Plate II. Figs. 1 and 2, Plate III. Fig. 3) will give an idea of how closely the head in Budin's case resembles the heads in my two cases, both as regards form and as regards relative length of the diameters. The maximum diameter in Budin's case was 5 mms. longer than the O.M., 1·1 ctms. longer than the O.F., and 2·6 ctms. longer than the s.O.B.; in the case of the seven and a half months' fœtus, whose head I measured, the maximum exceeded the O.M. by 5 mms., the O.F. by 1·6 ctms., and the s.O.B. by 3 ctms.; and in the case of the full-time infant, six days old, the maximum exceeded the O.M. by 5 mms., the O.F. by 1·7 ctms., and the s.O.B. by 3 ctms. In regard to the transverse diameters, the Bi-P., in Budin's case (Plate II. Fig. 4), exceeded the Bi-T. by 1·3 ctms.; in the seven and a half months' infant the Bi-P. measured 8 mms. more than the Bi-T.; whilst in the six days old infant the Bi-P. measured 1·4 ctms. more than the Bi-T. In the case of the seven and a half months' infant, it will be observed that both the absolute and relative lengths of the two transverse diameters differ considerably from those seen in the full-time child; but this difference is to be accounted for by the relatively small development of the head of the fœtus in a transverse direction, along with the small size of the parietal eminences. From Budin's researches and those of Labat (*La tête du fœtus au point du vue obstétrical*, Labat, 1881), it is probable that, in the normal unmoulded head, the bi-parietal diameter is a little more than 1 ctm. greater than the bi-temporal diameter. Whilst we may regard the head, in the three cases given above, as showing the normal unmoulded form, we may also provisionally state that

the diameters of the normal head of an infant of from 48 to 51 ctms. (19 to 20 inches) in length are as follows:—

Maximum,	13 ctms.	$5\frac{1}{8}$ inches.	
Occipito-Mental,	12·5 ,,	$4\frac{7}{8}$,,	(nearly 5 inches).
Occipito-Frontal,	11·5 ,,	$4\frac{1}{2}$,,	
Sub-Occipito-Bregmatic,	10·3 ,,	$4\frac{1}{16}$,,	(about 4 inches).
Bi-Parietal,	10·0 ,,	$3\frac{15}{16}$,,	(about 4 inches).
Bi-Temporal,	8·7 ,,	$3\frac{7}{16}$,,	(about $3\frac{1}{2}$ inches).

In Barbour's case it is to be noted that whilst the occipito-mental agrees closely with that diameter in the other cases, the occipito-frontal is less and the sub-occipito-bregmatic greater.

Form of the Head during Labour: The Moulding Head.—It is well known that the head becomes moulded during its passage through the pelvis. This moulding is, in the first place, due to the fact that the expulsive powers are propelling the head through canals or passages which offer considerable resistance even in normal cases. But it is also due to certain inherent characteristics of the head: for there exist in the head certain sutures and fontanelles which permit the bones to glide one upon the other; there is incomplete ossification of the bones themselves; and there is the presence of the cartilaginous hinge of the occiput. Our ideas of the form of the head and of the length of its diameters during labour have hitherto been derived from an examination of the head immediately after labour, and from clinical examination by touch during the progress. From these two methods, which are neither of them free from fallacy (for the immediate elastic recoil of the head after its expulsion from the canals must be considerable, and the obstetrician's conclusions derived from the sense of touch may not be accurate)—from these two methods it has been affirmed, that during labour the frontal bone is somewhat depressed under the margins of the parietal bones, the tip of the occiput is also depressed below the parietals, and the parietal bone, which lies anteriorly in the pelvis, slightly overrides that which lies next the sacrum. In a recent contribution (*Reports of Laboratory of Royal College of Physicians, Edinburgh*, vol. ii.) Barbour and Webster give a drawing of a very interesting frozen section of a woman who died at the end of the second stage of labour, and in this section the vertical

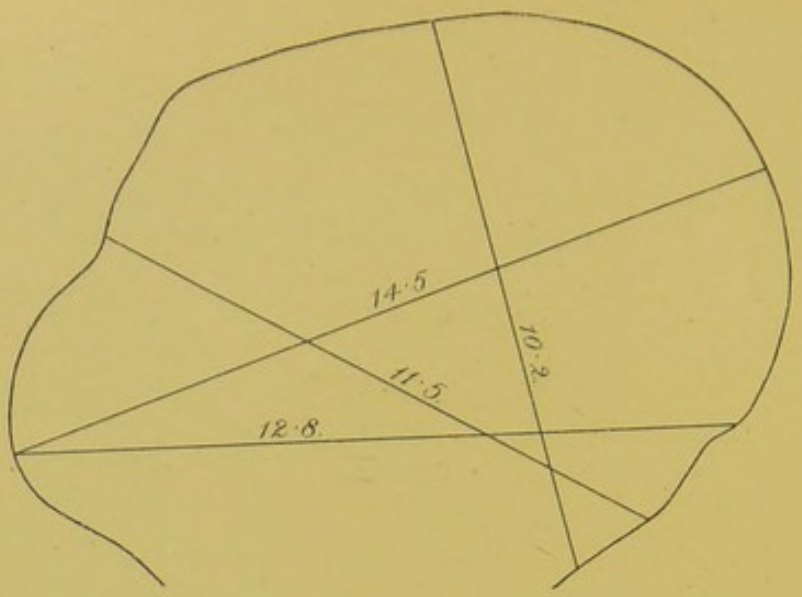


Fig. 1.

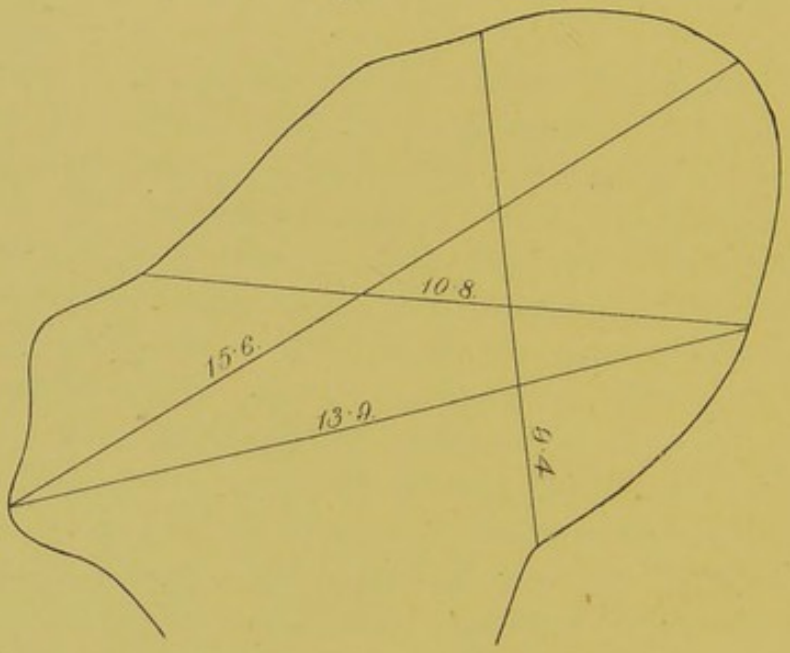


Fig. 2.

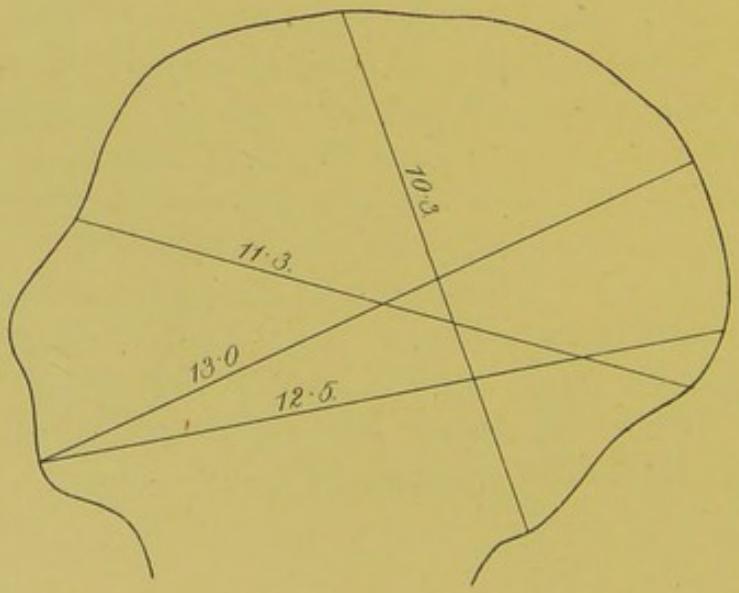


Fig 3.

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PLATE III.

Outline Sketches of Head of Infant, showing the modifications in form produced by Labour, etc.

FIG. 1.—Sagittal Section of Head immediately after labour (O.D.P. position).

FIG. 2.—Sagittal Section of Head immediately after labour (O.D.P. position, after Budin), half natural size.

FIG. 3.—Sagittal Section of Head of Infant 6 days old, half natural size.

elongation and lateral deformity of the moulding head are well displayed.

The measurements of the head in this case were as follows:—

Maximum,	16	ctms.	6	inches	(approx.)
Occipito-Mental,	13	,,	5	,,	,,
Occipito-Frontal,	10	,,	4	,,	,,
Sub-Occipito-Bregmatic,	10·8	,,	4¼	,,	,,
Bi-Parietal,	8·8	,,	3½	,,	,,
Bi-Temporal,	8·7	,,	3½	,,	,,

Form of the Head immediately after Labour.—Countless observations have been made upon the form and diameters of the infant's head immediately after labour. The moulding which has occurred during labour is present, but, no doubt, in a less marked degree, after parturition is completed. If the diameters be compared with those of the normal unmoulded head, it is seen that the O.M., the O.F., and the s.O.B. are diminished, whilst the maximum diameter is increased. In one of Budin's cases in which the head lay in the O.L.A. position, the measurements were:—Max. = 13·9 ctms.; O.M. = 11·8 ctms.; O.F. = 11 ctms.; and the s.O.B. = 8·6 ctms. The average measurements which I have found so closely agree with those as to be practically identical. There is, therefore, a compression of the head in the sub-occipito-bregmatic plane, and a compensatory enlargement in the plane of the maximum diameter. In addition, there is present in many cases what is known as the parietal deformity. This transverse deformity has been specially studied by Fankhauser (*Die Schadelform nach Hinterhauptslage*, Bern, 1872), Labat, and others. The parietal bone which lies posteriorly *quâ* the pelvis, the left parietal therefore in O.L.A. cases, is depressed at the sagittal suture below the contiguous margin of its fellow. In other words, the bone which lies anteriorly is at a lower level *quâ* the pelvis than that which is in relation with the posterior wall of the pelvis. Further, the parietal eminence, which lies anteriorly, is carried backwards *quâ* the head, and the whole of this side of the head is flattened. Barbour's specimen, to which reference has already been made, shows that this parietal deformity is produced during labour, and that it may be unaccompanied by any overlapping of the parietal bones. The cause of its production is probably to be found in the existence of a triangular deficiency in the anterior pelvic wall, and in the presence of firm resisting structures posteriorly.

In occipito-dextra-posterior cases the moulding of the head and consequent change in form is more marked than in occipito-læva anterior cases, and this is more especially the case in the labours where the head has not rotated well. In one case in which I made frozen sections of the infant, the peculiar moulding of the head is well seen (Plate III. Fig. 1). The tip of the occiput is depressed below the margins of the parietal bones at the posterior fontanelle, and there is also great parietal distortion, for the right parietal bone, which lay posteriorly *quâ* the pelvis, is depressed below that which lay anteriorly, and the sagittal suture is displaced to the left of the middle line of the infant's body. In one of Budin's cases the head lay in the O.D.P. position, and the following were the head measurements as compared with those in my own case :—

	Budin's Case.	My Own.
Maximum,	15·6 ctms.	14·5 ctms.
O.M. diameter,	13·9 ,,	12·8 ,,
O.F. ,,	10·8 ,,	11·5 ,,
s.O.B. ,,	9·4 ,,	10·2 ,,

The figures show that in Budin's case the elongation of the maximum diameter and the shortening of the O.F. and s.O.B. diameters have been greater than in my case, and this fact is also shown in the drawings (Plate III. Figs. 1 and 2).

Form of the Head a few Days after Labour.—From elaborate statistics, Budin shows that during the days that follow birth, all the diameters of the head increase with the exception of the maximum diameter, which diminishes in length. After the first week of life, however, the maximum diameter also begins to increase in length. The increase in the diameters is due to the enlargement of the sutures and fontanelles, which in turn is due to the fact that the bones of the cranial vault no longer over-ride one another, but lie in the same plane. In a typical case (Plate III. Fig. 3) I found the head diameters at birth and six days afterwards to be as follows :—

	At Birth.	Six Days after Birth.
Maximum,	13·5 ctms.	13·0 ctms.
O.M.	12·3 ,,	12·5 ,,
O.F.	10·4 ,,	11·3 ,,
s.O.B.	8·3 ,,	10·3 ,,
Bi-P.	8·0 ,,	9·7 ,,
Bi-T.	7·0 ,,	8·3 ,,

From the above table it will be seen that there is six days after birth a great increase, varying from 1 ctm. to nearly 2 ctms., in the length of the occipito-frontal, sub-occipito-bregmatic, bi-parietal, and bi-temporal diameters. The occipito-mental shows a trifling increase, whilst the maximum shows a decrease of 5 mms. There is, therefore, six days after labour, a return to the conditions of the head which existed before labour began, with the exception that the sub-occipito-bregmatic diameter does not quite regain its former length.

Proportionate Size of Vault and Base of Cranium.—In a recent memoir ("Form of the Human Skull," Cleland, *Memoirs and Memoranda of Anatomy*, vol. i. pp. 13–26, 1889) Cleland makes the following statement:—"The arch elongates more rapidly than the base in fœtal life, until at birth, or soon afterwards, the arch, as measured from the root of the nose round to the back of the foramen magnum, has reached its highest proportionate length, as compared with a straight line uniting the same points, namely,—a proportion slightly exceeding 3 to 1." I have measured the cranial vault and base in a number of full-time children, and have obtained the following results:—

		Vault.	Base.
Case	I.	22·2 ctms.	8·0 ctms.
,,	II.	23·0 ,,	8·0 ,,
,,	III.	24·5 ,,	7·5 ,,
,,	IV.	26·0 ,,	8·5 ,,
,,	V.	21·0 ,,	7·5 ,,
,,	VI.	23·0 ,,	8·4 ,,
,,	VII.	19·0 ,,	6·0 ,,
,,	VIII.	23·0 ,,	7·5 ,,
,,	IX.	20·5 ,,	6·8 ,,
,,	X.	21·0 ,,	8·0 ,,

These measurements were made upon full-time children with no obvious deformity of the cranium, and the result is that the vault was on an average nearly three times the length of the base. The exact proportion was 2·93 times, or 223·2 ctms., to 76·2 ctms., in the ten cases. I also measured the vault and base in fœtal skulls, in cases where labour had expelled the fœtus before the seventh month, with the following results:—

		Vault.	Base.
Case	I.	17·0 ctms.	5·5 ctms.
,,	II.	17·5 ,,	5·7 ,,
,,	III.	9·5 ,,	3·0 ,,

The vault in these cases was therefore almost exactly three times the length of the base, for on taking the average the relation is seen to be as 3·09 to 1 (vaults 44·0 ctms., bases 14·2 ctms.). In two older children I ascertained the relation of vault to base; thus, in the case of a child of six the vault measured 34 ctms. and the base 12 ctms., whilst in a child of thirteen years of age the proportion was 38 ctms. to 13 ctms. In these cases the vault was 2·88 times longer than the base. In the adult, Cleland finds that in Scotch skulls the proportion is as 2·72 to 1. It will be seen that with regard to the measurement of the arch and its relation to that of the base at birth, the figures in my cases do not quite give the relative proportion of a little over 3 to 1 which Cleland finds to be the rule. The probability is that Cleland measured heads of children a few days old, in which the compressing effects of labour had passed off, whilst I measured the skulls of still-born children at the time when the bones were overlapping. Cleland, in the case of five skulls of new-born children, finds the proportion of arch to base to be 3·06 to 1; my measurements made upon ten skulls gave a proportion of 2 93 to 1. It is not, therefore, altogether certain that the arch bears a greater proportion to the base at the time of birth than at any time either before or after birth; it is most probable that during the last three months of intra-uterine life and the first ten years of extra-uterine, the arch of the cranium bears to the base the proportion of 3 (or nearly 3) to 1. After ten years of age, the proportion sinks to 2·7 or 2·8 to 1.

Changes in the Skull during Infancy.—The frontal suture, if not solidified at birth, becomes obliterated in the first weeks of life; but the date of disappearance of the other sutures is very variable. With regard to the involution of the anterior fontanelle there has been some difference of opinion. Whilst Elsässer and many others have held that there is during the first year, or at any rate the first nine months of life, an increase in size of this fontanelle followed thereafter by a steady diminution, Kassowitz (Pediatric Section of meeting of Naturalists and Physicians at Strasburg, 1885) has found, as the result of 465 measurements, that the involution of this space proceeds gradually and steadily from birth onwards. There is, it is true, an increase in size of the fontanelle during the first days of life; but this is due to the elastic recoil of the parts after the compressing effect of labour has passed away: thereafter it is probable that in normal cases Kassowitz is right

in describing a steady diminution in size. Normally, all the fontanelles have completely closed at or soon after the eighteenth month of life. The air sinuses in the frontal and other bones of the cranium do not become large until about the ninth year of life, and are, indeed, absent in the infant.

It is not possible to lay down invariable rules for the rate of increase in size of the head in infancy; but Liharzik's law of growth is approximately correct. According to this observer, if the normal circumference of the head at birth be 35 ctms., then at the end of one month it will be 37·5 ctms.; at the third month, 40 ctms.; at the sixth, 42·5 ctms.; at the tenth, 45 ctms.; at the fifteenth month, 47·5 ctms.; and at the end of the twenty-first month, 50 ctms. During this period, therefore, the rate of growth has been 2·5 ctms. (1 inch) each arithmetical interval; subsequent to the twenty-first month the rate of increase is much less. It is important to remember that during the first two years of life the head circumference is greater than the chest, that during the third year they are nearly equal, and that thereafter the chest circumference exceeds that of the head.

The different regions of the cranium do not increase at the same rate. The occipital cavity grows very rapidly, the parietal portion increases more slowly, and the frontal portion scarcely at all. At birth the first amounts to 5 per cent., the second to 81·11 per cent., and the third to 13·89 per cent. of the whole capacity of the cranium. The rapid increase of the occipital cavity occurs simultaneously with the rapid growth in size and weight of the cerebellum.

In the preceding pages attention has been more especially directed to the osseous framework of the head; but, as will be seen, the soft structures also present characters which differ somewhat from those found in the adult condition.

The Hairy Scalp.—The skin of the infant is thin and delicate, but in the region of the head it is thicker than elsewhere; furthermore, it is in this position intimately united to the aponeurosis of the occipito-frontalis muscle, and moves with it. At the time of birth there is often found a serous or sero-sanguineous effusion lying beneath the cranial aponeurosis in that region of the cranium which has presented during labour, and this constitutes what has been called a pseudo-cephalhæmatoma. This effusion must be distinguished from the true extra-cranial cephalhæmatoma which sometimes appears, usually a day or two after labour, and which lies

beneath the pericranium, the latter being loosely attached to the skull bones in infancy.

The Membranes of the Brain and the Cranial Sinuses.—In the infant at birth the arrangement and relations of the membranes of the brain do not differ in any marked way from those found in the adult; but there is a peculiarity as regards the relation of the cranial sinuses to the cranial vault which it is of importance to consider. The superior longitudinal venous sinus lies immediately beneath, and is in relation to the frontal suture, the anterior fontanelle, and the sagittal suture; and, as there is during parturition a varying amount of displacement of the borders of the parietal bones which form the boundaries of the sagittal suture, it follows that a considerable strain is put upon this venous sinus, with the result that occasionally rupture of the walls of the bloodvessel occurs, followed by extravasation of blood into the membranes. In two of the still-born full-time infants extravasations of blood, in one case into the falx cerebri, in the other into both the falx cerebri and tentorium cerebelli, were found (*v.* Plate I.); and I believe that this form of intra-cranial cephalhæmatoma is not nearly so rare as an examination of the literature of the subject would lead us to believe. M'Kee, in a paper on "Intra-cranial Cephalhæmatomata" (*Medical Record*, 26th September 1885), lays special stress upon the great rarity of this variety as compared with the extra-cranial; but it is probable that the rarity is more apparent than real, for whilst all cases of the external blood extravasations are easy to diagnose during life, the intra-cranial effusions give rise to symptoms which may be, and no doubt often are, ascribed to other conditions; and, further, post-mortem examinations of the brain of infants are neither easily obtained nor often carried out. Charpentier also (*Traité des Accouchements*, tom. i. p. 294) comments on the rarity of these cases, and points out their frequent association with placental disease, especially hæmorrhagic, and with the coiling of the umbilical cord round the child. In both the cases in which I found intra-cranial meningeal hæmorrhage in the new-born there was placental disease; and in one case, at any rate, the head was subjected to great and continued pressure, for the position was a persistent right occipito-posterior, and forceps were ultimately used to deliver the child. There was also coiling of the cord round the neck of the infant. In both cases the hæmorrhage was meningeal, and could be traced from the tentorium cerebelli

to the falx cerebri, and from the falx to the superior longitudinal sinus. In one of the cases there was also a large extra-cranial cephalhæmatoma of the sub-aponeurotic variety; but in the other case there was no blood extravasation outside the cranium, although there was an unusually large caput succedaneum. All authorities are agreed that the cerebral form of hæmorrhage is extremely rare in the new-born, and I have seen no example of it. In early life the meningeal form of hæmorrhage is more common than the cerebral, whilst in old age the cerebral variety is much more often met with than the meningeal; and these differences are due to the absence of disease of the arteries in early life, and to the comparative frequency of atheromatous changes in the senile vascular system. It is very probable that many cases of meningeal hæmorrhage in the new-born, beyond causing some difficulty in the resuscitation of the infants affected, and some transient paralytic or convulsive symptoms which are often unobserved, result in complete recovery. It is stated that there is a relatively greater amount of fluid in the sub-dural space in childhood than in adult life, and also that the sub-arachnoid space is well defined at that time of life.

The Brain.—The brain is not only relatively large at birth, but it also grows very rapidly until the seventh year of life is reached; thereafter its increase is slow. It may be stated generally that in infancy the brain convolutions are less complex and the sulci between them more shallow than in later life. In the new-born infant the brain, on account of its fluid condition, is a difficult organ to study topographically, yet a great deal has been accomplished in late years to clear up the relations of the cerebral fissures and convolutions to the cranial sutures and fontanelles. Various methods of research have been employed in the study of cerebral topography, but none of them has been found quite satisfactory. In the infants examined by the frozen sectional method, I endeavoured, before the sections were quite thawed, to trace the relation of the fissures to the cranial sutures, with the following results:—

The Sylvian Fissure, which, according to most authorities, is in the adult on a level with the spheno-parietal and squamous sutures anteriorly, is in the infant at a higher level *quâ* the cranium. In a child of one year and ten months, Symington found that the Sylvian fissure lay under cover of the parietal bone about half an inch above the level of the squamous suture, and my sections of the infant at

birth fully bear out this observation (Plate IV. Fig. 2). Thus in one case the fissure lay 1·5 ctms. above the suture, and in another case 1·7 ctms. above the level of the squamous suture. It is believed that the change in the relative position of the fissure and the suture to be found in the adult is due both to the ascent of the squamous suture and to the descent of the Sylvian fissure from widening of the base of the brain. It was also noted—and the fact may be of some value in the cranial surgery of the infant—that the fissure lay at a level about 2 ctms. above the helix of the ear. The GREAT TRANSVERSE fissure of the cerebrum, which passes into the descending horn of the lateral ventricles, was seen to be as closely as possible on a level with the squamous suture, and a little above the tip of the ear externally. The GREAT LONGITUDINAL FISSURE of the cerebrum, which contains the falx cerebri, followed, in the infants examined, the middle line of the head with considerable exactness, and lay immediately beneath the frontal and sagittal sutures and the upper branch of the linea cruciata on the inner surface of the occiput. It lay also under the anterior fontanelle in its antero-posterior diameter. Knott found that in the great majority of cases in the adult it had similar relations to the cranial vault ("On the Cerebral Sinuses," J. F. Knott, *Journal of Anatomy and Physiology*, vol. xvi. p. 27). The PARIETO-OCCIPITAL FISSURE was located in several of my specimens. It marked the division between the parietal and the occipital lobe, and corresponded in level with the tip of the occipital bone at the posterior fontanelle, lying rather behind than in front of the lambdoidal suture. According to Broca and Bischoff this is also its position in the adult; but Sir William Turner places it ·7 or ·8 of an inch in front of the lambdoidal suture—a statement with which Professors Ecker and Hare concur. Hamy (*Revue d'Anthropologie*, 1872) agrees with Broca as to its position in the adult, but finds that in the new-born infant it lies a few millimetres in front of the lambdoidal suture. The FISSURE OF ROLANDO, which divides the frontal from the parietal lobe, lies in the adult under cover of the parietal bone and behind the plane of the coronal suture; but in the infant, according to Hamy, the frontal lobes being less developed, it lies relatively further forwards, the upper end of the fissure being behind the coronal suture, whilst the lower end lies under cover of the frontal bone. D. J. Cunningham, in a recent contribution ("Fissure of Rolando," *Journal of Anatomy and Physiology*, vol. xxv. p. 1),

contradicts this statement, and says that in only two cases did the lower end of the fissure of Rolando touch the sutural line. In one of my cases exact measurements were made which showed that the upper end of the Rolandic fissure lay 4·2 ctms. behind the coronal suture, whilst the lower end reached almost to that suture. In this case also the fissure appeared to be less vertical than in the adult. The *calcarine fissure* seen on the internal surface of the cerebral hemisphere which separates the cuneate lobe from the uncinate convolution, and which, with the parieto-occipital fissure, serves to mark off the cuneate lobe, was traced in two of the infants examined, and found to lie about 1·5 ctm. below the parieto-occipital suture and approximately opposite to the occipital protuberance. No special facts of interest with regard to the remaining lobes, convolutions, and fissures of the brain in infants were brought out in these researches; but in connexion with the vexed question of the degree to which the cerebrum overlaps the cerebellum in the new-born infant, a word or two may be said. D. J. Cunningham (*Topographical Anatomy of the Chimpanzee, Orang, and Gibbon*, 1886) states that the overlapping is not so great in the infant as in the adult condition, and finds that in the case of mesial sagittal sections the cerebrum overlaps the cerebellum to the extent of 9 mms. in the male infant and 7 mms. in the female infant, whilst in the adult male the overlapping is to the extent of 25·5 mms., and in the adult female brain to that of 27 mms. Symington, however, found that in two male infants the projection in the middle line was 20 mms. and 19 mms. respectively, a projection relatively greater than that in the adult. In one of my cases the cerebrum measured 11 ctms. in length, and overlapped the cerebellum to the extent of 20 mms. In a second case the cerebrum was 8·5 ctms. in length, and the projection beyond the cerebellum was 15 mms. These measurements, therefore, support Symington in his conclusion that relatively the cerebrum overlaps the cerebellum at birth as much as or more than in adult life; at the same time we must, as this observer points out, remember the fact that in the infant the cerebellum is relatively small. At birth the cerebellum weighs 6·7 per cent. of the weight of the whole brain. At two months the percentage has increased to 9·1; at ten years to 12 or 13; and in adult life to 12 or 14.

It will be seen from much that has been said, that cerebral topography in the adult, but also more markedly in the infant, is still

very inexact; but with the discovery of more satisfactory methods of rapidly hardening the brain *in situ*, it is certain that the subject will soon be put on a more exact basis, and that the relation of the cerebrum to the bones of the skull will be as well known as those of the heart and lungs to the thoracic parietes.

The Ear.—The ear of the infant at birth presents two peculiarities: one is the very complete development of the internal ear, the tympanic cavity and ossicles, and the mastoid antrum; the other is the rudimentary state of the external auditory meatus, the mastoid portion of the temporal, and the Eustachian tube (Plate IV. Fig. 2). The most important characters which distinguish the infantile from the adult ear are, therefore, to be found in connexion with the last-named parts. The imperfect ossification of the temporal bone, and more especially of its tympanic ring, at the time of birth, explains the condition of the external auditory meatus. In the infant also the skull in the region of the ear is in a transition stage: there is anteriorly the antero-lateral fontanelle, which becomes the region *pterion;* whilst behind the ear is the postero-lateral fontanelle, the future region *asterion.* At and between these two fontanelles is found a medley of small bones and cartilage islands, which have no small importance from the point of view of the pathologist. It is not, however, within the scope of this book to consider the development of the temporal bone, a subject upon which there is as yet no general agreement among embryologists. Suffice it to state, that it is chiefly through the imperfectly developed condition of the tympanic and squamoso-zygomatic portions of the temporal bone at the time of birth that the outstanding characteristics of the infant's ear are produced.

The External Auditory Meatus.—In several of the coronal sections of the head that were made I was fortunate enough to open into the meatus in the greater part of its extent (Plate IV. Fig. 2). The osseous part of the meatus is insignificant in the infant, being represented by the annulus tympanicus. This ring of bone afterwards grows out to form the floor and the anterior, and part of the posterior wall, of the adult meatus. The roof of the osseous meatus is formed by the squamosal element of the temporal bone, which in the infant slopes gradually inwards towards the membrana tympani. In the adult the squamous part of the temporal forms at this point a much sharper angle than it does in the infant. From the annulus tympanicus a fibrous membrane is seen

Fig 1

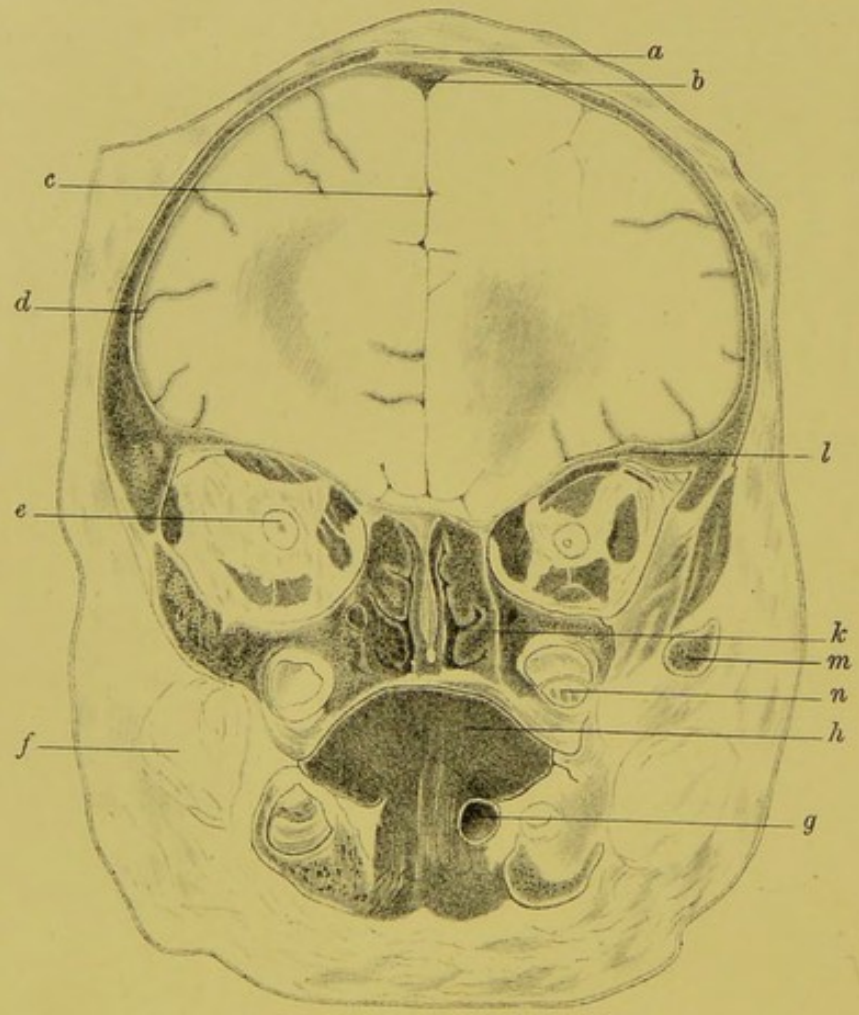

Fig 2

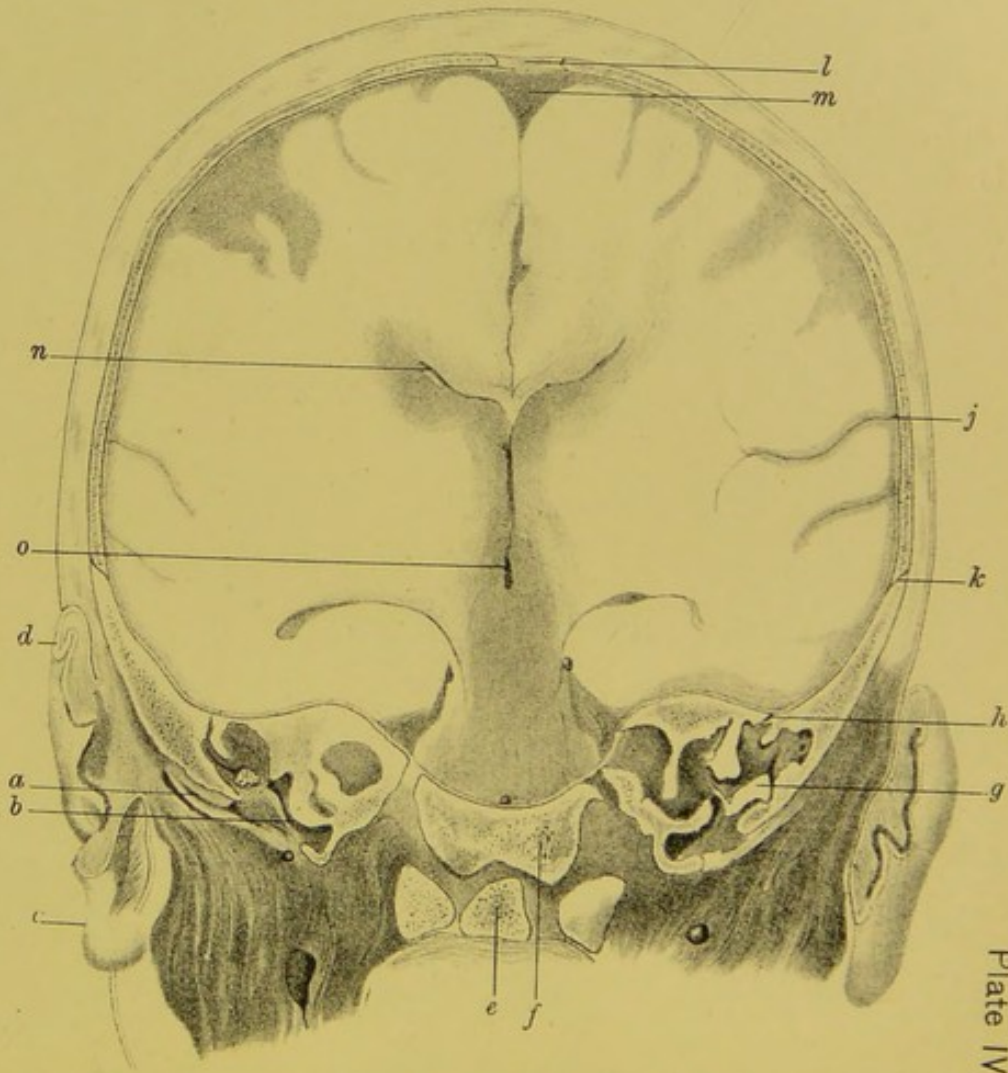

Plate IV.

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PLATE IV.

FIG. 1.—Coronal Section of Head in plane posterior to the eyeballs (viewed from behind), $\frac{5}{6}$ natural size.

a. Frontal Suture.
b. Longitudinal Sinus.
c. Longitudinal Fissure with Falx Cerebri.
d. Beginning of Sylvian Fissure.
e. Left Optic Nerve.
f. Left Sucking-pad.
g. Cystic Tumour below tongue.
h. Tongue cut transversely.
k. Right Nasal Fossa, showing superior, middle, and inferior meatuses.
l. Orbital Plate of Frontal Bone.
m. Zygoma near its root.
n. Tooth Germ in Upper Maxilla.

FIG. 2.—Coronal Section of Head in plane of the middle ear, viewed from behind, right side slightly posterior to left, $\frac{5}{6}$ natural size.

a. External Auditory Meatus (left).
b. Membrana Tympani.
c. Lobule of Left Ear.
d. Helix of Ear.
e. Odontoid Process of Axis Vertebra.
f. Basi-sphenoid.
g. Incus, with stapes in Fenestra Ovalis.
h. Petro-squamous Suture in roof of Tympanic Cavity.
j. Sylvian Fissure.
k. Squamous Suture.
l. Sagittal Suture.
m. Superior Longitudinal Sinus.
n. Lateral Ventricle.
o. Third Cerebral Ventricle.

passing outwards to two or three pieces of cartilage, and the membrane and the cartilages together form the floor of that part of the meatus which is not ossified. It is in this membrane that ossification occurs, leading to the formation of the tympanic plate; and Symington therefore suggests for this membrane the name "membranous or fibrous tympanic plate." The spaces between the cartilages at the outer end of the external auditory meatus are known as the fissures of Santorini. Whilst the floor of the meatus is thus membranous at birth, the roof is osseous, for the pars squamosa turns inwards, as already described, to constitute this part of the canal. It is correct, then, in the infant, as in the adult, to speak of an inner osseous part of the meatus and an outer cartilaginous portion; but in doing so it must be remembered that in the infant the inner part is osseous only in the roof, the floor being nearly entirely membranous, for the tympanic ring forms only a slight projection. It is wrong to state that the external auditory meatus is entirely cartilaginous in the new-born; it is partly osseous, partly membranous, and only to a very small extent cartilaginous. In the adult it is customary to look upon the osseous part of the canal as constituting two-thirds, and the cartilaginous part one-third of the total length of the meatus; but in the child at birth a very different proportion exists, for then the inner third alone is osseous, and that only in the roof, the floor being made up of the fibrous tympanic plate.

Varying statements have been made with regard to the length of the external auditory meatus in the infant. It has been stated to be short and rudimentary, and so it does appear if the skull only be considered; but if the soft parts are in position, the canal is seen to be of considerable length. In two cases (one an infant at birth, the other an infant that died on the sixth day of life) I found that the upper wall of the meatus measured 19 mms. in length, and the floor 21 mms., the difference in length of roof and floor being due to the oblique position of the membrana tympani. Symington comes to the conclusion, from the study of coronal sections of infants and young children, that the external auditory meatus is in the infant and child relatively as long as or longer than in the adult, and the measurements in my cases fully support this statement; in fact, in the two cases above alluded to, they are even greater than those found by Symington in full-time infants.

In infants the external auditory meatus has a general inclination

downwards as it passes in towards the tympanum; but it has, as a rule, no anterior or posterior curve, for coronal sections of the head in this plane usually expose the meatus in its entire extent, although sometimes a small portion of the external ear has to be removed to show the outer end of the meatus. The inner (tympanic) end of the canal is a little larger than the rest of the meatus, and is called its sinus; should a foreign body, therefore, get lodged in this part, its extraction is a matter of considerable difficulty.

The Membrana Tympani forms the boundary between the tympanic cavity and the external auditory meatus. It is directed obliquely in the infant as it is in the adult; but some authors state that it is much more oblique, nearly horizontal, in fact, in the infant. I have been able to convince myself, from the study of several frozen sections, that the membrane is not horizontal, although the fact that the external auditory meatus has a downward trend gives to the tympanic membrane an appearance as if it lay almost transversely. In one case I found that the membrane formed an angle of 12° with the floor of the meatus and of 33° with the horizon. In the adult it is stated to form an angle of 45° with the floor of the meatus.

The Tympanic Cavity.—One of the coronal sections (Plate IV. Fig. 2) showed very clearly the division of the tympanic cavity into two parts, the narrow *atrium* internal to the membrana tympani, and the broader *attic* above the level of that membrane. The cavity was seen also to have an irregularly triangular shape, the base being formed by the roof of the tympanum, and the apex by the narrow floor immediately internal to the tympanic membrane. The tympanic ossicles, malleus, incus, and stapes, were seen dividing the attic into an inner and an outer compartment, and their relations are the same as in the adult middle ear. In all the above-mentioned characters the tympanic cavity in the infant does not differ from that in the adult, but there is one point of difference of some clinical importance which has yet to be noticed, and that is the presence in the roof of the attic of an unossified suture. The roof of the tympanic cavity is formed by an outgrowth from the pars petrosa, which joins the squamosal part of the temporal bone; and at the point of junction there is, in the new-born infant, a suture, the *petro-squamous*, which, as Symington points out, increases the risk of an inflammation in the tympanic cavity spreading to and

involving the membranes of the brain. Clinical evidence shows that this complication of ear disease is very common in the infant, and that therefore the prognosis in otitis media occurring in early life is graver; but at the same time it must be remembered that the thinness of the mastoid portion of the bone will render the operation of trephining comparatively easy at this age and at this spot. If pus form here, and if the diagnosis be made with any degree of certainty, trephining the mastoid is indicated.

The Mastoid Antrum.—The mastoid cells are not developed till after puberty; but, as Symington has shown, there exists in that part of the periotic bone which is named the pars mastoidea a large space, the antrum, which communicates with the tympanic cavity. In all the infants that were examined I found this mastoid antrum, and noted that it had, like the tympanic cavity, a very thin roof, which formed the only separation between it and the cerebral membranes. As the infant grows older, the walls, and especially the roof of the antrum, get thicker, and about the time of puberty become hollowed out into air-cells which communicate with each other and with the cavity of the antrum. No reference is made to the presence of the mastoid antrum in the ear of infants in the ordinary anatomical text-books.

The Eustachian Tube.—The Eustachian tube is short in the infant. In one of my cases it measured 18 mms. in length, and Symington in two nine months' fœtuses found that its length was 17 and 18 mms. respectively. In the adult it measures from 35 to 36 mms., or twice its infantile length. Its direction is different in the infant from what it is in adult life, for in the former it runs almost horizontally. In one case it was traced throughout its whole course, and was found to run backwards with a slight inclination outwards and downwards, forming an angle of about 10° with the horizon. The osseous part of the Eustachian tube can scarcely be said to be present at all in the infant, although in the adult it forms one-third of the tube. The cartilage of the tube is peculiar in form, being deficient inferiorly and externally. The pharyngeal end of the tube is small in infants, and lies in the same plane as the inferior meatus of the nose. Its aperture is peculiar, there being a prominent margin above and internally, which is wanting below and externally; and this peculiarity makes the passage of the Eustachian catheter less difficult than it would otherwise be. At its tympanic end it is difficult to say where

tube ends and tympanic cavity begins, for the roof and walls of the latter gradually approximate to form the tympanic end of the tube.

The Face.—The relatively small size of the face as compared with the cranium in infants is rendered very evident by frozen sections, especially those in the vertical sagittal or transverse planes (Plate I.). In a sagittal mesial section the greatest vertical diameter of the face is less than 5 ctms., whilst the greatest vertical diameter of the cranium is more than 10 ctms., and the difference is even more striking when antero-posterior measurements of the two regions are compared. The face of the infant is nevertheless an important part, for physiognomy is a useful guide to the diagnosis of infantile maladies; and, further, the obstetrician requires to be able to recognise this region of the infant's body when it presents, as it occasionally does, at the os uteri.

The Superior Maxilla.—The relatively small size of the superior maxilla is one cause of the small dimensions of the infant's face. In the child at the time of birth the antrum of Highmore is a small cavity (Plate IV. Fig. 1), and therefore the body of the upper jaw-bone is also small; and further, the alveolar process of the superior maxilla is also in a rudimentary condition, from the imperfect development of the teeth. From an increase in the size of the antrum of Highmore, from an enlargement of the alveolar processes, and from the development of the teeth, the growth of the superior maxillæ and of the corresponding part of the face is brought about. The inferior maxilla also is small at birth, its symphysis not fully ossified, and its angle an obtuse one; but the development of the teeth during childhood brings it to its adult form and size.

The skin of the face is not so loosely attached to the subjacent bones as is that of the scalp, and hence in face presentations a marked caput succedaneum is rarely developed.

The Orbits and their Contents (Plate IV. Fig. 1, and Plate V.). —The orbits and eyeballs do not differ in the infant from the same parts in the adult. In several of the frozen sections made, the relations of the parts within the orbit were very clearly brought out. The eyeball measures a little more in its antero-posterior diameter in the middle line than in either its vertical or transverse diameter, the measurements being about 1·7 ctm. antero-posteriorly, and 1·5 ctm. vertically and horizontally. In one of my cases the pupillary membrane was still present. In a plane immediately posterior to

the eyeball the muscles have the following relations: the levator palpebræ superioris and the superior rectus lie in close apposition to the roof of the orbit, and are related externally to the lachrymal gland; near the inner wall is the internal rectus, and immediately above it is the superior oblique; close to the outer wall is the external rectus, and near to the floor is the inferior rectus, with the inferior oblique lying internal to it. The optic nerve does not lie in the axis of the orbit, but is nearer to its inner than to its outer wall, and its excentric position is more marked as it nears the eyeball; thus in one of my cases it lay 1·1 ctm. from the outer wall and 7 mms. from the inner wall (Plate IV. Fig. 1). As a result of this disposition of the nerve, the external rectus is the muscle which lies furthest from the optic nerve in its course through the orbit. The large amount of fat lying behind the eyeball is well demonstrated in frozen sections of the head.

The Nasal Cavities (Plate IV. Fig. 1).—The nasal cavities in the new-born infant are relatively small, but in childhood they grow quickly as the surrounding bones and air-cells increase in size and the posterior nares broaden out. The superior meatus has an average length of 1·5 ctms., and passes between the superior and inferior turbinated parts of the ethmoid. The middle meatus measures about 1·8 ctms. in antero-posterior extent, and lies between the inferior turbinated part of the ethmoid and the inferior spongy bone. The inferior meatus, which is the longest, measuring about 2 ctms., lies between the inferior spongy bone and the floor of the nasal fossa (Plate I.). In one of the infants examined, the fourth meatus of the nose was present. It is called by Meyer the recessus sphenoethmoidalis, and divides the superior turbinated part of the ethmoid into two portions, to the upper of which the name of concha suprema is given. Into the infundibulum the antrum of Highmore opens by a narrow chink. The septal cartilage of the nose showed in the cases examined no sign of any lateral deviation. The mucous membrane lining the nasal cavities is very vascular, and the specimens I have seen lead me to believe that it is more so in the new-born infant than in the adult. It may be, therefore, that at birth, when the first inspiration of air into the delicate lungs is taken, a special arrangement is made to warm the air passing in. In two of my cases the soft palate was seen to be tilted up at its posterior end towards the nasal fossæ, a circumstance which may have been due to attempts to expel mucus from the respiratory passages.

The Buccal Cavity.—In all the sections of the heads of infants which I have made, the mouth was seen as a potential cavity only, the dorsum linguæ came into contact with the vault of the palate above, and the tongue was in apposition to the inside of the cheeks and gums laterally (Plate I.). In all the specimens, also, the tip of the tongue lay upon the upper surface of the lower gums. It is a fact worthy of note, that even when the mouth is tightly closed the gums do not come into contact. This fact, which is revealed by frozen sections, Symington specially dwells upon as showing that provision exists at birth for a considerable development of the alveolar arches and teeth before the gums of the two jaws can really meet. I have not, however, been able in my cases to show that the distance between the jaws is so great as Symington found it, namely, 6 mms., for in the specimens examined it measured from 2 to 4 mms., and in one case the jaws were in contact. Another peculiarity about the buccal cavity in the new-born infant is the fact that the lower jaw lies in a plane posterior to that of the upper jaw. In a sagittal vertical section of the head, the anterior surface of the lower jaw is seen to lie in the same vertical plane as the posterior surface of the upper jaw. As life advances the jaws come into line with each other, and with the development of the teeth the space between the gums disappears.

If the tip of the tongue be raised in the case of the new-born infant, two folds of the mucous membrane are seen, one of which, the larger and outer, has a dentated margin, and is called the plica fimbriata; the other, which is smaller and is situated nearer to the middle line and the frenum, is known as the plica sublingualis. In one of my cases there was found under the tongue on the right side a congenital ranula which contained a small quantity of clear limpid fluid (Plate IV. Fig. 1).

The Sucking Pads (Plate IV. Fig. 1).—H. Ranke has in a recent paper (Ein Saugpolster in der menschlichen Backe, *Virch. Arch.*, Bd. xcvii. pp. 527–547) drawn special attention to pads of adipose tissue which exist in the cheeks of new-born infants, and which are, as Symington shows, present also in the child. Ranke was led to the study of these bodies by the fact that in a child one year old, in a state of great emaciation from continued diarrhœa, the cheeks presented a swollen appearance. This swelling he found to be due to the presence of a distinctly encapsulated mass of adipose tissue, the so-called sucking pad (Saugpolster). He made sections

of the face, coronal and horizontal, in the new-born infant, and also dissections from the skin surface inwards, and found that these pads were distinct structures which were not continuous with the subcutaneous adipose tissue. In several of my sections the relations of these pads could be seen, and they were always easily differentiated from the surrounding fat by the fact that on putting the sections into spirit the pads changed their colour slightly, and shrank from the adjacent tissues in one case to the extent of being easily removable. Each pad lies in the neighbourhood of the duct of the parotid gland, upon the buccinator, and partly upon the masseter muscle, and has superficial to it the musculus risorius of Santorini. An offshoot from the pad passes into the spheno-palatine and zygomatic fossæ (Plate V.). Each has a vertical diameter of about 2 ctms., a transverse of about 1·5 ctm., and an antero-posterior of a little over 1 ctm. They are found not only in the infant, but also in the child and adult, and are present even when the adipose tissue in other parts of the body is extremely small in amount. They are no doubt connected physiologically with the act of sucking, hence the name of sucking cushion given to them; and probably act by distributing equally the atmospheric pressure, and preventing the drawing inwards of the buccinator muscle between the gums during the efforts of suction when a vacuum is created in the buccal cavity.

The Clinical Examination of the Region of the Head in the Infant.

From an examination of the cranium and face of the infant much valuable information concerning his health may be obtained. It is true that the high hopes entertained concerning the value of cerebral auscultation have not been realized; but, still, the knowledge the medical man can gain from the inspection, the palpation, and to a lesser degree from the percussion of the region of the head, is neither small in amount nor of inferior quality.

Inspection.—The inspection of the cranium will reveal irregularities in form, size, and constitution, and if the medical man keep constantly before his mind's eye a picture of the normal appearances of the head in the infant, he will be able with great accuracy to detect any abnormalities which may be present. The whole cranium may be too large, as in chronic hydrocephalus and in rickets; or it may be too small, as in micro-cephalic idiocy; or, again, there may

be marked asymmetry of the cranium, proceeding from cerebral defects or disease. In the case of the infant at birth, the head may reveal the marks of instrumental interference in labour in the form of wounds, or abrasions, or indentations; or there may be present the tumefaction produced by pressure during parturition, and known as the caput succedaneum. Various congenital malformations may also be present, such as the herniation of the cerebral contents, the meningocele and the encephalocele; or there may be found the fatal defect known as anencephalus. Shortly after birth may be sometimes seen the external cephalhæmatomata or blood tumours of the scalp. Inspection alone may often serve to diagnose between the enlarged head of rickets and that of hydrocephalus, the flattened crown in the former disease giving to the head a somewhat polygonal form, whilst in the latter disease the cranial outline is circular. The prominent or the depressed condition of the anterior fontanelle ought also to be observed.

Inspection of the *cranium* is important, but inspection of the *face* is even more necessary for the diagnosis of infantile maladies. Such marked deformities as hare-lip and abnormalities of the eyes and ears are very evident, and can scarcely be overlooked; but there are also the signs of disease which manifest themselves in the general expression of the face which require to be carefully noted. The healthy infant has a physiognomy which may be described as expressionless, and probably no one save the fond mother will deny the accuracy of the description; but in disease the face becomes altered in many ways. Much may be learnt from the study of the physiognomy—a study too much neglected; but, at the same time, the physician ought not to depend solely upon it in the formation of his diagnosis, but must pay due attention to all the other signs and symptoms which may be present. It was at one time thought that from the facial expression alone it might be possible to discover the system which was the seat of the disease: thus Jadelot described an oculo-zygomatic line or *trait* pointing to disease of the nervous system, a labial line denoting respiratory affections, and a nasal trait found in disease of the digestive organs; but Jadelot's lines, which would render diagnosis easy indeed, are, unfortunately, to some extent fanciful and not to be depended upon. The expression of the face is, nevertheless, an important guide to diagnosis. In acute diseases of the brain or meninges there is often

strabismus, or a half-open condition of the eyes, or convulsive tremors of the facial muscles; in pneumonia the rising and falling of the alæ nasi with each respiration is very characteristic; in infantile diarrhœa the fat rapidly disappears from the face, although the sucking cushions may long remain: the nose becomes pointed, the lips become sharp and thin, the eyeballs sink in their sockets, and the facial muscles contract, giving a peculiar "senile" or "Voltairean" expression to the face; and in many of the eruptive fevers the characteristic rash can be seen on the face. The colour, also, of the face is an important sign: it may be yellow in icterus neonatorum, red in whooping-cough and in pneumonia, intermittently red in meningitis, bluish in cases of cardiac abnormality and in laryngeal affections which interfere with the oxygenation of the blood, and pale in diphtheria.

The presence of strabismus in brain inflammation has been mentioned, but the examination of the eyes also yields good results in other affections. Bouchut emphasizes the importance of a thorough examination of the eye with the ophthalmoscope; he states that through the infant's eyes it is possible to see what is going on in the brain and medulla, and he gives to this method of exploration the name cerebroscopy. The examination of the fundus of the eye may reveal retinal congestion, infiltration, or hæmorrhage, conditions which point to meningitis, cerebritis, or to cerebral tumours. The discovery of the contracted state of the pupil may in some instances serve to clear up the diagnosis in the case of infants to whom narcotics have been given in the form of sleeping draughts or soothing syrups. The ophthalmoscopic examination is not specially difficult to carry out in infants; in fact, it is often much easier than the examination of the mouth, which now falls to be discussed.

Some young children are trained by their parents to open their mouths and show their tongues when required, and for the sake of ease in diagnosis this training is admirable, even although it may lead to ludicrous incidents in the public streets when the physician meets his little patients; but in the case of infants it is often extremely difficult to obtain a good view of the interior of the mouth. The difficulty can, however, usually be overcome by squeezing the cheeks in between the jaws or by pressing upon the chin; but, perhaps, the best method is that recommended by Henoch, in which the under lip is pressed in over the margin of the lower jaw, for by

this means the finger of the physician is saved from a bite, the child naturally not wishing to bite his own lip. The buccal mucous membrane in new-born infants is normally of a dark red colour, and is usually dry, for the amount of saliva secreted during the first two months of life is small. It has also been pointed out that in many new-born infants there are to be seen in the middle line of the palate "little yellowish-white round or oval nodules, from the size of a pin's head to that of a millet seed, projecting only a little from the mucous membrane" (Henoch). These are not to be regarded as of any pathological significance, and are considered by Epstein to be due to the spaces filled with epithelium which have been left after the union of the two halves of the palate. Such appearances are normal; but the mouth of the infant very often presents pathological changes: thus there may be seen the little white blisters or the superficial ulcers of simple stomatitis, the white patches of thrush, or the black appearance of cancrum oris or gangrenous stomatitis. The state of the tongue is less important as an index of disease in infancy than in adult life, for children with serious intestinal disease often present a perfectly normal tongue, whilst healthy infants often show a markedly furred tongue, for copious desquamation of the lingual epithelium may be normally present in infancy. The coloration of the tongue produced by milk or by sweetmeats must be borne in mind. Inspection may also reveal the presence of cleft palate, whilst in other cases it may be possible to confirm or to disprove the existence of the condition known as tongue-tie. The shape of the palate, also, ought to be noted, for it has been proved that in neurotic and in idiotic children the shape of the roof of the mouth differs markedly from the normal (Clouston).

The inspection of the throat is perhaps the most difficult part of diagnosis in infancy, and it ought, as has been already stated, to be left to the last. It ought not to be omitted altogether, for the condition of the tonsils, uvula, or fauces may often give the key to the disease. In order that a good view may be obtained, it is usually necessary to depress the tongue with the tip of the finger or with a spoon handle. A good light from the window or from a taper is necessary; and then, even if the infant cries, a thorough inspection of the back of the mouth may be obtained. The physician is often well rewarded for any trouble he may have had by the discovery of the white patches of diphtheria, of the reddened tonsils of scarlet fever, or of the enlarged and inflamed

tonsils of quinsy. Other forms of sore-throat may also be diagnosed, as may chronic enlargement of the tonsils and uvula, and an obscure case may be entirely cleared up by the discovery of a post-pharyngeal abscess.

Palpation.—Many facts ascertained by the means of inspection may be confirmed by palpation, whilst others will be first discovered by this method of exploration. The palpation of the cranium reveals the condition of the sutures and fontanelles; in the infant at birth there may be, on account of premature ossification, a partial or complete closure of these membranous spaces in the vault; or, on the other hand, both the sutures and fontanelles may, from the existence of chronic hydrocephalus, be unusually wide and open. In rachitic infants there is a retarded closure of the fontanelles, especially the anterior; and a delay in the involution of this fontanelle is, if hydrocephalus can be excluded, pathognomonic of rickets. Palpation is an aid in the detection of the fissures or fractures in the cranial bones which have resulted from instrumental interference during labour, and it enables the medical man more thoroughly to ascertain the nature and relations of any swelling which may be present on the head of the new-born infant. The touch may also reveal a craniotabetic condition of the bones of the vault of the cranium: here and there may be felt thinned, almost parchment-like, areas of bone, and the presence of these areas is a characteristic feature both of congenital rickets and of inherited syphilis (Parrot). When the period of life associated with dentition has arrived, the palpation of the mouth ought not to be omitted; the physician ought to pass his finger rapidly along the alveolar borders of the jaws, in order to ascertain the number of teeth which have appeared, and to note whether or not other teeth are in process of eruption. The examination of the mouth with the finger makes it possible more thoroughly to investigate the condition of cleft palate or of tongue tie when these abnormalities are present, and it may reveal in some cases the presence of a ranula or cystic swelling in the floor of the buccal cavity. Further, in cases of threatened suffocation, the medical man ought never to neglect the passage of the finger into the pharynx, for he may there find the cause of the mischief, although in many instances the foreign body will have already made its way into the larynx or œsophagus.

Percussion.—The percussion of the skull is a diagnostic method which has never been widely employed; but the researches of Betz

many years ago, and of MacEwen in later times, are suggestive, and would seem to show that the sounds elicited by percussion may yet yield important information in the detection of abnormal intra-cranial conditions. Whilst the value of percussion sounds is still *sub judice*, there can be no doubt that the presence of areas of tenderness in the cranial vault can by the percussion method be ascertained, and their locality marked out; but there are fallacies arising from inequality in the strength of the stroke and from irritability of the infant, which must be constantly borne in mind in estimating the value of such observations. If it be possible to exclude all such fallacies, then localized tenderness of the skull points to some superficial cerebral or meningeal disease.

Auscultation.—Auscultation of the cranium either directly by the ear of the physician or by means of the stethoscope is, like percussion, a diagnostic method which has not as yet yielded very satisfactory results. It must always be remembered that the sounds due to respiration can be clearly heard by auscultation over the anterior fontanelle, and it is, in the present state of our knowledge, impossible to estimate with any degree of accuracy the value of the other murmurs or bruits which may be present in disease.

Mensuration.—The measurement of the various cranial diameters and circumferences, by means of callipers and the tape measure, is a means of diagnosis never to be omitted when there exists any suspicion of irregularity in head-growth or form.

CHAPTER III.

THE ANATOMY OF INFANCY—Continued.

ANATOMY OF THE SPINE AND OF THE REGION OF THE NECK—CLINICAL EXAMINATION OF THE SPINE AND NECK.

In many anatomical characters the spine of the infant differs from that of the adult. In its method of articulation to the head, in the relative length of its regions, in its curves, and in the degree of ossification of its component parts, are to be found peculiarities which are all worthy of study. The topographical anatomy of the region of the neck also must be familiar to the surgeon who contemplates tracheotomy, intubation, or other operative interference in diseases of the larynx and neighbouring parts.

The Articulation of the Head and Vertebral Column.—In the case of the infant at birth the head has a large range of movement. It can be completely flexed upon the chest or it can be fully extended, and the ease with which one position can be converted into another is well known to every one who has had occasion to use Schultze's method of artificial respiration, or who has handled in any way a young infant. These movements, however, do not occur at the occipito-atlantoid articulation, but in the joints between the cervical vertebræ; at any rate, it may be definitely stated that the occiput moves only to a slight extent upon the atlas vertebra, the principal movements occurring at the cervical articulations. If an examination be made of the articulation between the condyles of the occiput and the articular facets on the lateral masses of the atlas, the reason of the small degree of mobility seen at this joint in the infant is made manifest. The condyles of the occiput are nearly flat at birth, and there is hardly any trace of that convexity (antero-posterior and lateral) which exists in later life (Plate V.). The articular surfaces upon the atlas also are flatter than in the older child, and the degree of movement between them and the facets on the occiput must necessarily be limited. The occipital

condyles measure from 1 to 1·3 ctms. in length, and from ·5 to ·6 ctms. in breadth, and lie chiefly upon the ex-occipitals, only a small part anteriorly belonging to the basi-occipital part of the bone. In later life the condyles become more curved, and are consequently better adapted for extensive movement. Cleland (*Anatomical Memoranda*, vol. i. p. 18) describes specially two changes in the form of the occipital condyles which occur after birth,—the one is the curving of the articular surfaces; and the other is the growth of a wedge of bone in front of each condyle, which serves the purpose of preserving the balance of the head whilst the face and fore part of the brain are increasing in a relatively greater degree than the cranium and posterior part of the brain. The movements between the cervical vertebræ, which are extensive at birth, become restricted as infancy advances; and this restriction is in a large degree due to the fact that the muscles of the neck become stronger, and are more under the influence of the will.

Rotation of the head occurs at the atlanto-axial articulation, and it has been stated that since this joint permits only of rotation through a quarter of a circle, any further twisting of the head of the infant must be dangerous. It has, however, been said by Tarnier—and his statements are supported by Ribemont's sections—that the head can be rotated through half a circle without causing any damage to the spinal cord or vertebral column. No doubt the explanation of the safety of such a degree of rotation is to be found in the fact, that a great part of the movement occurs at the other cervical articulations.

The fact that the head is articulated to the spine at a point nearer to its posterior than to its anterior end has been adduced as the anatomical datum for the so-called Lever Theory of head flexion in labour.

Relative Size of the Regions of the Vertebral Column.

Aeby, in his paper on the "Age-Differences in the Human Spine," * states that the cervical and lumbar regions of the spine are practically equal in length in the infant at birth. In the adult the proportion between these two regions of the spine is as 2 to 3, the lumbar being half as long again as the cervical. Cunningham comes to similar conclusions; and Symington, from frozen sections

* "Die Altersverschiedenheiten der menschlichen Wirbelsäule," Aeby, *Arch. f. Anatomie und Entwickelungs-geschichte*, 1879, pp. 78–138.

(four) of new-born infants, finds that the cervical part of the spine is very nearly equal in length to the lumbar. Aeby founds his conclusions upon an examination of eight full-time infants and thirteen adults. In the new-born he finds the average length of the cervical region to be 4·51 ctms., and that of the lumbar region to be 4·75 ctms. The dorsal region he found to measure on an average 8·39 ctms. In the adult male Aeby gives the average length of the cervical region as 12·99, of the lumbar 18·41, and of the dorsal 27·34. Taking Aeby's figures, we, therefore, note that he is quite justified in concluding from them that the cervical region in the infant is practically equal to the lumbar, whilst in the adult it stands in the proportion of 2 to 3.

I have measured the regions of the spine in the case of four full-time or very nearly full-time infants, with the following results:—

Height of Infants.	Length of Spine.	Length of			
		Cervical.	Dorsal.	Lumbar.	Sacro-coccygeal.
43 cms.	16·7 cms.	2·8 cms.	6·7 cms.	3·7 cms.	3·5 cms.
39 ,,	13·5 ,,	3·0 ,,	5·5 ,,	3·0 ,,	2·0 ,,
46 ,,	17·0 ,,	2·5 ,,	7·2 ,,	3·7 ,,	3·6 ,,
43 ,,	16·6 ,,	2·5 ,,	7·1 ,,	3·5 ,,	3·5 ,,
Average, 42·75 cms.	15·95 cms.	2·70 cms.	6·62 cms.	3·47 cms.	3·15 cms.

In these cases the infants were skeletonized, hence the relative lengths were also measured in frozen sections of infants, where the soft parts were of course *in situ*, with the following results:—

Height of Infant.	Length of Spine.	Length of			
		Cervical.	Dorsal.	Lumbar.	Sacro-coccygeal.
1st Case, 56 cms.	23 cms.	4·4 cms.	8·9 cms.	5·4 cms.	4·3 cms.
2nd ,, 43·5 ,,	16 ,,	3·5 ,,	6·5 ,,	3·3 ,,	2·7 ,,
3rd ,, 38 ,,	20 ,,	3·7 ,,	8·3 ,,	4·5 ,,	3·5 ,,
Average . .	19·6 cms.	3·8 cms.	7·9 cms.	4·4 cms.	3·5 cms.

In the above table the second and third cases were those of children born before the full time, and it will be better for purposes of comparison to leave them out of account, and to pay attention only to the first case, which was that of a well-developed full-time infant. The comparison of the measurements in the

skeletonized infants with those in the case above mentioned may be represented in tabular form thus:—

Height of Infant.	Length of Spine.	Length of			
		Cervical	Dorsal.	Lumbar.	Sacro-coccygeal.
	Ctms.	Ctms.	Ctms.	Ctms.	Ctms.
The skeletons, 42·75 ctms.	15·95	2·70	6·62	3·47	3·15
Frozen infant, 56·00 ,,	23·00	4·40	8·90	5.4	4·30

Since the total length of the spine was much greater in the frozen child than in the skeletonized infants, the average percentages of the different regions have also been calculated, with the following results:—

	Length of Regions.			
	Cervical.	Dorsal.	Lumbar.	Sacro-coccygeal.
	Per cent.	Per cent.	Per cent.	Per cent.
Skeletons, . . .	16·87	41·37	21·68	19·68
Frozen infant, . .	19·13	38·69	23·47	18·69

Whilst the figures thus obtained do not exactly coincide, they are still sufficiently near to warrant the statement that, in the cases examined by me, there is not that relation between the length of the cervical and that of the lumbar region of the spine which Aeby found. The measurements would seem to show that the lumbar region is longer, and considerably longer, than the cervical region of the infant at birth. The cervical region may be stated roughly to form 18 per cent. of the length of the spine, the lumbar region 22·5 per cent., the dorsal region 40 per cent., and the sacro-coccygeal region a little over 19 per cent. Whilst the cervical is not so markedly smaller than the lumbar region in the infant as it is in the adult and in the child (of 6, 10, or more years), still the two regions cannot be said to be of equal length at birth (Plate I.).

The Curves of the Vertebral Column.—In the fœtus, at a very early stage of intra-uterine life, the vertebral column presents one general curve with an anterior concavity; later, the sacral promontory appears, and there arise two curves, one above and one below the promontory, each with its concavity directed forwards; and in the case of the infant at birth, it is usually stated that there is a curve with anterior concavity in the dorsal region.

The making of frozen sections has demonstrated the fact that the position in which the body is placed is a most important factor in the production or in the abolition of spinal curves both in the infant and in the adult, but more especially in the case of the former. In the case of the infant at birth the spine is soft and flexible, and its curves can easily be changed by altering the position of the body. It is certainly not the firm, rigid rod which those who believe in the lever theory of flexion in labour assert, and the death of the child is not necessary in order that the vertebral column may become limp and flaccid ("On Head-Flexion in Labour," A. R. Simpson, *Trans. Edin. Obst. Soc.*, 1879). With the exception of the projection forwards of the sacral promontory, the vertebral column may, in the infant, be made practically straight, or may have certain curves developed in it simply by placing the body in certain positions. Thus, in one case in which the infant was placed on its back in the freezing mixture with the head acutely flexed, and the thighs flexed and rotated slightly outwards, there was a cervical curve and a lumbar curve both with concavity forwards, and in the dorsal region there was a slight concavity forwards in the upper part, and a slight convexity forwards in the lower part (Plate I.). In the case of an infant frozen lying upon the back with the legs flexed but not abducted or rotated outwards, there was a dorsal concavity forwards and a lumbar convexity directed anteriorly. In yet another infant frozen in the genu-pectoral position, the lumbar and lower dorsal regions were practically straight, there being only the suggestion of a lumbar convexity forwards, whilst in the upper dorsal region there was a slight concavity directed anteriorly. These cases, therefore, demonstrated the variability of the curves in the infantile spine. Careful measurements of the vertical diameters of the vertebral bodies anteriorly and posteriorly revealed no marked difference save in the lumbar region, where the anterior vertical diameter was a little greater than the posterior (about 1 mm.). Neither did the inter-vertebral cartilages show any difference between their anterior and the posterior vertical measurements.

At birth there is no indication of a cervical curve with anterior convexity. Balandin states that this curve begins to be formed at the third month of extra-uterine life, when the infant begins to sit up in the nurse's arms; but Symington is of opinion that the cervical curve is never consolidated, and that it can, even in the

adult, be obliterated by strong flexion of the head upon the chest. In the infant, at any rate, the cervical part of the spine can be made practically straight, or can be curved with either a convexity or a concavity to the front by altering the position of the head with regard to the chest.

A dorsal curvature with concavity forwards is usually found at birth; but this curve cannot be looked upon as constant, for by altering the position of the infant the dorsal part of the spine can be straightened out. Balandin states that when the child begins to walk a lumbar curve appears, but that this is not consolidated till adult life, and this is no doubt the case. The lumbar curve, like the dorsal and cervical, may be straightened out during infancy.

A sacro-coccygeal curve with its concavity directed forwards does exist at birth, and is permanent (Plate VIII. Figs. 1 and 2, Plate IX. Fig. 2); but in some cases the sacrum and coccyx are directed downwards and backwards in a straight line, and in these cases there is often an abnormality in development shown by the presence of what is called the "post-anal dimple."

The Ossification of the Vertebral Column in Infancy.—At birth there are three primary centres of ossification found in each vertebra,—one for the body, and two lateral centres for the arches and processes. It is usually stated that the lateral centres are not united posteriorly at birth; but in several specimens I found bony union posteriorly—in one or two cases extending even into the spinous processes. The lateral centres are separated from the central centre for the body of the vertebra by cartilage—the neuro-central suture.

Certain of the vertebræ differ in their method of ossification from the above general plan. The atlas vertebra has its anterior arch cartilaginous at birth; and it has two centres, one for each lateral mass, which unite posteriorly about the third year of life. In the case of the axis vertebra there exist at birth one centre for the body and two lateral centres for the arch and processes; but there are also two primary lateral centres for the odontoid process, which are often found fused together in the full-time infant. An apical epiphysary centre for the tip of the odontoid process is not present at birth. The body and odontoid process are said to ossify into one mass at the third year of life; but Symington's frozen sections show that this union may not be complete even at the thirteenth year, an island of cartilage existing with a layer of bone in front and another

behind (*v.* Symington's *Atlas*, plates i. and ii.). The anterior layer of bone is probably formed about the third year. D. J. Cunningham ("Ossification of Odontoid Process," *Journ. of Anat. and Phys.*, vol. xx. p. 238) believes that the cartilage between the body and odontoid process of the axis does not disappear till old age (60 or 70); and supposes that authors have been misled upon this point by the peripheral ossification. He believes the odontoid process to be the displaced body of the atlas, and regards the apical centre as its upper epiphysary plate.

At birth the five parts of the sacrum usually show one central and two lateral primary centres in each; but the coccyx is then, as a rule, entirely cartilaginous, the centre for the first coccygeal vertebra appearing shortly after birth.

The Relation of the Spinal Cord to the Vertebral Canal.—At the fourth month of intra-uterine life the spinal cord occupies the whole of the vertebral canal; but, thereafter, the cord grows less quickly than the canal, and at birth it is found to terminate at the level of the first lumbar vertebra, the remaining part of the canal being occupied by the leash of nerves, and the *filum terminale*, which together constitute the *cauda equina* (Plate I.). In this particular, therefore, the spinal cord of the infant does not differ from that of the adult; but the spinal enlargements (cervical and lumbar) are in infancy relatively smaller than they are in later life.

The Region of the Neck.—Whether the cervical part of the spine be equal in length to the lumbar or not, it is certain that the new-born infant has an apparently short neck. The neck is seen to be short even when the head is fully extended, and this shortness is due to the high position of the sternum in the new-born, and also, in part, to the relatively large size of the head and small size of the face at birth, and to the abundance of subcutaneous adipose tissue in the cervical region. It is always difficult to lay down exactly the limits of the region of the neck; but for convenience the larynx, the trachea, the hyoid bone, the pharynx, and the thyroid body may be described as structures belonging to this region.

The Hyoid Bone.—The hyoid bone varies in its position according to the flexed or extended condition of the head, and, therefore, its relations with the thyroid cartilage of the larynx and with the vertebral column are also variable. In one case in which the head was flexed during freezing the hyoid bone lay almost in contact with the upper margin of the thyroid cartilage, there being prac-

tically no thyro-hyoid space, and it was seen to correspond in level with the lower part of the body of the third cervical vertebra, and with the disc between it and the fourth cervical body (Plate I.). In another case, in which the head was not so acutely flexed, there was a distinct thyro-hyoid space, and the hyoid bone lay at the level of the body of the axis vertebra. In Rudinger's vertical mesial section of a new-born infant (*Topographische-Chirurgische Anatomie des Menschen*, parts 1 and 2, plate xi.), in which the head is extended, the hyoid bone also lies opposite to the body of the axis vertebra. In a twelve months old child in which the head is extended it lies at the level of the body of the axis (Symington's *Atlas*, fig. 25, p. 63); and in a boy of six years it lies opposite to the disc between the third and fourth cervical vertebræ (Symington's *Atlas*, plate i.). In the adult it lies opposite to the fourth or fifth cervical vertebra (Gegenbauer). There is, therefore, a descent of the hyoid bone as infancy passes into adult life, in the same way as there is, as will be seen, a descent of the larynx and epiglottis. The ossification of the basi-hyal and of the great wings of the hyoid bone has commenced at birth.

The Larynx.—The larynx lies at a higher level in the neck of the new-born infant and young child than it does in the adult. In the full grown man the larynx extends from a point opposite to the middle of the third cervical to a point opposite to the upper border of the seventh cervical vertebra; in the infant it is situated much higher in the neck, being, according to Symington, two vertebral bodies and two intervertebral discs higher. In one of my cases, in which the head was sharply flexed, the tip of the epiglottis lay opposite to the cartilage between the body and odontoid process of the axis vertebra, and the lower border of the cricoid cartilage lay at the level of the disc between the fifth and sixth cervical vertebræ (Plate I.). In one of Symington's specimens, a male nine months' fœtus, with head flexed, the upper limit of the larynx was at the same level as in my specimen; but the lower end of the larynx lay opposite to the middle of the body of the fifth cervical vertebra. In the case of a seven months' female fœtus, frozen with the head erect, Symington found the larynx to extend from a point opposite to the middle of the fourth cervical vertebra to one opposite to the lower border of the atlas vertebra. In one of my cases, an eight months' male fœtus, the larynx extended from a point opposite the disc between the third and fourth cervical

vertebræ to one in a level with the upper border of the anterior arch of the atlas vertebra. The relations of the larynx to the vertebral column in the case of seven and eight months' fœtuses, and of full-time infants, may be seen from the following table:—

Age.	Sex.	Upper Limit.	Lower Limit.	Position of Head.
7 mo. fœtus.	F.	Upper border of atlas.	Upper border of 4th C.V.	Erect.
,, ,,	F.	Lower ,, ,,	Middle of 4th C.V.	Erect.
8 ,, ,,	M.	Upper ,, ,,	Disc between 3rd and 4th C.V.	Erect.
9 ,, ,,	M.	Between body and odontoid process of axis.	Middle of 5th C.V.	Flexed.
9 ,, ,,	M.	Between body and odontoid process of axis.	Disc between 5th and 6th C.V.	Flexed.

In all probability, in the case of the new-born infant with head erect, the larynx normally extends from a point opposite to the cartilage between the body and odontoid process of the axis to the level of the upper border of the fifth cervical vertebra, or to that of the disc between it and the fourth cervical vertebral body. The descent of the larynx would seem, from Symington's measurements, to be a gradual process going on throughout childhood.

It has always been important that the surgeon who performs the operation of tracheotomy should be well acquainted with the position, size, and relations of the larynx and trachea; and the introduction of the operation known as intubation of the larynx has rendered this knowledge absolutely essential for the proper carrying out of the procedure. Those who perform intubation ought to bear in mind that the diameter of the glottis is only some three millimetres, and that it is, therefore, impossible to pass a tube through it which shall correspond in size to the larger laryngeal and tracheal diameters. In the new-born infant the vertical measurement of the larynx, from the tip of the epiglottis to the lower border of the cricoid cartilage, is from 1·8 to 2·0 ctms; and the larynx is therefore very nearly equal in extent to one-half the length of the cervical region of the spinal column. The proportions are as 1·8 or 2·0 ctms. to 4·4 or 4·5 ctms. in a well-developed infant; and the measurements in the adult give relatively nearly the same proportion, as 6 to 12. It is

useful to remember that the thyro-hyoid and crico-thyroid membranes are respectively about as wide as the breadth of the child's own finger, and that a finger's breadth below the cricoid cartilage is the isthmus of the thyroid body.

In infants, sex causes but little difference in the size of the larynx; but in boys at the age of puberty the larynx becomes markedly larger, the thyroid cartilage especially becomes prominent, and constitutes the *pomum Adami*. In infancy the cricoid and not the thyroid cartilage is the most prominent part of the larynx, and it forms, as all surgeons know, a most valuable guide in such operations as tracheotomy.

The Trachea.—It is convenient to consider the trachea here, notwithstanding the fact that in part of its course it lies in the thoracic cavity. It is, like the larynx, at a higher level in the body of the infant than in that of the adult. It usually extends from the level of the body of the fifth cervical vertebra to that of the third dorsal vertebra, where it bifurcates. In infants frozen with the head flexed it was found to be situated at a slightly lower level (Plate I.). In the adult the bifurcation of the trachea is about one vertebra lower than in the infant, lying opposite to the body of the fourth dorsal vertebra. The average length of the trachea in the new-born infant is 3 ctms., and its diameter is from 2 to 3 mms. The calibre of the trachea is easily gauged by the fact that it corresponds roughly with the size of the forefinger of the infant himself, and this fact is an important aid to the surgeon who may have to perform tracheotomy upon a young infant. Symington states that at the age of two years the trachea is 5 mms. in diameter, and that at the age of six months it is 4 mms. In a seven months' *fœtus* I found it to be little more than 1 mm. in diameter.

In front of the trachea, and lying in immediate relation to it, are the isthmus of the thyroid gland (which is only slightly vascular in early infancy), the inferior thyroid veins lying a little below the isthmus, the thymus gland lying still lower in the neck, the left innominate vein, the arch of the aorta, and the innominate artery (Plate I.).

The right bronchus is of slightly greater calibre than the left; and in this anatomical fact may be found at least in part the explanation of how it is that a foreign body more commonly passes into this primary division of the trachea than into that on the left side.

The Pharynx (Plate I.).—In the infant the pharyngeal cavity is, in part at least, a real and not a potential space, and its vertical extent is on an average about 4 ctms. The pharynx becomes continuous with the œsophagus at the level of the fifth or sixth cervical vertebra posteriorly, and of the cricoid cartilage anteriorly; and at this point, the pharyngeal cavity being narrower than elsewhere, foreign bodies are apt to lodge. Behind the posterior pharyngeal wall, and in front of the cervical vertebræ, is some loose areolar tissue; it is in this situation that the retro-pharyngeal abscess forms, and a glance at any of the drawings of this region will show how easy it is for pus from the bursting of such an abscess to pass into the larynx. In one of the frozen sections (Plate I.) it was found that the soft palate was tilted upwards, a condition of parts which made the buccal portion of the pharynx seem relatively large, and the nasal part relatively small.

The Thyroid Gland (Plate I.).—The isthmus of the thyroid gland lies in the middle line of the body, in front of the upper four or five tracheal rings in the infant, and opposite to the body of the fifth or sixth cervical vertebra. It is usually small in size in the infant, and hæmorrhage from it is not to be greatly dreaded by the surgeon. The lateral lobes of the thyroid gland usually extend from the lower border of the thyroid cartilage to the level of the fourth or fifth tracheal ring. The isthmus of the thyroid lies from 5 to 8 mms. above the manubrium sterni, the distance varying with the flexed or extended position of the head of the infant.

The Lymphatic Glands of the neck are very numerous, and they are specially liable to become enlarged in weakly children; in fact, the peculiar appearance given to the neck by their enlargement has given origin to the term scrofula.

A very thorough knowledge of the relations of parts in the region of the neck is necessary for the successful performance of the operations known as insufflation, intubation, and tracheotomy. From the study of his frozen sections, Ribemont was led to devise an insufflator tube for the treatment of apnœa neonatorum (*Recherches sur l'insufflation des Nouveau-nés et description d'un nouveau Tube laryngien*, Alban Ribemont, Paris, 1878), which differed both in size and form from the instruments of Chaussier, Depaul, and Pinard. Ribemont's laryngeal tube is an exact model of the form of the buccal, pharyngeal, and laryngeal cavities as seen in frozen sections of the neck of the new-born infant; it has the amount of curvature necessary to

carry it over the back of the tongue and then downwards nearly in a straight line into the larynx and trachea; and it is certainly easier of introduction than previously invented instruments. The procedure of insufflation for asphyxia neonatorum has, however, of late years been to a great extent replaced by the various ready methods of artificial respiration, and, therefore, the insufflator tube is not so usually found in an obstetrician's armamentarium; still its use may be efficacious in some instances when other methods have failed. If insufflation has to a large extent lost its popularity during recent years, another operation requiring no less accurate knowledge of the anatomy of the neck has, on the other hand, come to be widely employed. The intubation of the larynx in cases of croup and diphtheria has been advocated as an easier and safer operation than tracheotomy, but it requires for its successful carrying out a knowledge as great, if not greater, of the topographical anatomy of the region as does the older operation. Thus, it demands an acquaintance with the degree of curvature of the dorsum linguæ, of the arch of the palate, and of the upper end of the larynx, and it necessitates a not inconsiderable degree of dexterity on the part of the operator. It cannot be said to be essentially an easier operation than tracheotomy, although, at the same time, it must be admitted that it has the following advantages: it is not a cutting operation, and is, therefore, free from the risks of hæmorrhage and septicæmia; it is a procedure to which parents have not the same objections as they have to tracheotomy; and it permits the air to enter the lungs by the natural passages. Surgeons ought to study carefully frozen sections of the infant's neck before attempting either intubation or tracheotomy.

The Clinical Examination of the Spine and of the Region of the Neck in the Infant.

Inspection of the Spine.—It is important that the infant's spine at the time of birth be inspected, in order early to detect any abnormality in that region. The lateral primary ossific centres in some of the vertebræ may be absent at the time of birth, and thus is produced a spinal canal open posteriorly, from which there is a protrusion of the membranes of the cord with the contained cerebro-spinal fluid. The tumour thus formed, which is found most commonly in the low lumbar and sacral regions, is known as *true spina-bifida*. There may

also be found somewhere in the extent of the spine the variety of swelling known as false spina-bifida, and this tumour may consist of a dermoid cyst, a lipoma, or simply a shrivelled spina-bifida. Abnormal curvatures of the spine, although rare in infancy, ought to be looked for, and the peculiar fixed position of the head in occipito-atloid disease is an easily recognised phenomenon.

Palpation of the spinal column will give great aid in the diagnosis of minor curvatures and in the detection of the abnormality known as *spina-bifida occulta*, which, occurring usually in the lumbar region, is often found associated with hypertrichosis of the part and with club-foot. Localized tenderness, when it exists, may also be detected by careful palpation and percussion of the spine.

Inspection of the Region of the Neck may reveal the existence of swelling of the lymphatic glands or the presence of various abnormalities, such as branchial cysts or the congenital growth known as cystic hygroma. The existence of wry-neck, congenital or acquired, may also be noted. The examination of the larynx and trachea by means of the laryngoscope is an extremely difficult procedure to carry out in infancy; but it is in certain cases necessary to attempt to put this diagnostic method into practice.

The Palpation of the Neck is of importance in enabling the medical man more clearly to diagnose the nature of the swellings found in this region; and in some cases he may thus obtain the first hint, from the presence of enlarged glands in the neighbourhood of the angle of the jaw, that the case is one of diphtheria.

CHAPTER IV.

THE ANATOMY OF INFANCY—Continued.

THE ANATOMY OF THE REGION OF THE THORAX—CLINICAL EXAMINATION OF THE INFANT'S THORAX.

THERE is no part of the infant's body in which such important changes in size and form occur immediately after birth as in the thorax; these changes are manifestly due to the establishment of respiration. Further, the thorax of the infant differs from that of the adult in its form and in its relation to the vertebral column. The superior limit of the thorax, the upper border of the manubrium sterni, lies in the infant at the level of the body of the first dorsal vertebra, usually exactly opposite to the middle of that vertebral body (Plate I.), whilst in the adult it lies at the level of the lower border of the second dorsal vertebra. The upper border of the sternum is, therefore, a vertebra and a half higher in position in the infant than in the adult condition; and it is found that the lower limit of the thorax is also situated higher in relation to the vertebral column in infant as compared with adult. In the still-born infant the central tendon of the diaphragm lies at the level of the disc between the eighth and ninth dorsal vertebræ, whilst in the adult it is usually situated about one vertebra lower. I have not been able to demonstrate any change in level of the central tendon of the diaphragm in the case of infants who have breathed and lived for some days after birth; but it must be remembered in relation to such observations that death has probably occurred during expiration. It may be safely stated that the whole thorax lies at a slightly higher level in the infant than in the adult, and it may also be inferred that the descent of the thorax is connected with the development of the normal spinal curves.

THE DIAMETERS OF THE THORAX.—In the infant at birth in whom respiration has not been established, the transverse diameter is twice as great as the antero-posterior, whilst in the adult the transverse is three times as great as the antero-posterior. The diameters above

mentioned are the *internal* measurements of the chest cavity, the external diameters do not bear the same relation to each other as do the internal, for the vertebral column increases the antero-posterior diameter to a greater extent than do the thoracic lateral walls the transverse. The internal antero-posterior diameter varies from 4 ctms. at the level of the fourth dorsal vertebra to 5 ctms. at the level of the eighth, whilst the internal transverse measurement varies from 10 to 11·5 ctms. The external antero-posterior diameter varies from 6 to 9 ctms., and the transverse from 11 to 12 ctms. The mesial vertical diameter of the thorax in the still-born infant varies from 4 ctms. anteriorly to 6 or 6·5 ctms. posteriorly; and in infants that have breathed, this diameter is about 1 ctm. greater in extent. Ribemont has given elaborate tables showing the difference between the diameters of the thorax in still-born infants and those in infants who have breathed or have been insufflated; and from these tables he has shown that all the diameters of the thorax increase after the establishment of respiration, but the antero-posterior more than the transverse and vertical. He has also demonstrated that the antero-posterior diameter of the right side of the thoracic cavity is greater than that of the left side, and that the hollow at the right side of the vertebral column is larger than that at the left side. It may be stated shortly that the thorax in the still-born infant has walls which are flattened to a greater or less extent, whilst in the child that has breathed the contours become to a greater or less degree convex externally. The diaphragmatic floor of the thorax forms, however, an exception to this statement, for it is more convex in the still-born infant than in the child who has breathed (Plate V., Plate VI. Fig. 2).

To the obstetrician it is a point worthy of note that the bis-acromial diameter of the thorax of the new-born infant measures on an average 12 ctms., and that this diameter can (according to Tarnier) be reduced by pressure to 9·5 ctms. As the greatest antero-posterior diameter of the chest has also an average length of 9·5 or 10 ctms., it is evident, therefore, that the bis-acromial diameter can, by compression (*e.g.*, during labour), be reduced to the length of the sterno-dorsal diameter.

The Osseous Framework of the Thorax.—The ossification of the sternum is usually well advanced at birth, and there are then found a large ossific centre in the pre-sternum and three smaller centres in the meso-sternum. Cartilage intervenes between these

centres at birth, and the meta-sternum is entirely cartilaginous. In one or two infants I have found a fourth ossific centre in the body of the bone at birth (Plate I.); but this does not usually appear until after birth, whilst that for the meta-sternum is not commonly present till after the sixth year of life. At birth the manubrium sterni has an average length of 2 ctms., the body of 4 ctms., and the ensiform cartilage of 1·5 ctm.; the component parts of the sternum have in the adult similar relations to each other.

The ribs, although ossified at birth, are yielding, and are especially affected by pressure at their junctions with the costal cartilages. They are also flatter and less curved in infancy than in later childhood.

The Mammary Glands.—In infants of both sexes the mammary glands are often found to form swellings, each of the size of a walnut or pigeon's egg. This swelling, which usually begins five days or a week after birth, and persists till the end of the first two or three weeks of life, is not a pathological but a normal occurrence. It may, however, become pathological if the breasts be squeezed,—a procedure which is, unfortunately, too common amongst ignorant midwives. The swollen mammæ of the new-born infant contain a whitish alkaline fluid resembling watered milk both in appearance and in composition. Schlossberger states that the milky fluid contains no colostrum corpuscles; but both Guillot and Sinéty found them to be present.

The Thymus Gland (Plates I., V., and VI.).—The large size of the thymus gland at birth causes the anterior mediastinum to be a very distinct and definite space. Its large size is one of the most striking features in the anatomy of the infantile thorax. It consists, as a rule, of two lobes, right and left, which are in close apposition in the middle line of the thorax; but occasionally an intermediate or central lobe is present. The thymus is usually described as a narrow elongated body; but in several of my specimens it was found to have a transverse diameter of considerable extent (transverse, 2 to 3·5 ctms.; vertical, 4 to 5 ctms.; antero-posterior, 1·5 to 2·5 ctms.). The cervical part of the thymus gland is relatively small at birth on account of the high level at which the manubrium sterni lies. The gland corresponds in its vertical extent to the first four dorsal vertebræ posteriorly, and to the manubrium and upper part of the body of the sternum, and to the three upper costal cartilages anteriorly. It projects above the supra-sternal notch

to a distance of about 5 mms., and comes almost into contact with the isthmus of the thyroid. It rests upon the anterior surface of the pericardium, covering the auricles and part of the ventricles of the heart. Above the level of the heart it rests upon the arch of the aorta, the innominate artery, the left innominate vein, and the trachea; whilst it also passes laterally to rest upon the lungs, being separated from them by the pleura. Its external border is in contact with the mediastinal pleura in the thorax, and in the neck it comes into relation with the sheath of the carotid artery. It sometimes, it is said, reaches the diaphragm inferiorly, and in one case I found that it nearly attained this level.

The thymus gland persists till the second year of life, after which time it begins to atrophy, and after the ninth or tenth year is represented only by a small quantity of adipose and fibrous tissues. In exceptional cases it may not undergo this retrogressive change, remaining then till the thirtieth year of life. Waldeyer, however (*Sitzber. d. Akad. d. Wissench.*, Berlin, xxv. p. 433), has recently fully investigated the retrograde metamorphosis of the thymus gland, and has found that in all cases, even in old age, there exists in the anterior mediastinum a structure having the shape of the thymus, and this he has termed the retro-sternal or thymus fat body. The fat is the changed gland tissue of the thymus which has remained in the connective tissue framework. The presence of the thymus gland is of importance both to the physician and surgeon,—to the former, on account of its influence upon the results of percussion of the upper part of the thorax, and to the latter, because it seriously complicates tracheotomy in the infant.

The Heart: the Size of the Heart.—Whilst it is true that the heart is relatively heavier at birth than in adult life (Vierordt), the statement that it is also relatively large in infancy must be considered in connexion with the fact that the thorax is narrower from side to side at birth than in later life. It is probable that the heart is only apparently large in the infant, and that its large appearance is due to the narrowness of the thorax. The size of the heart is approximately that of the closed hand of the infant to whom it belongs.

The Position of the Heart (Plate VI. Figs. 1 and 2).—The study of frozen sections of the thorax shows that by far the greater part of the heart lies to the left of the middle line; a part of the

right, and a small part of the left auricle are the only portions which lie to the left of the mesial body plane. The ventricles are almost entirely to the left of the middle line; sometimes, however, the right ventricle at a point near the cardiac apex is cut into in a sagittal mesial section of the thorax (Plate I.). The heart is situated more transversely in the thorax in infancy than in adult life, and it is also placed a little higher in relation to the vertebral column. In vertical extent the heart corresponds to the fifth, sixth, seventh, and eighth dorsal vertebræ; the upper limit (the base) being the disc between the fourth and fifth dorsal vertebræ, the lower that between the eighth and ninth dorsal vertebral bodies. The apex of the heart is at a higher level and is further to the left in the infant than in the adult, and the apex beat is, therefore, usually found in the left mammillary line, lying in some cases immediately inferior to the left nipple, in other cases corresponding exactly to the mammilla. The position of the cardiac cavities has been found to be as follows:—The auricles lie under cover of the second left intercostal space, the right extending also beneath the sternum nearly to its right border; the right ventricle lies beneath and to the left of the sternum, its lower border being in line with the head of the sixth costal cartilage; and the left ventricle is situated beneath the third and fourth intercostal spaces and the fourth rib on the left side of the chest. When respiration has been fully established, and when, therefore, the left lung is filled with air, the heart is tilted very slightly towards the right side; but this change in position is trifling. The foramen ovale and the opening of the inferior vena cava lie almost exactly in the middle line, the former extending also towards the right ride. The opening of the superior vena cava into the right auricle lies to the right of the middle line. The valvular openings in the heart lie all very near each other in an area not more than 1·5 ctm. square. The mitral valve lies at the left border of the sternum on a level with the upper border of the third costal cartilage, and the tricuspid lies in front and a little below the mitral, and more under cover of the sternum (Keating and Edwards). The pulmonary orifice lies opposite to the lower margin of the second costal interspace, and the aortic is slightly inferior to the pulmonary in an oblique direction.

The Relations of the Heart.—Many of the relations of the heart to the chest have been already indicated; but there remain for consideration its relations to the other thoracic viscera. In

still-born infants the heart is in relation with the sternum in the middle line anteriorly; but the pericardium intervenes between the heart wall and the posterior surface of the sternum, and the thymus gland is interposed between the manubrium sterni and the upper two parts of the meso-sternum and the base of the heart (Plate I.). On the left side of the middle line the heart is related anteriorly to the costal cartilages and sternal ends of the upper six ribs; but in the case of the first and second costal cartilages and ribs the thymus gland intervenes; at a lower level the pericardium alone lies between the heart and the ribs, cartilages, and intercostal spaces (Plate V.). The sharp anterior border of the left lung, however, insinuates itself to a varying extent between the heart and the left anterior chest wall (Fig. 1.). In infants in whom respiration has been established,

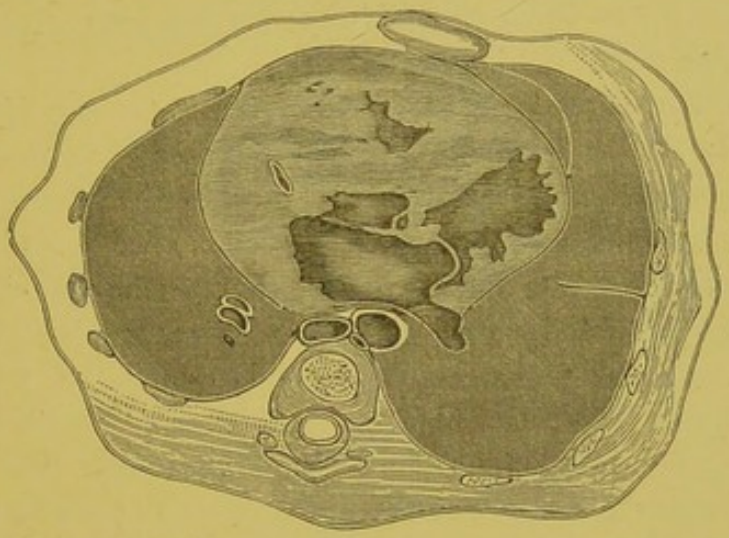
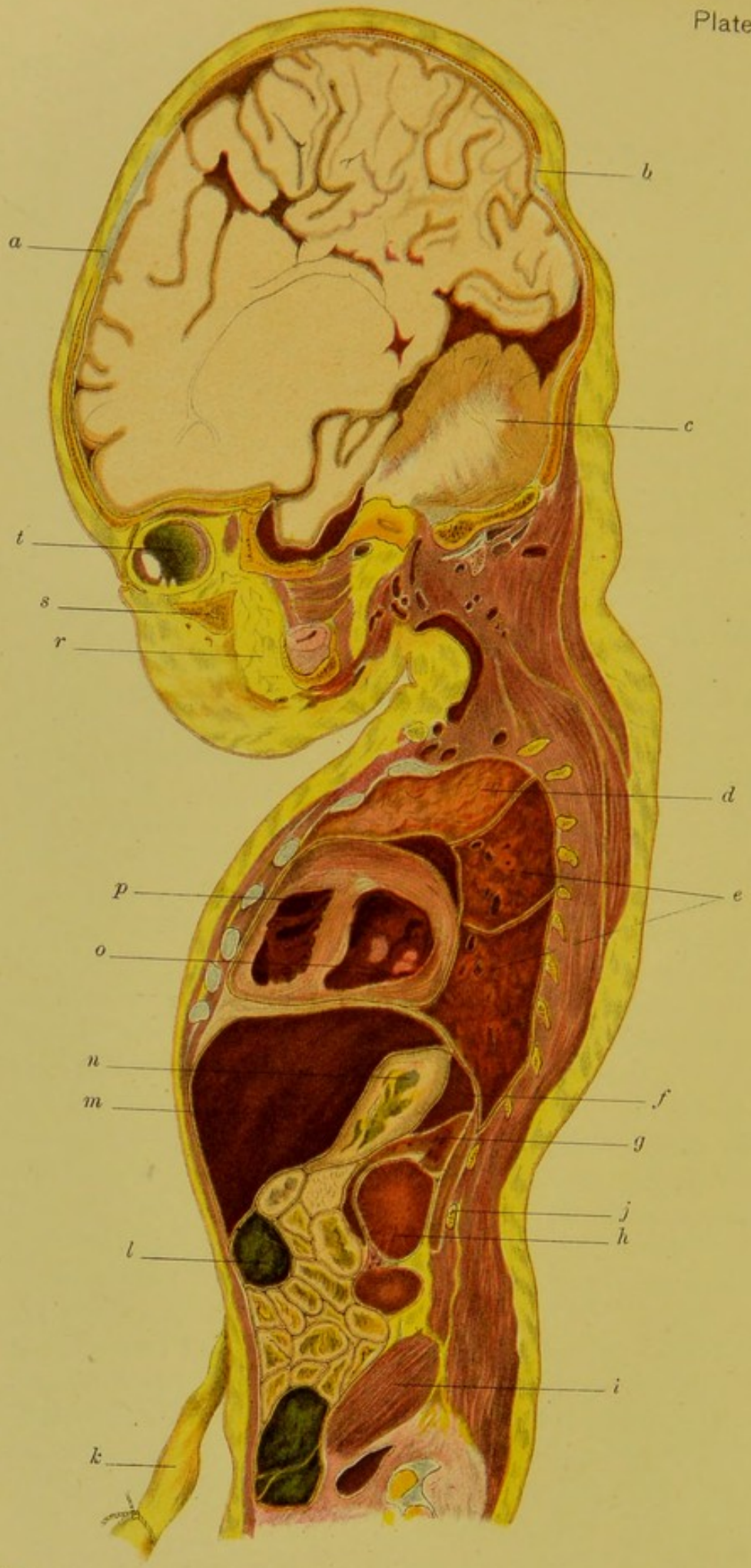


Fig. 1.—Transverse section of Thorax of Infant that lived for a few minutes, showing relation of the lungs to the heart.

this insinuation of the left lung in front of the heart becomes more marked, so that in them only a small triangular area of the heart surface, including the tip of the left and a small part of the right ventricle, is in immediate contact with the chest wall. This somewhat irregular triangular area has for its angles the apex of the heart immediately below the left nipple, the junction of the sternum with the ensiform cartilage, and the junction of the third left costal cartilage with the sternum. The establishment of respiration also causes the anterior margin of the right lung to come forwards to extend to the mid-sternal line, and so to cover the portion of the heart which lies to the right of the middle line of the body.

The relation of the heart to the extremities of the spinal column and to the cephalic and pelvic ends of the infant has been investigated by Ribemont. He found that the centre of the heart corresponded in level to the body of the sixth dorsal vertebra, and that it lay nearer to the upper end of the spine (the tip of the odontoid process of the axis) than to the lower end (the sacro-vertebral angle). Some measurements which I have made fully bear out this statement, but the difference in distance from the upper and lower end of the spine varies considerably—in one case being 3 ctms., in another only ·5 ctm. Ribemont also found that the centre of the heart usually lay nearer the pelvic than the cephalic extremity of the infant. My measurements did not permit me to come to this conclusion, for they showed that in some cases the heart lay nearer the cephalic end of the infant. It may be stated generally that the heart lies midway between the cephalic and pelvic extremities of the infant.

Structural Peculiarities of the Heart in the New-born Infant.—In the heart of the infant at the time of birth are found certain anatomical peculiarities, consisting in the presence of an open foramen ovale, a well-marked Eustachian valve, and a patent ductus arteriosus. The foramen ovale, the patency of which was necessary for the fœtal circulation, is no longer required when the circulation peculiar to extra-uterine life is established, and it soon begins to close. The Eustachian valve, which has served the purpose of directing the blood from the inferior vena cava into the left auricle through the ovale foramen, also begins to atrophy with the establishment of the pulmonary circulation. It is not possible to fix any definite time for the complete closure of the foramen ovale. It has in some cases been found closed on the first day of life, in others it has been discovered to be patent as late as the twelfth day or even the third week of life, but it is usually completely closed from the eighth to the tenth day after birth. In one case, an infant of six days old, I have noted that the foramen was closed by membrane, but still pervious at one side where the membrane had not yet become attached to the circumference of the opening. The persistence of the foramen ovale after the third week of life leads to the disordered state of the circulation, which gives rise to the disease known as morbus cæruleus, and infants affected with this abnormal patency of the foramen are called by the laity "blue babies." The ductus arteriosus, the canal which leads from the



Left Lateral Sagittal Section of New-born Infant (§ *Natural Size*).

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PLATE V.

Left Lateral Vertical Section of New-born Infant. Right face of section seen, $\frac{5}{6}$ natural size.

a. Anterior Fontanelle.
b. Posterior Fontanelle.
c. Cerebellum.
d. Thymus Gland.
e. Left Lung, Upper and Lower Lobes.
f. Spleen.
g. Left Supra-renal Capsule.
h. Left Kidney.
i. Left Psoas Muscle.
j. Twelfth Rib.
k. Umbilical Cord.
l. Transverse Colon.
m. Liver, Left Lobe.
n. Stomach.
o. Left Ventricle of Heart.
p. Right Ventricle of Heart.
r. Left Sucking-pad.
s. Left Malar Bone.
t. Left Eye.

pulmonary artery to the aorta, has, at the time of birth, its walls in close approximation, but both water and mercury can easily pass through it. At birth the tunica intima of this vessel is enormously thick, and the canal usually closes before the foramen ovale, although it may, like the foramen, remain patent, or at any rate pervious, until the eighth or tenth day of life. A few weeks after birth hyaline degeneration has commenced in all the tissues of the ductus arteriosus; and it soon thereafter becomes converted into the ligamentum arteriosum, the structures of which it was originally composed having been changed into fibrous tissue.

The Lungs (Plates V. and VI.).—In the infant that has not breathed, the lungs are situated at the back of the thorax; but they are not the flattened structures that they are often stated to be. They differ markedly in size before and after the establishment of respiration; but their difference in form is only slight. In the case of two infants of nearly equal size, one of whom was still-born, the other having, however, lived for a few days, the difference between the measurements of the lungs in the two infants may be gathered from the following table:—

	Still-born Infant.		Infant that Lived for Five Days.	
	Right Lung.	Left Lung.	Right Lung.	Left Lung.
	Ctms.	Ctms.	Ctms.	Ctms.
Vertical diameter (post.) .	6·1	5·8	7·5	7·0
,, ,, (mesial)	4·2	3·8	5·2	5·3
Length of anterior border	4·7	5·1	4·5	6·0
Greatest ant.-post. diameter	3·8	3·5	5·6	4·2
Greatest transverse diameter	2·7	2·5	4·2	3·0

From the above Table the conclusion may be drawn that, after making allowance for individual variations in the size of the lungs, all the diameters in the case of lungs that have contained air are greater than those of the lungs of infants who have never breathed. It may also be noted that the greatest vertical, antero-posterior, and transverse diameters are larger in the right lung than in the left; and that, on the other hand, the length of the anterior border is less in the right than in the left lung. Further, in the case of the infant that lived a few days, the vertical diameter in the axis of the right lung is greater than that in the left, whilst in the still-

born infant this measurement is practically the same in both lungs. It would seem, also, that after respiration has been established, the right lung expands to a greater extent in the antero-posterior and transverse directions than does the left, a fact which is to be accounted for by the presence of the heart in the left side of the thorax.

In addition to size, there are other manifest differences between lungs which have contained air and those which have not. In the case of lungs from a still-born child, the anterior and inferior borders are thin and sharp, whilst in the lungs of infants that have breathed these margins are rounded. Again, in lungs that have contained air, the surface in contact with the ribs becomes more convex than in lungs from still-born children; and on removing the organs from the chest, the rib-markings on the pulmonary costal surface are more distinct in the former than in the latter.

The lungs in still-born infants are darker in colour and firmer in consistence than those in children that have lived, even if only for a short time. As children grow older, the pinkish-gray colour of the lungs as seen on section darkens and becomes more mottled in appearance.

In the infant the presence of the large thymus gland prevents the approach of the lungs towards each other in their upper portions. In the case of infants who have breathed, the apices of the lungs reach to practically the same level above the clavicles as they do in adult life; whilst inferiorly and posteriorly they reach as low down as the space between the tenth and eleventh ribs. Symington states that in infants that have not breathed, the posterior borders of the lungs will be found to reach as low as in infants in whom respiration has been fully established. Ribemont's conclusion is not in accordance with this statement; but my cases seem to support Symington's view of the matter.

The Œsophagus.—The œsophagus leaves the middle line, and inclines to the left side at the level of the sixth cervical vertebra. It returns to the middle line at the level of the fourth dorsal vertebra; and again inclines to the left at the level of the ninth dorsal, where it pierces the diaphragm and lies anterior to the aorta. Its relations, therefore, are practically the same as in the adult. It is about 7 or 8 ctms. in length in the new-born infant.

The Great Vessels in the Thorax.—The vascular trunks of the thorax bear practically the same relations to each other and to

the viscera in the infant that they do in the adult; but the aortic arch reaches to a slightly higher level (the disc between the second and third dorsal vertebræ) in the former than in the latter.

The Diaphragm.—The relations of the central tendon of the diaphragm have been already stated (see p. 62); but it remains to be noted that the lateral portions vary slightly in their level, the right being higher than the left, and this difference is due to the large size of the right hepatic lobe, and to the presence of the heart on the left side. In one of my cases this is not so; but there was in this specimen a markedly hypertrophied spleen (Plate VI. Fig. 2), which caused a projection upwards of the diaphragm in its left portion. The lateral portions of the diaphragm are more convex on their thoracic surface than the central tendon, which shows an almost flat area upon which rests the heart and pericardium (Plate VI. Figs. 1 and 2).

The Clinical Examination of the Thorax.—In the clinical investigation of the thoracic viscera in infancy it is well, in the first place, to examine the back of the chest before the anterior aspect, and, in the second place, to employ percussion only after the other methods have been put in practice, for infants are intolerant of percussion. The examination of the back of the chest may often be carried out without the child's being aware that anything unusual is being done, the infant lying on the nurse's knee or at the mother's breast, and the medical man standing well out of sight. Inspection, palpation and auscultation may first be employed both posteriorly and anteriorly, and thereafter percussion may also be engaged in if it be necessary to do so.

Inspection.—The inspection of the chest may reveal the presence of the characteristic rashes of measles or scarlatina, the signs of previous medicinal treatment in the form of blisters or discolorations from the use of iodine; and the characters of the respiration may now be noted. The various deviations from the normal form of the thorax are also evident to the eye, and the medical man may detect the rachitic pigeon-breast and "rosary," or the distension of the chest due to pleurisy with effusion. In inspecting the præcordial region, it is necessary to remember that it is often more prominent in infants than in adults, and also that the apex beat in infancy is often situated in, or even external to, the left mammillary line in the fourth or fifth intercostal space, and that it is usually widely visible at this time of life. Starck (*Rev. Mens. des Mal. de l'Enf.*, 1888) has, from the examination of 300 children, come to the following

conclusions with regard to the apex beat:—(1.) That it is often quite impossible to determine the exact point at which the apex strikes the chest wall in infants under two years of age. (2.) In most infants of less than four years the apex beat lies outside the mammillary line; but that in exceptional cases the beat may be found upon the mammillary line even in the first year of life, although it is never present *within* that line until after the second year of life, and then only rarely till the seventh year. (3.) It is usual in the first year of life to find the apex beat in the fourth intercostal space, and it is not found constantly in the fifth space till the seventh year of life is reached.

Palpation.—The examination of the chest is of great value in infancy, and in order to carry it out successfully the hands must first be thoroughly warmed, and then applied gently over the posterior and anterior surfaces of the chest in turn. The characters of the respiration may thus be accurately noted, the vocal fremitus estimated, and the presence of crepitations and rhonchi. The crying or coughing of the child may, instead of being a hindrance to palpation, aid the diagnosis. The voice fremitus may be felt, not only over the trachea and larynx, but also very distinctly along the spinal column, in the space between the shoulder blades, and in all parts of the chest where the heart and liver do not come into immediate contact with the thoracic walls. In morbid conditions, differences in the fremitus can be estimated; thus it may be increased in pulmonary consolidation, and diminished or absent in the cases where a pleuritic effusion intervenes between the lung and the chest wall. Crepitations also can be felt in cases of bronchitis, etc.; and even the character of the breathing in pneumonia, croup, bronchitis, etc., can be ascertained by the trained hand of the physician. The palpation of the præcordia is also of importance. In health the apex beat will be felt well marked and punctuated, in the form of a long, dull vibration, followed by a short and distinct impulse. In diseased conditions of the heart and pericardium, the palpating hand is an important diagnostic means, for if the pericardial surfaces be roughened a distinct thrill will be felt; if the heart be dilated, the area of the apex beat will be recognised as enlarged; and if the heart be hypertrophied, there will be increase both in the area and in the force of the cardiac impulse.

Auscultation.—The auscultation of the lungs may be carried

out either by means of the ear applied directly to the chest or by means of the stethoscope, preferably the binaural stethoscope. Whilst the ear can be applied directly to the back of the thorax, it is always better to use the stethoscope for the anterior auscultation. The binaural instrument is specially useful in the auscultation of the infant's chest, for by its use the medical man can completely control the amount of pressure exerted upon the yielding thoracic walls, and can conveniently follow the movements of the chest; but he must always be able to eliminate any adventitious sounds produced in the stethoscope itself. The physician must be on the watch to seize a favourable opportunity for carrying out auscultation, for such opportunities are in young children often few in number in the course of a ten minutes' visit.

The medical man, also, must be well acquainted with the normal pulmonary auscultatory phenomena in infants, in order to be able to differentiate between what is healthy and what is morbid in the sounds heard. During the first few weeks of life the breath sounds are still weak in character; but after the sixth month the breathing that would be called "puerile" if it occurred in adults is fully established. In puerile breathing the inspiratory murmur is well marked, rough, and almost blowing in character, whilst the expiratory whiff is often scarcely audible. This peculiarity in the breath sounds of the healthy infant must constantly be borne in mind in estimating the condition of the lungs. In disease of the lungs and pleura the breath-sounds vary much in character. In bronchitis there are heard sonorous or moist râles; in broncho-pneumonia there is sometimes tubular breathing, at other times fine crepitations, with weak breath sounds; and in pleurisy with effusion, there may be tubular breathing instead of the weak bleating sounds heard in this disease when it affects adults.

From the auscultation of the heart sounds in the infant, it is often difficult to gain much information on account of the rapidity of heart beat; but, on the other hand, it is usually possible to hear the cardiac sounds, not only over the præcordial area, but also over the back of the thorax. The stethoscope must be lightly applied to the chest wall, for adventitious sounds are easily produced by the pressure of the instrument against the ribs. Two sounds are usually present, for both the periods of silence in the cardiac cycle are well marked. The first sound is long, low, and dull in character, then follows the short pause; the second or diastolic sound is

short, abrupt, clacking, or ringing, and thereafter occurs the long pause. The sounds from the mitral valve are best heard over the apex beat; those from the aortic, over the second right costal cartilage near the sternum; those from the tricuspid, just above the ensiform cartilage; and those from the pulmonary valves, in the second intercostal space near the left sternal border.

The heart murmurs of disease are always difficult to differentiate in infancy. The endocardial bruits are often very similar in character to the friction sounds of pericarditis, and it is often especially difficult to recognise hæmic murmurs. Re-duplication of heart sounds is more common in infancy than in adult life. Although cardiac auscultation in childhood is surrounded by many difficulties, it ought not to be neglected as a means of diagnosis, especially in cases of chorea, scarlet fever, rheumatism, and nephritis, for in all these diseases the mitral valve is not uncommonly affected.

Percussion.—The use of the stethoscope in young children is often productive of fear; but percussion is the means of diagnosis which is specially distasteful to them, and, therefore, as has already been stated, the examination of the chest by percussion ought to be left to the last. On this account, also, the percussion strokes ought to be light ones; and there is a further reason for this lightness of touch, for strong percussion will, on account of the elastic character of the chest walls, give in almost every case a resonant note. Percussion must in all cases be carried out with much care, the strokes be made both during inspiration and expiration, and they must be made with the fingers of the medical man in exactly the same position, otherwise fallacious results will be produced. The lateral regions of the chest often yield more valuable results on percussion than either the front or the back of the thorax. The outlines of the thymus gland are often difficult to define; but the presence of the organ must be kept constantly in view whilst auscultating the infantile thorax. In the case of young infants only a slightly resonant note is obtained on percussion. Vogel points out that when we percuss the lungs posteriorly in a child under three years of age, we get during calm breathing a sonorous, feeble, or strong tympanitic note; but if the child become restless there is a change, a moderately dull percussion sound prevails over the left lung, and a flat, empty sound over the right lung, up to the spines of the scapulæ. The strong abdominal pressure has forced upwards the viscera, and especially the liver, and therefore the histories of basal pneu-

monias in infancy are to be received with caution, unless percussion has been practised during quiet respiration.

The percussion of the lungs in infancy is, nevertheless, of great value if the above-mentioned peculiarities be borne in mind, and if it be remembered that, from the presence of the "cracked-pot sound" alone, the diagnosis of a cavity cannot be made in childhood, that dulness is more common at the apex than at the base of the lung in infantile pneumonia, and that tubercular phthisis with large cavities is rare in early life. The percussion of the heart dulness is a difficult procedure in infancy, but it is a method of diagnosis which ought not to be omitted if there are signs of cardiac dilatation or hypertrophy; and by keeping in mind the anatomical relations of the heart to the chest wall at this time of life, reliable information can be thus obtained.

CHAPTER V.

THE ANATOMY OF INFANCY—Continued.

THE ANATOMY OF THE REGION OF THE ABDOMEN—CLINICAL EXAMINATION OF THE ABDOMEN IN THE INFANT.

The comparatively small size of the face, thorax, and pelvis of the infant gives to the region of the abdomen the appearance of disproportionate largeness; but the abdomen is also really voluminous on account of the normally large size of the liver. It is not uncommon to find the abdomen pathologically enlarged in children from tabes mesenterica, ascites, distension of the bladder, etc., and among the specimens dissected examples of these different conditions were found.

The Umbilicus (Plates V., VI., VII., and IX. Fig. 1).—At birth, and for about a week afterwards, there is found attached to the abdomen the portion of the umbilical cord left after ligature and section. The point of insertion of the umbilical cord into the anterior abdominal wall of the infant differs in its relative position from that of the umbilicus in the adult condition. It is usually stated that during the first two years of life the umbilicus occupies the central point of the body (M'Clellan, *Keating's Cyclop. of Dis. of Children*, i. p. 30); but I have found it more commonly to be placed a little nearer to the feet than to the cephalic vertex in the infant. If the total length of the infant be 50 ctms., then the umbilicus will be distant from the vertex 27 or 28 ctms. As the child grows older, and as the legs lengthen, the central point of the body is found to come near to, and ultimately to coincide with the pubes. In its relation to the vertebral column also the umbilicus differs somewhat in the infant. It is, in the normal infant, found to coincide in level with the disc between the fourth and fifth lumbar vertebræ, and to lie at, or a little above the level of the highest point in the iliac crests. In the adult the umbilicus is situated opposite to the lower border of the third, or the upper border of the fourth lumbar vertebræ, and is, therefore, fully one vertebra higher than in the infant.

On the internal aspect of the anterior abdominal wall in the infant the component parts of the umbilical cord can be distinctly seen. The umbilical vein passes upwards in the falciform ligament of the liver (Plate VII.), and sometimes shows in its course a rounded swelling containing blood clot, of about the size of a marble; the two arteries of the cord pass downwards to the bladder, and diverge as the hypogastrics to join the internal iliac arteries, which, in the infant, appear as if they were the branches and not the parent trunks of the umbilical arteries, and the urachus passes downwards in the middle line to the apex of the bladder.

On the fourth or fifth day after birth the portion of umbilical cord left after section drops off, leaving a raw surface—the umbilical cicatrix. The umbilical cicatrix at first projects slightly above the surrounding skin of the abdomen; but as shrinking takes place from the hyaline and later fibrous changes which occur in the umbilical arteries and vein inside the abdomen, the navel is drawn inwards and forms the umbilical depression.

Certain outstanding peculiarities in the relation of the abdominal viscera are revealed when the abdomen is opened. The very delicate transparent character of the great omentum is noteworthy (Plate VII.); but the most striking feature is found in the large size of the liver. Roughly speaking, it may be said that the liver occupies nearly one-half of the abdominal cavity. Ribemont demonstrates its position and size as follows:—A plane passing along the inferior surface of the liver divides the abdomen into two compartments, pyramidal in form and nearly symmetrical. The one has its base above, occupying the right hypochondrium and the epigastric region, whilst its apex is turned toward the iliac crest of the same side. This compartment contains the liver. The other, with base inferior, and apex turned towards the posterior part of the left hypochondrium, contains the intestinal coils, the spleen, and the stomach. The liver extends vertically from the diaphragm to a point some millimetres above the left iliac crest, and from the right hypochondrium to the left in a transverse direction. Ribemont's description in the main agrees with what the dissections and frozen sections show; but I have not in any case found the lower limit of the liver to be so near to the right iliac crest as he makes it. Doubtless there are considerable individual differences in the size of the liver within the limits of health in children.

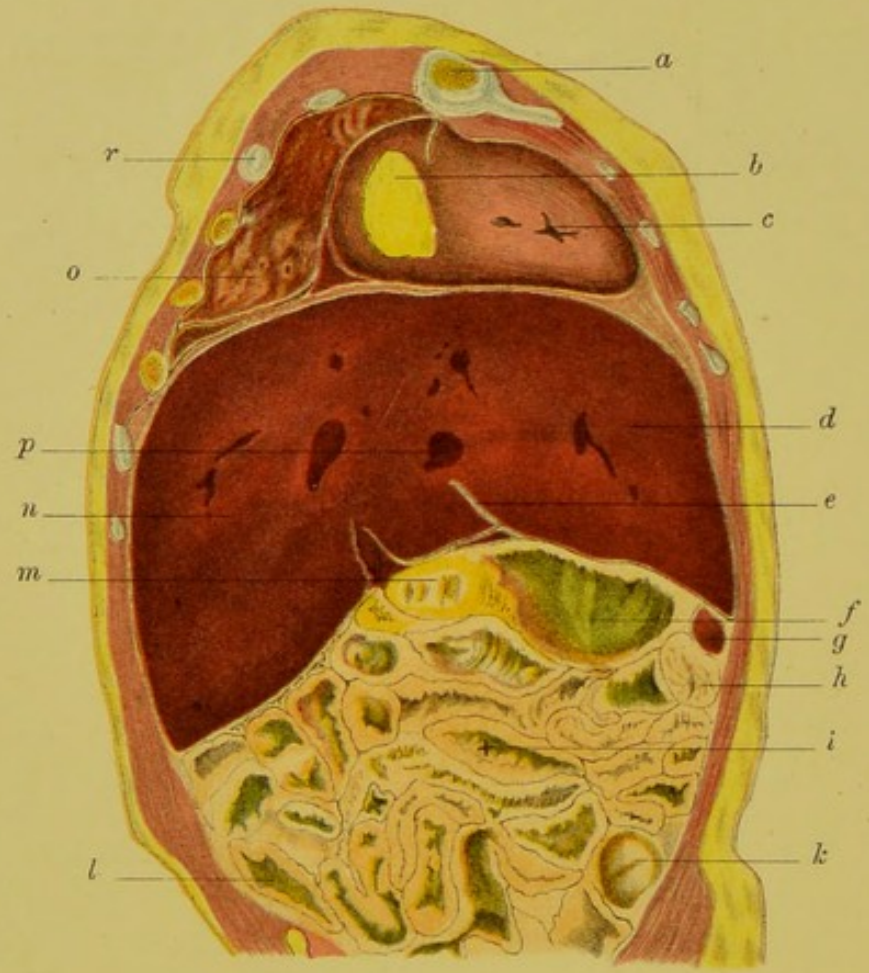
Upon the subject of the Form of the Liver the sectional method

by freezing has thrown an immense amount of light. Dr Symington, in a masterly paper on the liver in the adult (*Edinburgh Med.-Chir. Soc. Trans.*, vol. vii. p. 53), showed that most erroneous notions prevailed with regard to the form and surfaces of the liver. When removed from the body and laid upon a plate, the organ seems to have only two surfaces, an upper and an under; but when hardened by freezing and studied *in situ*, the liver at once appears with at least five surfaces. The liver may be roughly compared to a jelly made by a cook which has not set properly, and which when turned out upon a plate collapses: no one can tell the original form of the jelly from the flattened mass on the plate. As seen in frozen sections, sagittal and coronal, the liver is found to possess five surfaces:—a posterior pointed out by His in 1878; a superior; an inferior; and an anterior and a right, as demonstrated by Symington in his paper above referred to. The inferior surface is more correctly termed left inferior, for it is directed not only downwards, but very markedly towards the left side. Now, these hepatic surfaces which are present in the case of the adult liver, are all particularly well defined in the case of the infantile organ, and can be recognised with the greatest ease. Some of my sections have led me to describe a left surface in addition to the others (Plate VI. Figs. 1 and 2), but I am not certain that this surface is constantly present in all infants.

Looking upon the liver, therefore, as "a right angled triangular prism with the right angles rounded off," we find that it shows five, or in some cases six surfaces. From the consideration of sagittal, coronal, and transverse sections of the abdomen, and from the subsequent building up of the liver from the separate sections, the relations of the various surfaces can be accurately described. *The superior surface* (Plates I., V., and VI.) is in contact with the diaphragm to which it is accurately moulded, and has, therefore, a general convexity with a local concavity immediately underlying the heart. One of my sections might appear at first sight to be opposed to this statement, for in that specimen the left portion of the superior hepatic surface is as high on the left as on the right side; but in that case there was a hypertrophied spleen, which had pushed up the liver on the left side (Plate VI. Fig. 2). The superior surface is in infants very clearly marked off from the anterior surface, from the small posterior, and also from the left inferior surface; but the line of demarcation dividing it from the right surface is not so easily determined.

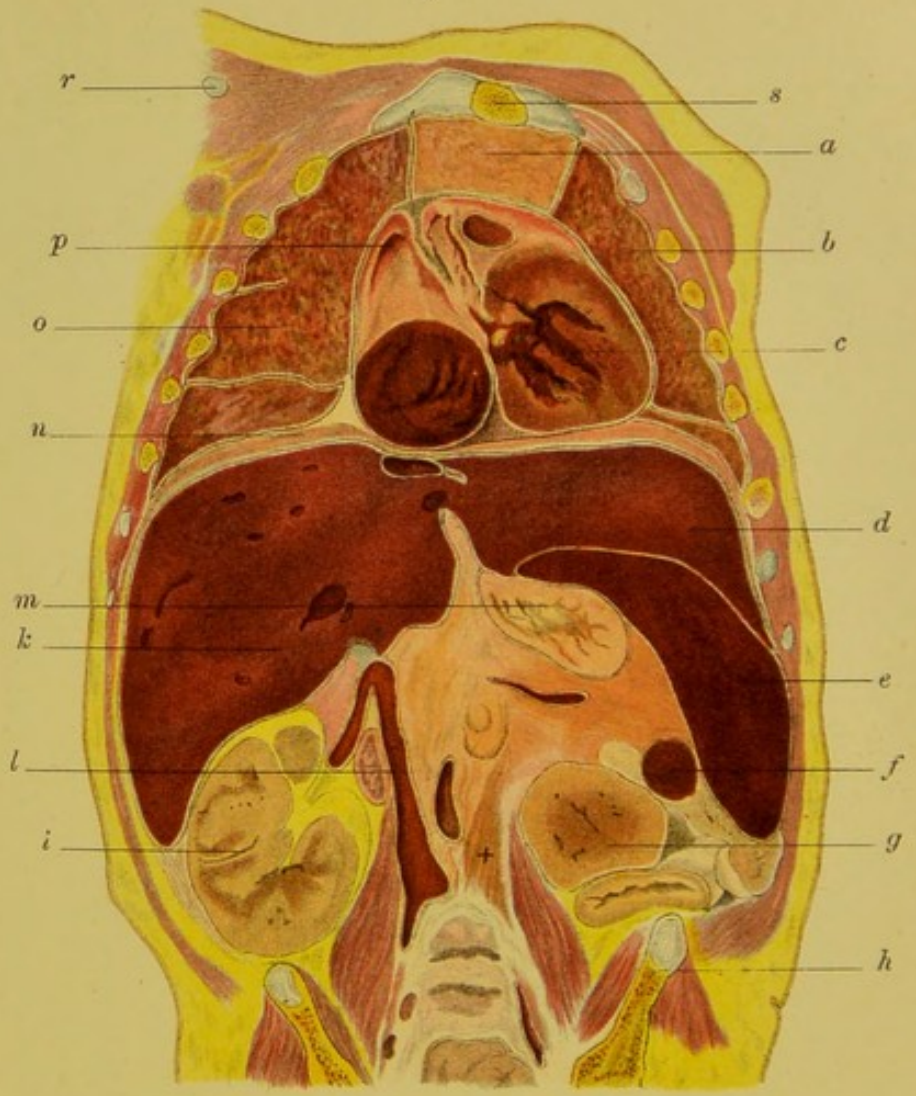
The *anterior hepatic surface* (Plates I. and V.) is a clearly marked

Fig 1



Coronal Section of Thorax and Abdomen of New-born Infant (§ *Natural Size*).

Fig 2



Coronal Section of New-born Infant, Thorax and Abdomen, posterior to Fig. 1 (§ *Natural Size*).

Plate VI

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PLATE VI.

Coronal Sections of Thorax and Abdomen of New-born Infant, $\frac{2}{3}$ natural size.

FIG. 1.—Coronal Section of Thorax and Abdomen in plane of Stomach.

a. Sternum, Third Ossific Centre.
b. Clot in Right Auricle of Heart.
c. Right Ventricle of Heart.
d. Left Lobe of Liver.
e. Longitudinal Fissure of Liver.
f. Stomach.
g. Spleen.
h. Transverse Colon.
i. Position of Umbilicus.
k. Sigmoid Flexure.
l. Cæcum.
m. Duodenum.
n. Right Lobe of Liver.
o. Right Lung, Middle Lobe.
p. Umbilical Vein.
r. Fourth Costal Cartilage (right).

FIG. 2.—Coronal Section of Thorax and Abdomen in plane posterior to that in Fig. 1.

a. Thymus Gland.
b. Left Lung, Upper Lobe.
c. Left Ventricle of Heart.
d. Left Lobe of Liver.
e. Hypertrophied Spleen.
f. Accessory Spleen.
g. Left Kidney.
h. Left Iliac Crest.
i. Right Kidney.
l. Vena Cava Inferior.
k. Right Lobe of Liver.
m. Stomach near Fundus.
n. Diaphragm.
o. Right Lung, Middle Lobe.
p. Opening of Superior Vena Cava.
r. Coracoid Process.
s. Manubrium Sterni.

one in the infant, and is divided from the left inferior surface by the thin so-called anterior border of the liver. This surface has, in the case of the adult liver, had its form compared to that of a right-angled triangle; but in the case of infants in whom there is a left hepatic surface the anterior surface of the liver is more quadrangular than triangular in shape. Even if the left hepatic surface be merged in the superior surface it will still make the triangular form of the anterior area in the infant; in the adult the left surface, on account of the relatively small size of the left lobe, is non-existent, and therefore the anterior aspect of the liver has a triangular form, the rounded right angle of which marks the meeting-point of the right and superior surfaces, whilst the hypothenuse of the triangle passes downwards and towards the right side. The anterior liver surface in the normal infant corresponds in its vertical extent in the middle line with the 9th, 10th, 11th, and 12th dorsal, and with the 1st and 2nd lumbar vertebræ, and its free border reaches to within 2 ctms. of the umbilicus. On the left side of the middle line the vertical extent of the anterior surface gradually diminishes in area, whilst on the right side it gradually increases, so that the border of the liver there comes to within 1 or 1·5 ctm. of the right iliac crest.

The *right surface* (Plate VI.) of the liver is the least clearly defined, for it is separated from the other surfaces (except the left inferior) by rounded, ill-defined borders; nevertheless it is present in both the adult and the infantile organ, although it is of much larger extent in the case of the latter.

The *posterior surface* (Plates I. and V.) is small, and is, like the right, not very clearly marked off from the others. It is, however, very evident in sagittal mesial sections. According to His, it includes the notch for the œsophageal end of the stomach, the posterior part of the longitudinal fissure containing the ductus venosus, the groove for the inferior vena cava, the lobus Spigelii, the depression for the supra-renal capsule, and that part of the right hepatic lobe above the kidney which lies in direct contact with the liver. It is a small surface, and corresponds in vertical extent with the 10th, 11th, and 12th dorsal vertebræ in the infant.

The *left inferior surface* (Plates I., V., VI., and VII.) is very clearly marked off from the others by the so-called anterior border of the liver and by the groove anterior to the lobus Spigelii. It is a large surface, and is in relation with many organs which leave impressions upon it easily recognisable in frozen sections and in

hardened specimens. The organs in contact with this surface are the stomach, the spleen, part of the supra-renal bodies, the duodenum, transverse colon, the hepatic flexure of the colon, and some of the coils of small intestine lying in the upper part of the abdominal cavity. On this surface lie, as every student of anatomy knows, the longitudinal and transverse fissures, and that for the gall bladder; and the area is made up of the under surfaces of the right and left lobes, and of the quadrate and caudate lobes of the liver. The *left* hepatic surface (Plate VI.), which is sometimes, but not always, found in the infantile organ, is ill defined, and has, for the sake of comparison with the adult liver, been merged in the upper surface.

The *relative size* of the various liver surfaces is of some importance, and in estimating their limits I have followed the directions laid down by Symington. In two normal cases the superficial extents of the various surfaces were ascertained to be as follows:—

	Case I.	Case II.
Anterior surface—transverse extent,	9·5 ctms.	9·5 ctms.
So-called anterior border,	15·0 ,,	15·2 ,,
Superior surface—transverse extent,	8·7 ,,	8·8 ,,
,, ,, antero-posterior extent,	2·7 ,,	2·0 ,,
Right surface—vertical extent,	5·5 ,,	4·8 ,,
,, ,, antero-posterior extent,	3·8 ,,	3·5 ,,
Posterior surface—vertical extent,	3·3 ,,	3·0 ,,
,, ,, transverse extent,	5·7 ,,	5·3 ,,
Left inferior surface—transverse extent,	9·2 ,,	10·0 ,,
,, ,, ,, antero-posterior extent,	4·2 ,,	3·3 ,,

From the foregoing table it will be seen that the anterior and left inferior surfaces were the largest. The superior right and posterior surfaces showed much smaller areas. The surfaces come in order thus: anterior, left inferior, superior, right, and posterior.

With regard to the above description of the characters and extents of the various surfaces of the liver, it may be said *cui bono?* The answer is not difficult to find. If the clinical investigation of the abdominal viscera in the infant is to reach the same state of perfection as that in the adult, then it is necessary that the relations and dimensions of all the parts to be palpated or percussed be accurately ascertained in normal cases.

In Dr Symington's paper above mentioned, allusion was made to displacement of the liver due to distension of the stomach; in none of my specimens was the stomach distended, but in one case (Plate

VI. Fig. 2) there was hypertrophy of the spleen, and in that instance there was a displacement of the liver similar to that described by Symington. The liver as a whole was rotated towards the right side on a vertical axis passing through the inferior vena cava, and the left lobe of the liver was also pushed slightly forwards and upwards. The displacement was easily ascertained by comparing the line of attachment of the falciform ligament to the liver with the middle line of the body.

The lobes of the infantile liver differ in relative size from those in the adult organ. Both the right and the left lobe is very large, and the lobus Spigelii is of extremely variable dimensions. The longitudinal fissure is very large in the infant, and contains the umbilical vein and the ductus venosus. In one specimen there was found a very large pons hepatis bridging over the anterior part of this fissure.

In all the still-born infants dissected by me, and in one infant who died on the sixth day of life, the gall bladder was found to be distended with bile (Plate VII.). The liver in the infant has a darker colour than in the adult, and its weight in relation to the general body weight is as 1 to 18.

The explanation of most of the peculiarities in the anatomical relations of the abdominal viscera in the infant is to be found in the large size of the liver at that period of life.

The Stomach.—It has been frequently stated that in the case of the new-born infant that has not breathed, the walls of the stomach are in close contact, the gastric cavity being only potential; but in all the cases examined by the sectional method there was a real gastric cavity containing frothy, watery mucus (Plates V. and VII.). In the case of the infant that died six days after birth (Plate VI. Fig. 1), the stomach contained milk, mucus, and air bubbles; this infant died suddenly from heart clotting.

In one of the still-born infants there was a small quantity of meconium in the stomach, and in this case there had been great delay in the labour and forceps had been used. It is, of course, difficult to say how far post-mortem changes may serve to account for these conditions of the stomach contents, and medico-legal proofs of "live-birth" founded upon the state of the contents of the stomach are apt to be fallacious.

The stomach is small in size at birth, and can contain only 1 or $1\frac{1}{2}$ oz.

of fluid without being over distended. During the first two months of life there is a rapid increase in gastric capacity; but thereafter the increase is slow.

Symington does not believe that the stomach in the new-born infant differs in form from that in the adult; but my specimens have led me to believe that the fundus of the stomach is relatively small at birth, and that the lesser curvature forms a more acute angle than in the adult organ (Plate VII.). The upper part of the lesser curvature runs vertically downwards and slightly forwards, and then turns sharply round to the right, forming an angle which is smaller than a right angle. The vertical position of the lesser curvature is now by many anatomists regarded as normal even in the adult stomach, and yet it is still described in many text-books as the upper curvature. It is certainly not the upper border in the infant's stomach; there the fundus is distinctly the highest part of the viscus. As regards position, in all the cases examined the stomach lay entirely to the left of the middle line, the pylorus being situated immediately in front of the body of the 1st lumbar vertebra (Plate I.). It must be remembered that in none of these cases was the stomach greatly distended. In all the specimens also, the stomach lay entirely under cover of the liver; hence on opening the abdomen of the new-born infant one must not expect to see the stomach until the liver be raised. The anterior relations of the stomach were with the left inferior surface of the liver; whilst posteriorly the viscus was in contact from above downwards with the anterior surface of the spleen, the left supra-renal capsule, the upper end of the left kidney, and with the tail and body of the pancreas. Below the greater curvature of the stomach was the transverse colon. The lesser curvature runs at first parallel to the left side of the vertebral column, and then turns to pass transversely to the right side in front of the spine. The relations of the stomach with the left kidney are not extensive in the infant, for the large adrenal of that side intervenes.

The well-known ease with which an infant vomits has found many explanations; but, to my mind, it is chiefly due to the fact that the stomach is surrounded on all sides by firm resistent organs. In front lies the liver, and behind are the spleen, supra-renal body, and kidney; and therefore any increase in abdominal pressure will tell with greater effect upon the stomach thus surrounded, than if it

were in contact with the more resilient anterior abdominal wall (Fig. 2). It may be also, as is suggested by Gubaroff (*Arch. f.*

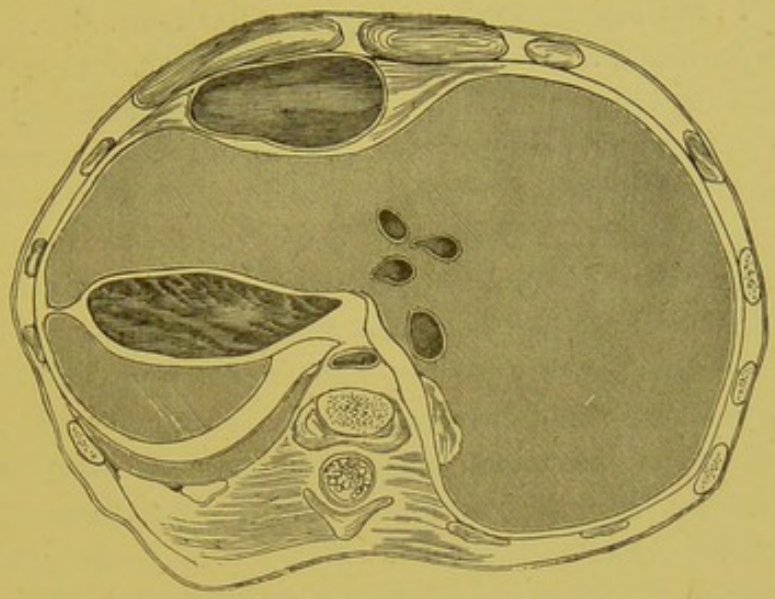


Fig. 2.—Transverse section of upper part of Abdomen and lower part of Thorax, showing stomach situated between the liver and the spleen.

Anat., 1886), that the valvular action of the cardiac end of the stomach is weak in new-born infants.

The Intestines.—The Small intestine, according to Treves, measures 9 ft. 5 in. in length at birth, and grows about 4 ft. in the first two months of life; but it is very probable that the length varies considerably in different infants. The duodenum is continuous with the pyloric end of the stomach in the middle line of the body, and opposite to the body of the 1st lumbar vertebra (Plate I.). The duodenum, in its three parts, has the same relations with the pancreas as in the adult, for it forms a curve with an internal concavity in which lies the head of that organ. The third part of the duodenum crosses over the vertebral column at the level of the 2nd lumbar body, and so reaches the left side of the middle line, where it becomes continuous with the commencement of the jejunum. The jejunum and ileum are less fixed in position than the duodenum; in the new-born infant they contain, as a rule, a little meconium, and they call for no further special notice.

The Large Intestine.—In the infants which were examined by the frozen sectional method, there were several peculiarities in the arrangement of the large intestine, and it will be necessary to study these cases in some detail. The cæcum and ascending colon first

call for description. In two cases (Plate VI.) the cæcum was found in the position which it occupies in the adult, that is to say, in the right lumbar and right iliac regions. In one of these cases (Plate VI. Fig. 1) the cæcum was found lying a few mms. above the crest of the right ilium, at which point it became continuous with the termination of the ileum by the small rounded aperture known as the ileo-cæcal valve. It was firmly fixed to the anterior surface of the iliac fossa, and to the posterior abdominal wall in the right lumbar region above the right iliac crest. Thence the ascending colon passed upwards and towards the left side into the immediate neighbourhood of the gall bladder on the under surface of the liver, where there was a feebly marked hepatic flexure. This infant had lived for five days; and consequently the intestine contained only a small quantity of meconium, and was not in a distended condition. The vermiform appendix was more conical in form than in the adult condition, the base of the cone was attached to the bowel, the appendix was 3·1 ctms. in length, was twisted upon itself, and was firmly attached to the outer surface of the cæcum by a thin piece of mesentery.

In the other case the cæcum was situated in the right lumbar region, 1 ctm. above the level of the right iliac crest, and lay, therefore, at a higher level than in the preceding case. The ileo-cæcal valve was 5 mms. in diameter, and the ileum opened into the cæcum at an acute angle. The cæcum was largely distended with meconium (the infant was still-born), and was firmly attached by a short mesentery to the posterior abdominal wall in the right lumbar region. There was a well-marked appendix vermiformis coming off in a conical manner from the cæcum; it measured 4 ctms. in length, and was, as in the former case, firmly attached to the cæcum by a thin mesentery. The appendix was also folded upon itself. The ascending colon passed upwards, along the right lateral abdominal wall, to the under surface of the right lobe of the liver at the border separating the right surface from the left inferior; at this point there was a well-marked hepatic flexure. In this case, therefore, the arrangement of the cæcum and ascending colon closely resembled that found in the adult, with the single exception that the cæcum lay at a level slightly superior to what it occupies normally in the adult. In the former case, whilst the cæcum was practically in the position in which it is found in the adult, the course of the ascending colon upwards and slightly to the left into the neighbourhood of the gall-

bladder and head of the pancreas showed that this portion of the bowel had a position which is normal at the stage of intra-uterine life, before the complete revolution of the large intestine round the axis of the superior mesenteric artery has taken place.

In yet a third case (Plates I. and V.) a state of affairs still more closely resembling the embryonic disposition of the cæcum and ascending colon was found, for in this infant (also still-born) the cæcum lay in the middle line of the body, at the level of the umbilicus in front, and of the fifth lumbar and first sacral vertebræ behind, rested upon the posterior surface of the bladder, and was in contact with the anterior surface of the spinal column (Plate IX. Fig. 1). The ileo-cæcal valve lay at the level of the lower border of the last lumbar vertebra. From the cæcum the ascending colon passed almost vertically upwards to the liver, with which it came in contact in front of the pancreas and first part of the duodenum, and there formed the hepatic flexure. In this case, therefore, the ascending colon lay only a few mms. to the right of the middle line, whilst the cæcum lay in the middle line and extended slightly to the left side of it. The ileo-cæcal valve lay, as nearly as might be, in the exact middle line of the body behind the umbilicus. There was, therefore, here an arrangement of parts very closely simulating that found in the embryo before the cæcum and ascending colon of the primitive intestine have taken up their mature position in the right lumbar and right hypochondriac regions. It is usually stated that in the process of development the cæcum, after crossing over the small intestine, passes to the right hypochondrium, and then pushes downwards into its ultimate position in the right lumbar and right iliac regions; but my cases, above recorded, go to support the view of the development of the colon stated by Bruce Young (Cleland's *Memoirs of Anatomy*, vol. i. p. 81) in the following words:—"The portion of colon from which in normal circumstances the ascending and right half of the transverse colon are developed, already exists as part of the primary loop before the twist of the intestine to the right occurs, so that when the rotation does take place it is the whole loop with its peritoneal surroundings which revolves round the superior mesenteric artery, until the cæcum lies in the lower part of the right lumbar region; a slight downward growth is then all that is needed to carry it into the adult position."

The above-named anatomist records the case of an adult male in whom the cæcum projected into the pelvis, and with the lower part of

the ascending colon lay free on the *left* side of the middle line. The ascending colon passed upwards on the left side of the middle line, and in contact with the anterior abdominal wall, to the upper end of the duodenum; it then turned abruptly to the left, descended as low as the left iliac fossa, and then passed upwards again in a series of closely packed convolutions to reach the splenic flexure. The descending colon, he states, ran normally into the sigmoid flexure and rectum. In this case the loop of bowel descending from the neighbourhood of the duodenum to the left iliac crest was regarded as part of the ascending colon, and, therefore, according to this view, there was no transverse colon at all; but, for reasons to be stated immediately, I am inclined to regard this loop as transverse colon displaced downwards and to the left.

Dr Bruce Young's case, taken in conjunction with the three just described, represents gradations in abnormality from the degree in which the cæcum and ascending colon lie entirely to the left of the middle line to that in which there is only a slight displacement of the cæcum. In Bruce Young's case both cæcum and ascending colon lay to the left of the middle line. In my case (Plate IX. Fig. 1) the cæcum lay in the middle line behind the bladder, and the ascending colon passed upwards, lying only a few millimetres to the right of the middle line. In another case (Plate VI.), the cæcum was approximately normal in position; but the ascending colon passed upwards and towards the left side till it reached the second part of the duodenum and head of the pancreas. And in yet another case the ascending colon may be said to have been normal in position, but the cæcum was situated at a slightly higher level than was normal in the adult. In the four cases there were, therefore, four stages in the process of rotation of the ascending colon and cæcum from their primitive position in the left of the middle line to their adult position in the right iliac, lumbar, and hypochondriac regions. Dwight, also, in his *Atlas*, shows the cæcum in a three-year old child lying on the right side at the level of the umbilicus; and he says, "I doubt very much if, as a rule, the cæcum has reached its permanent position at birth, and think that not very rarely it does not reach it for a year or two afterwards." My specimens seemed to support Dwight's conclusion; but, on examining a further series of new-born infants, I found that the cæcum was perfectly normal in position, and the only conclusion which it is, therefore, permissible to draw is that the cæcum and

Fig 1

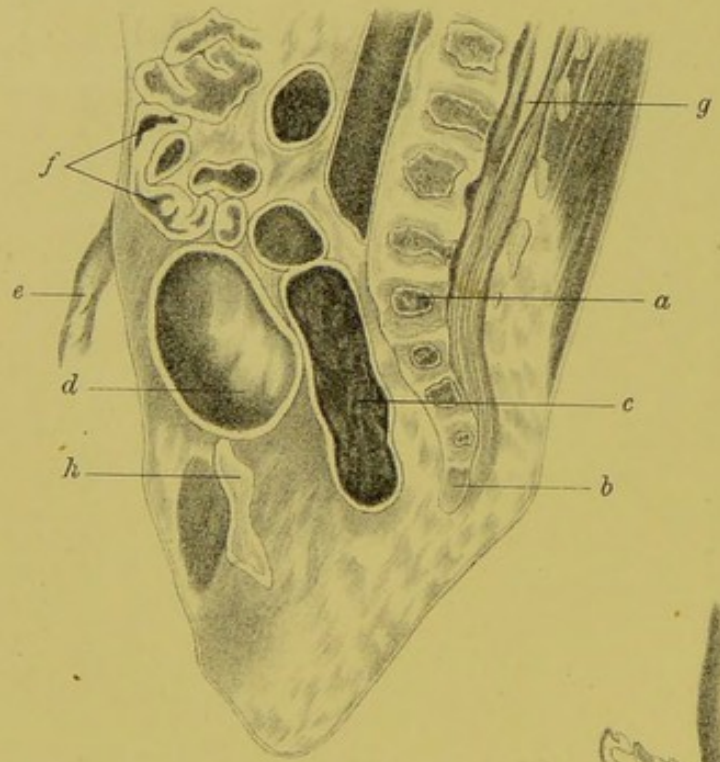
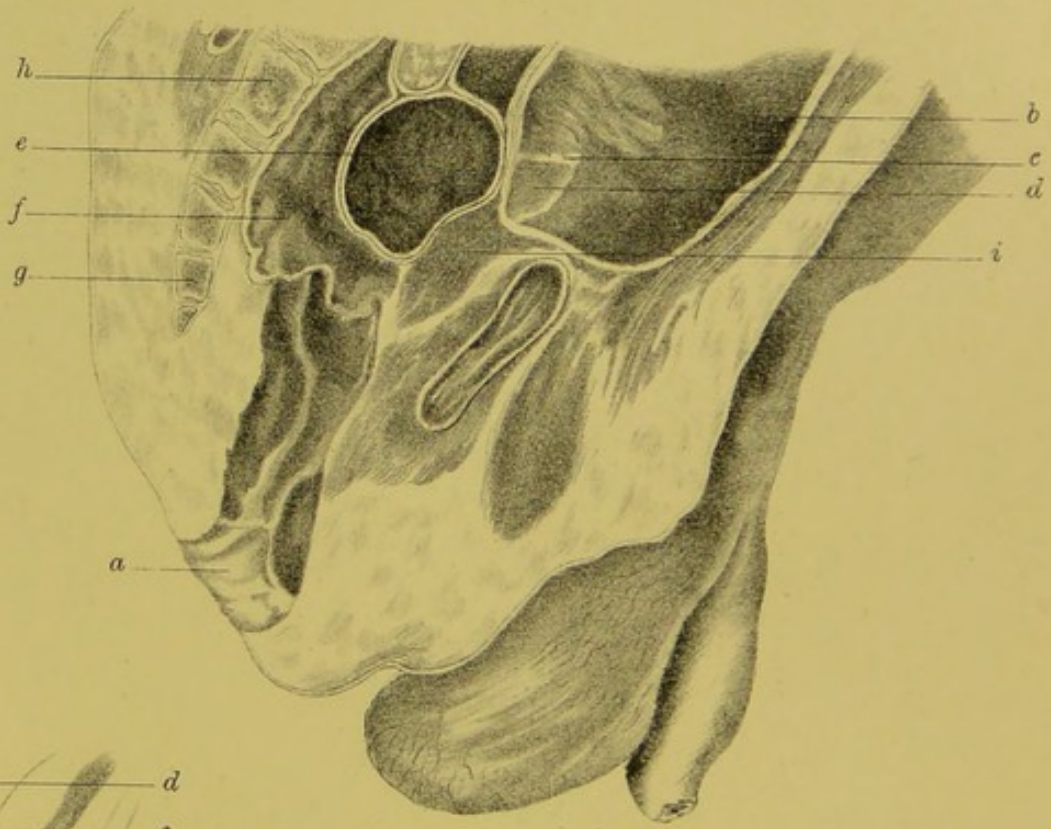


Fig 2



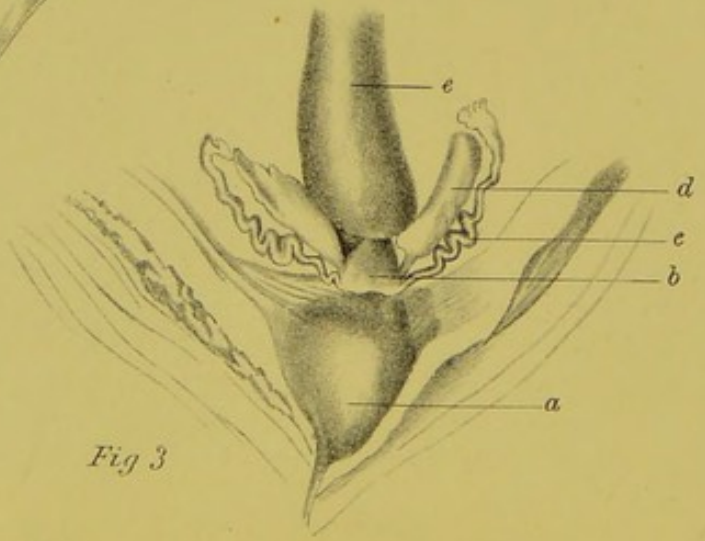


Fig 3

Wm CATHIE, DEL. ET LITH.

Plate VIII.

PLATE VIII.

FIG. 1.—Vertical Sagittal Section of Pelvic Region in six months' male Fœtus.

a. First Sacral Vertebra.
b. Coccyx.
c. Rectum.
d. Bladder, distended with Urine.
e. Umbilical Cord.
f. Coils of Large Intestine.
g. Filum Terminale of Spinal Cord.
h. Pubic Bone.

FIG. 2.—Vertical Sagittal Section of Pelvic Region of full-time male Infant (section slightly to right of middle line anteriorly).

a. Anal Aperture.
b. Bladder, greatly distended with Urine.
c. Opening of Left Ureter.
d. Vesical Trigone.
e. Loop of Sigmoid Flexure in Pelvis.
f. Rectum.
g. Coccyx.
h. Third Sacral Vertebra.
i. Prostate Gland.

FIG. 3.—Dissectional View of Pelvic Viscera in six months' Fœtus from above and from the front.

a. Bladder.
b. Fundus Uteri.
c. Left Fallopian Tube, showing tortuosities.
d. Left Ovary.
e. Rectum.

ascending colon have frequently, at the time of birth, a position more or less removed from that which they normally occupy in the adult.

The Transverse Colon (Plates I. and V.).—In the specimens already described, in which the cæcum and ascending colon were abnormally situated, the transverse colon also had an unusual arrangement. Instead of passing simply across from the hepatic to the splenic flexure, the transverse colon passed downwards in the form of a loop to the level of the left iliac crest; and then it turned upwards again, lying in front of the descending colon, to become continuous with the splenic flexure. In the case of infants in whom the cæcum was normally situated, the transverse colon did not form this accessory loop lying superficial to the splenic flexure and descending colon; but its occasional occurrence, in association with malposition of the cæcum, ought to be borne in mind by the abdominal surgeon.

The Descending Colon was found in all cases to have the same relations in the infant as in the adult; but the *sigmoid flexure* has, in the infant, a peculiar arrangement, which is well worthy of note. It is relatively large at the time of birth, becomes continuous at the level of the left iliac fossa with the lower end of the descending colon, and terminates, after having described one or two curves, in the first part of the rectum. In all the cases examined by the sectional method (Plates VIII. and IX.) a loop of the sigmoid flexure was found lying below the brim of the pelvic cavity, and posterior to the bladder in the male and to the uterus and annexa in the female infant. This loop of the sigmoid flexure is usually situated a little to the right of the mesial line in the pelvis, and to its presence in the narrow infantile pelvis has been ascribed a very obstinate form of constipation in the infant, which has in consequence been named anatomical constipation. I know not whether the presence of a loop of sigmoid flexure in the pelvis is a constant occurrence in infancy or not (Jacobi makes the statement that "the sigmoid flexure is bent upon itself several times in the narrow pelvis of the infant"); but it is well known that this part of the bowel is relatively long at birth, and that it has a rather long meso-sigmoid.

The Spleen (Plates V. and VI.).—Luschka describes the adult spleen as possessing three surfaces—a phrenic, a gastric, and a renal; but this description will not suffice for the infantile spleen. In the

infant, the liver comes into contact with the spleen behind and external to the stomach; in fact, in one case the spleen was entirely hidden by the left lobe of the liver, and lay in a concavity on the left inferior surface of that organ. Further, in the infant the spleen has a direct relationship with the left supra-renal capsule instead of with the left kidney. The spleen in the infant may, therefore, best be described as having four surfaces; and these may be named gastric, hepatic, phrenic, and supra-renal. These surfaces are all clearly marked, and show the impressions of the organs which have lain in contact with them. Lateral sagittal sections serve to demonstrate these surfaces. Thus, in a section made a little to the left of the middle line three of the surfaces are seen—the phrenic posteriorly, the gastric in front, and the supra-renal inferiorly (Plate V.); but at a point further from the middle line all the four surfaces are visible—phrenic, posteriorly; hepatic, anteriorly; gastric, antero-internally; supra-renal, inferiorly. The antero-internal or gastric surface is in relation with the tail of the pancreas as well as with the stomach. If it be deemed advisable, the surfaces may be named according to the direction in which they point. Thus the phrenic surface becomes the posterior; the hepatic becomes the antero-external; the gastric and pancreatic surface becomes the antero-internal; and the supra-renal becomes the inferior surface. Near the middle line of the body the spleen shows three surfaces, and therefore vertical sections here represent the organ as triangular. Further to the left, however, there are four surfaces, and the spleen is there quadrangular in vertical section. In one case (Plate VI.) the spleen was much hypertrophied, and, therefore, in that case the antero-external surface came into contact not only with the liver, but also with the anterior abdominal wall; whilst the antero-internal surface was related to the stomach and pancreas, and also to the mesentery and splenic flexure of the colon, and to an accessory spleen (which was present).

The following table contains the measurements of the infantile spleen in two cases (A and D), in which it might be regarded as normal, and in one case (C) in which it was much enlarged:—

Surfaces.	Cases A. and D.	Case C.
Antero-external or hepatic—		
Vertical extent,	4·0 ctms.	6·1 ctms.
Transverse extent,	2·9 ,,	3·2 ,,
Length of anterior notched border,	3·9 ,,	5·3 ,,

Surfaces.	Cases A and D.	Case C.
Antero-internal or gastric surface—		
Vertical extent,	2·8 ctms.	5·5 ctms.
Antero-posterior extent,	2·2 ,,	1·9 ,,
Posterior or phrenic surface—		
Vertical extent,	2·6 ,,	4·5 ,,
Transverse extent,	1·4 ,,	2·0 ,,
Inferior or supra-renal surface—		
Vertical extent,	1·1 ,,	1·7 ,,

The antero-external or hepatic surface is, therefore, the largest; and it is interesting that in the infant at birth this large surface is under cover of the left lobe of the liver. As the stomach grows rapidly in size during the first weeks of life, the hepatic surface of the spleen is quickly encroached upon by the gastric surface of that organ; but at birth the hepatic surface is the largest, the gastric comes next, then the phrenic or posterior, and the inferior or supra-renal is normally the smallest. In the case in which the spleen was hypertrophied, it is interesting to note that the large size of the organ was chiefly due to increase in a vertical direction (Plate VI. Fig. 2).

The relations of the spleen with the surrounding viscera have been already in part described. The upper end of the organ reaches as high as the fundus of the stomach, *i.e.*, to the level of the 9th rib near its attachment to the spinal column. The posterior surface rests upon the diaphragm, and behind the diaphragm is the base of the left lung. The relations of the spleen to the liver, stomach, transverse colon, and splenic flexure, are well brought out in Plate VI. Fig. 2.

The anterior border of the spleen is sharp and notched, there being, in most cases, four notches—two close together and two further apart. None of the notches were deep in the cases examined.

The spleen is darker in colour in the new-born than in the adult, and is very easily torn.

The Supra-renal Capsules (Plate V.) are relatively large in the new-born infant, each being usually equal in size to one-third of the kidney. They have the form of a triangular pyramid; and each rests upon the upper end of the kidney, covering it like a cap. The base of the adrenal descends upon the kidney anteriorly to the level of the hilus of that organ, and is hollowed out to fit the renal convexity. The apex of the right adrenal lies between the liver and

the right crus of the diaphragm, at about the level of the 10th rib; that of the left is wedged in between the spleen and the left diaphragmatic crus at a point a little above the level of the 11th rib. The posterior surface rests upon the diaphragm at the side of the vertebral column; and anteriorly the right adrenal comes into contact with the left inferior surface of the liver, and with its posterior surface: whilst the left supra-renal gland is related to the spleen, stomach, pancreas, and small intestine. Antero-posteriorly the adrenal measures on an average 1 ctm., and its greatest transverse diameter at its base is 1·5 ctm. Its vertical diameter from apex to anterior border of base measures 3·5 ctms., to posterior border of base 1·5 ctm. It, therefore, descends to a lower level in front of the kidney than behind it.

The Kidneys (Plates V. and VI. Fig. 2).—These organs correspond in level with the 1st, 2nd, and 3rd lumbar vertebræ, with the disc between the 12th dorsal and 1st lumbar, and with that between the 3rd and 4th lumbar vertebræ. The right kidney measures about 3·8 ctms. vertically, the left about 3·5 ctms. The greatest antero-posterior diameter is from 1·5 to 1·8 ctms., and the greatest transverse about 2·3 ctms. It is usually stated that the left kidney is longer than the right, and is situated at a higher level in the abdomen; but I have not found this to be the case in the infant. The position of each kidney was practically the same, and in vertical measurement the right and not the left was the longer. The relations of the kidney to surrounding viscera are practically the same as in the adult, with the exception that the supra-renal capsule covers a greater part of its surface anteriorly (Fig. 3). The hilus of the kidney lies at the level of the 2nd lumbar vertebra. The renal lobulation is more marked at birth than in later life, but is not so distinct as it is in the fœtus. The lower end of the kidney reaches to within a distance of a few millimetres from the iliac crest.

The Pancreas (Plates I. and V.).—This viscus has the same relations with surrounding organs and vessels in the infant as in the adult. In the middle line, the head and commencement of the body of the pancreas lie opposite to the first and second lumbar vertebræ. The left renal vein crosses immediately behind the pancreas, the superior mesenteric vein and artery lie partly behind it and partly in its substance, and the first part of the duodenum and the transverse colon lie in front of it. From head to tail the

pancreas measures in the infant about 3·5 ctms., and the antero-posterior diameter of the head is a little over 1 ctm.

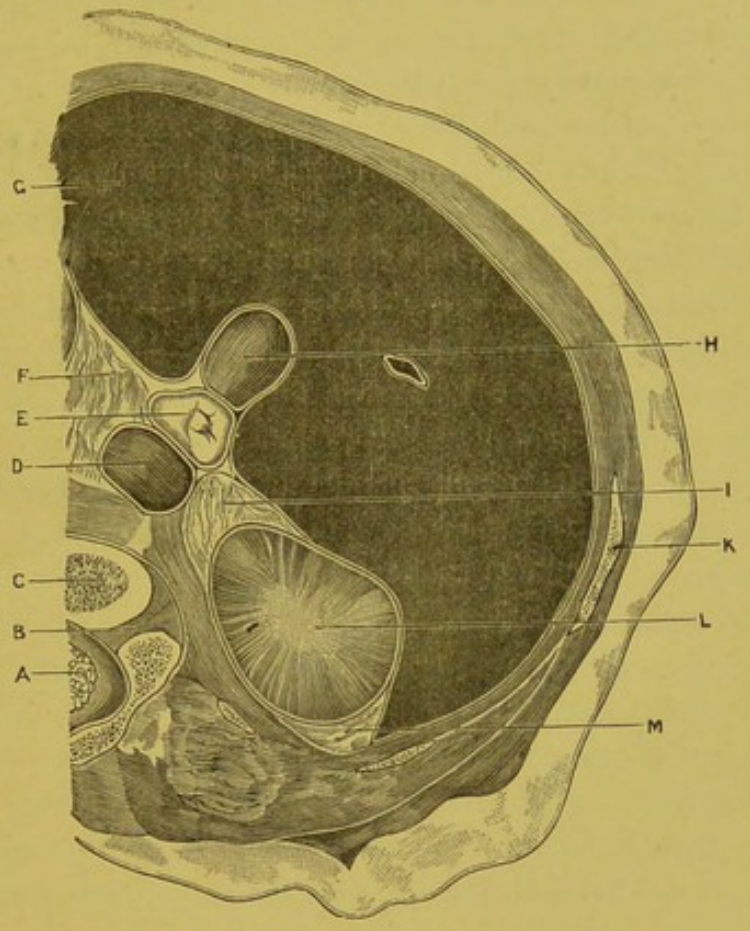


FIG. 3.—Transverse section of right half of Body at level of 1st lumbar vertebra.

A, spinal cord; B, neuro-central suture; C, 1st lumbar vertebra; D, vena cava inferior; E, second part of duodenum; F, pancreas; G, right lobe of liver; H, gall-bladder; I, right supra-renal capsule; K, 11th rib, L, right kidney; M, fat behind kidney.

Clinical Examination of the Abdominal Viscera.

If the physician keep constantly in mind the anatomical peculiarities of the abdominal viscera in the infant, he will be able more correctly to appreciate any deviations from the normal, and to discover the physical signs of disease in the abdomen. The clinical examination of the abdomen is often with difficulty carried out satisfactorily on account of the struggling of the infant, which renders tense the abdominal muscles, and, therefore, whenever it is practicable, the abdomen ought to be examined when the child is quiet, and preferably during sleep.

Inspection.—In the case of a new-born infant, the inspection of the abdomen will include the examination of the stump of the umbilical cord, for at this early time in life various pathological conditions of the cord may be present. There may be umbilical hernia, inflammation, ulceration, or hæmorrhage; or, again, small vascular growths may occupy the umbilical depression. The degree of prominence of the abdomen is readily apparent to the eye, and is usually very marked in tubercular disease of the abdominal viscera; but it is always necessary to remember that the abdomen is normally voluminous in the infant. The presence of fluid in the peritoneum gives an appearance of uniform distension to the abdomen, whilst tumour growths in the viscera cause localized swellings. Distension of the veins of the abdominal walls is often seen in tubercular disease, and in the rarer condition of malignant affection of the contained viscera. The abdominal walls may be found retracted or depressed, as occurs in acute tubercular meningitis. The skin of the abdomen also may reveal the characteristic eruptions of scarlet or typhoid fever, or the diffused redness of erysipelas.

Palpation.—In making abdominal palpation the hands ought to be warm, and ought to be firmly and continuously applied, for sudden movements cause contractions of the abdominal muscles, and so render impossible this method of examination. A time when the infant's attention is distracted by a bright object or by a toy ought to be chosen for the palpation of the abdominal viscera, and the pressure should be at first gentle, and then firm and deep. The condition of laxity or of tenseness of the abdomen can be more readily appreciated by palpation than by simple inspection; and if the tenseness due to struggling and crying can be eliminated, then the contracted condition of the abdominal walls points to inflammation of the peritoneum or of the bowels. In typhoid fever the phenomenon of gurgling in the right iliac region may be elicited. The presence of pain and tenderness on pressure is always established with difficulty in infants, for in them wincing on palpation is not uncommon even in perfect health; and, further, the absence of tenderness on pressure cannot always be said to exclude peritonitis. Diarrhœa, colic, and typhoid fever usually are accompanied by pain.

Palpation also enables the medical man to determine the position and size of the viscera, and the presence or absence of tumours. In palpating the liver its relations and large size must be kept con-

stantly in mind; and it must also be remembered that in some cases, as in rickets, it may appear to be abnormally large, whilst really it is only displaced downwards. It is a matter of some difficulty to palpate the spleen if that organ be normal in size; but if it be enlarged, and especially if it be displaced downwards as well, then it can be easily felt by the two hands of the examiner, one being placed posteriorly in the neighbourhood of the left false ribs, the other being firmly applied anteriorly. In great splenic enlargement the notched border can be easily felt, and the lower end of the organ may be found reaching as low down as the level of the symphysis pubis. The causes of splenic enlargement are various; but rickets, scrofula, malaria, and leukæmia may be mentioned as the most important etiological factors. The kidneys, if enlarged and also if displaced, may often be palpated; and it is also very necessary in many diseases to map out the mesenteric glands. These glands, which are typically enlarged in tabes mesenterica, and also in tubercular meningitis, will be found as hard lumps, which can, if care be exercised, be grasped between the fingers of the physician palpating firmly and deeply through the abdominal walls.

Percussion.—By percussion the physician is able to confirm the results of palpation, and more accurately to map out the levels of the various organs, tumours, or fluid collections in the abdomen. In young infants the attempt to percuss out the limits of the stomach will usually be unsuccessful, for in them this organ, unless considerably distended, lies under cover of the left hepatic lobe; and it must also be remembered that the great tension of the gas in the bowel in cases of distension may mask the tympanitic note, and cause even a certain amount of dulness.

CHAPTER VI.

THE ANATOMY OF INFANCY—Continued.

THE REGION OF THE PELVIS AND THE EXTREMITIES—CLINICAL EXAMINATION.

In the new-born infant the bladder, the Fallopian tubes, the ovaries and part of the body of the uterus cannot, with strict accuracy, be spoken of as pelvic viscera, for they lie above the plane of the pelvic brim; but as the child grows and the pelvis enlarges, these organs descend below the brim, and it is convenient for descriptive purposes to apply the term "pelvic" to these structures as well as to the rectum, cervix uteri, vagina, and urethra. The relations of the pelvic viscera in the infant are greatly influenced by the form and dimensions of the bony pelvis at birth, and it is therefore necessary to state briefly the characters of that part of the infant's skeleton.

The Pelvis.

The sacrum, which in the fœtal state is quite straight, is very nearly so in the infant at birth, having only a small anterior concavity. The wings of the sacrum also are but slightly developed, and hence the length of the bone is greater than its breadth. From several measurements I find the length of the sacrum to be on an average 2·7 ctms., and the average breadth to be 2·0 ctms.; thus the sacral index in the new-born infant is 76, and the sacrum, therefore, is markedly dolichohieric. In the adult, on account of the relatively large size of the sacral alæ, the platyhieric condition is arrived at, the sacral index being 112. The sacrum in the infant, therefore, resembles that bone in the bush Kaffir, in the Andamanese, in some Australian tribes, and also in the higher apes. The promontory of the sacrum is feebly developed at birth. The iliac bones, also, have in the infant an almost inappreciable anterior concavity, and the iliac fossæ can scarcely be said to exist.

The angle of devarication of the ilia is much greater at birth than in adult life. Cleland gives 86° as the angle of devarication at birth as compared with 50°·5 in the adult female, and 53° in the adult male skeleton. The following were the measurements of the interspinous and intercristal diameters in six infants' pelves :—

	Interspinous diameter.	Intercristal diameter.		Interspinous diameter.	Intercristal diameter.
Case 1,	6·2 ctms.	6·3 ctms.	Case 4,	4·8 ctms.	5·3 ctms.
,, 2,	5·5 ,,	6·0 ,,	,, 5,	5·5 ,,	6·0 ,,
,, 3,	4·8 ,,	5·2 ,,	,, 6,	4·9 ,,	5·4 ,,

In the adult female the average measurement of the interspinous diameter is 23 ctms., whilst that of the intercristal diameter is 25·5 ctms.

The rami of the pubic bones are stumpy, and, therefore, the symphysis is short. The primary ossific centres are present in the innominate bones, but they are separated by cartilage, and the acetabulum is principally cartilaginous.

The pelvis, as a whole, differs markedly from the adult condition. Superficial inspection is sufficient to show that the pelvic canal has a different form when compared with that in the full-grown pelvis. The canal is somewhat funnel-shaped, and the pelvic brim is very oblique to the horizon. The greater obliquity of the pelvis in the infant is seen in the relation which the promontory of the sacrum bears to the symphysis pubis. The promontory is situated at a much higher level as regards the symphysis in the infant than in the adult, and, therefore, the plane of the brim comes to run nearly perpendicularly to the horizon. On the other hand, a line drawn from the lower border of the symphysis pubis to the tip of the coccyx runs very nearly parallel to the horizon, and this fact demonstrates the absence of obliquity in the plane of the pelvic outlet.

Varying statements have been made with regard to the length of the various pelvic diameters in the infant. It is evident at a glance that the distance between the promontory of the sacrum and the upper border of the symphysis pubis (the conjugata vera) is greater than either the transverse or oblique diameters of the pelvic brim. In the adult pelvis, on the other hand, the conjugata vera is less than either the transverse or the oblique diameters of the inlet. In the infant the conjugata vera has an average length of 3·5 ctms., whilst the transverse diameter at the brim measures

about 2·5 ctms.; in the adult female pelvis the conjugata vera measures about 10 ctms., and the transverse about 12·5 ctms. In the infant, therefore, the brim of the pelvis is longer in an antero-posterior than in a transverse direction, whilst in the adult the transverse diameter at the brim exceeds the antero-posterior. It has, however, been pointed out that the conjugata vera in the infant does not truly represent the antero-posterior diameter of the pelvic brim, and that the true pelvic inlet is bounded posteriorly by the body of the 3rd, instead of that of the 1st, sacral vertebra. A line drawn from the upper part of the body of the 3rd sacral vertebra to the upper border of the symphysis pubis may be taken as representing the antero-posterior diameter of the brim, and this diameter has been called the conjugata vera inferior. Balandin, Fehling, Litzmann, and Veit, to whom we are indebted for most elaborate statistics of the pelvic diameters in the infant, take the conjugata inferior, and not the conjugata superior, as the antero-posterior diameter with which the transverse and oblique diameters at the inlet may be most usefully compared. I have measured the pelvic diameters in the case of six infantile pelves, and the results of these measurements are embodied in the following table:—

	I.	II.	III.	IV.	V.	VI.
Length of infant,	39 ctms.	42 ctms.	40 ctms.	42·5 ctms.	40 ctms.	42 ctms.
Conjugata superior,	3 „	3·6 „	3·1 „	3·8 „	2·9 „	3·4 „
Conjugata inferior,	2·1 „	2·6 „	2·6 „	3·0 „	2·0 „	3·0 „
Transverse diameter,	2·7 „	2·2 „	2·3 „	2·5 „	2·5 „	2·0 „
Oblique diameter,	2·5 „	3·1 „	2·5 „	3·0 „	2·6 „	3·1 „
Distance between ischial spines,	2·0 „	1·7 „	1·8 „	1·8 „	2·3 „	1·6 „
Antero-posterior diameter of outlet,	1·5 „	2·0 „	1·5 „	1·6 „	1·8 „	2·4 „
Distance between ischial tuberosities,	1·8 „	1·5 „	2·0 „	2·0 „	2·0 „	1·7 „

The smallest child measured 39 ctms. in length, and the largest 42·5 ctms. The average lengths of the diameters as obtained from the above table are as follow:—

Diameter conjugata superior,	= 3·3 ctms.
Diameter conjugata inferior,	= 2·55 „
Diameter transversa (at brim),	= 2·36 „
Diameter obliqua (at brim),	= 2·80 „
Distance between ischial spines,	= 1·86 „
Antero-posterior diameter (at outlet),	= 1·80 „
Distance between tuberosities of ischium,	= 1·96 „

The above figures represent the absolute lengths of the diameters. In the following table I have placed side by side the relative lengths of the diameters obtained by Balandin and by myself in the new-born infant, and by Litzmann in the adult female. The conjugata vera is represented by 100.

	Balandin, 14 pelves.	Ballantyne, 6 pelves.	Litzmann, in adult pelvis.
Conjugata vera, ...	100	100	100
Transversa at brim, . . .	105	92	129
Obliqua at brim, ...	108	109	120
Distance between ischial spines, .	75	72	96
Antero-posterior at outlet, . .	92	70	119
Distance between ischial tuberosities,	73	76	115

From the study of the foregoing table it will be seen that my figures agree with those of Balandin in showing that in the infant the longest pelvic diameter at the brim (leaving out of account the conjugata superior) is the oblique; but they differ in the fact that whilst Balandin gives the antero-posterior diameter as the shortest, my measurements would seem to show that the transverse is the shortest brim diameter. In the adult female pelvis, as every obstetrician knows, the shortest diameter at the brim is the antero-posterior, the longest is the transverse, whilst the oblique occupies an intermediate position. With regard to the distance between the ischial spines and that between the ischial tuberosities in the infant, my results tally with those of Balandin; but as regards the antero-posterior diameter of the outlet, my figures are larger than those obtained by Balandin. In the adult the three above-named diameters are all greatly increased in length, showing the extent to which the lower part of the pelvis opens up. In the adult female pelvis, therefore, the ischial tuberosities and the ischial spines are much more widely separated than in the infant, and the separation of the tuberosities is relatively greater than that of the spines.

It is thus easy to understand how several of the viscera which are pelvic in position in the adult come to lie above the brim of the pelvis at the time of birth. The bladder, rectum, and the uterus and annexa may now be conveniently studied in detail.

Pelvic Viscera.

The Bladder.—Symington, in the *Topographical Anatomy of the Child*, states that the description of the bladder in the new-born

infant given in the text-books of Anatomy is meagre, unsatisfactory, and even inaccurate, and with this statement I can fully concur.

Position of the Bladder.—The bladder of the infant is even when fully distended almost entirely an abdominal organ. In the six months' fœtus (a male) the bladder, which was distended with clear pale-yellow urine, lay, as will be seen in the drawing of the sagittal mesial section of the pelvis (Plate VIII. Fig. 1), almost entirely above the pelvic brim, only a small part of the posterior lower segment lying below that plane. In the case of a full-time male infant (Plate VIII. Fig. 2), in which the bladder was very greatly distended with urine, a still smaller part of the lower end of the viscus lay below the pelvic brim, in the plane of which lay the vesical openings of the ureters. In this specimen the section passes slightly to the right of the middle line, for it cuts through the right ureter at its point of entrance into the bladder. In the case of another full-time male infant (Plate IX. Fig. 1), in which the bladder was only partially filled with urine, the same relation of that viscus to the plane of the brim was found to exist. In this case the whole bladder cavity is not laid open, as the section was made considerably to the right of the middle line of the body. In the cases of three full-time female infants (Plate IX. Fig. 2), in all of which the bladder was empty, an almost inappreciable part of the vesical cavity lay below the plane of the brim. Symington states that fully half the bladder in the infant lies within the cavity of the true pelvis and below the plane of the brim. The specimens above mentioned do not show this disposition of the bladder, but in three of the cases (two male and one female) there existed a circumstance which may serve to explain the difference in position. This circumstance consisted in the presence of a loop of the lower end of the descending colon or of the upper end of the sigmoid flexure within the pelvic cavity, lying in the female infant in the right part of the utero-rectal pouch, and in the male infants in the recto-vesical pouch. In the other female infants the bladder was empty, and was not, therefore, distended at its lower end; and it must not be forgotten that in them there lay part of the *uterus* within the pelvic brim. In the case which Symington figures in his *Atlas* (p. 68), in which half the bladder lay in the pelvis, the infant was a male, therefore there was no uterus to fill up the brim; the bladder also was distended, and bulged backwards towards the sacrum; and,

Fig 1

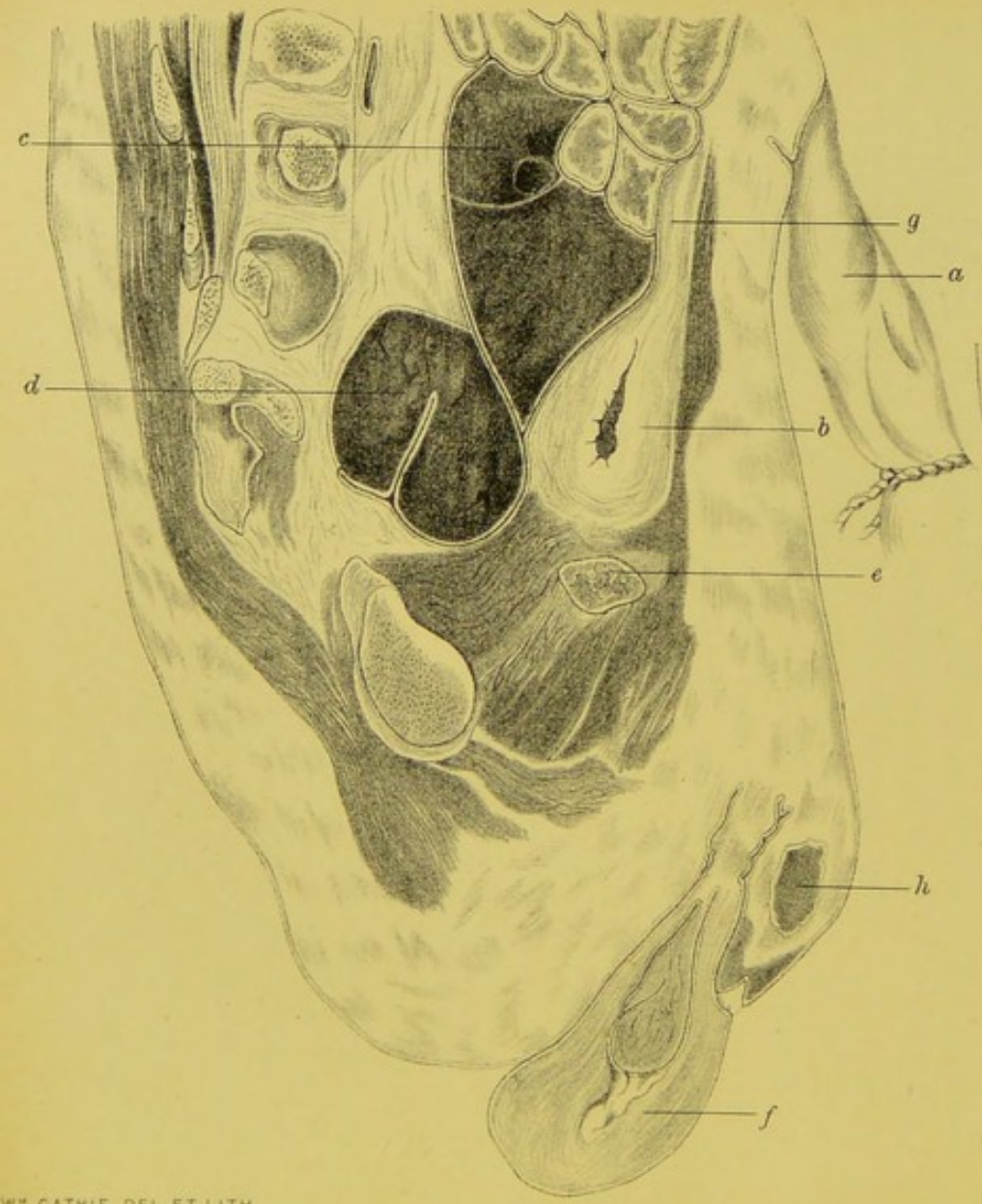


Fig 2

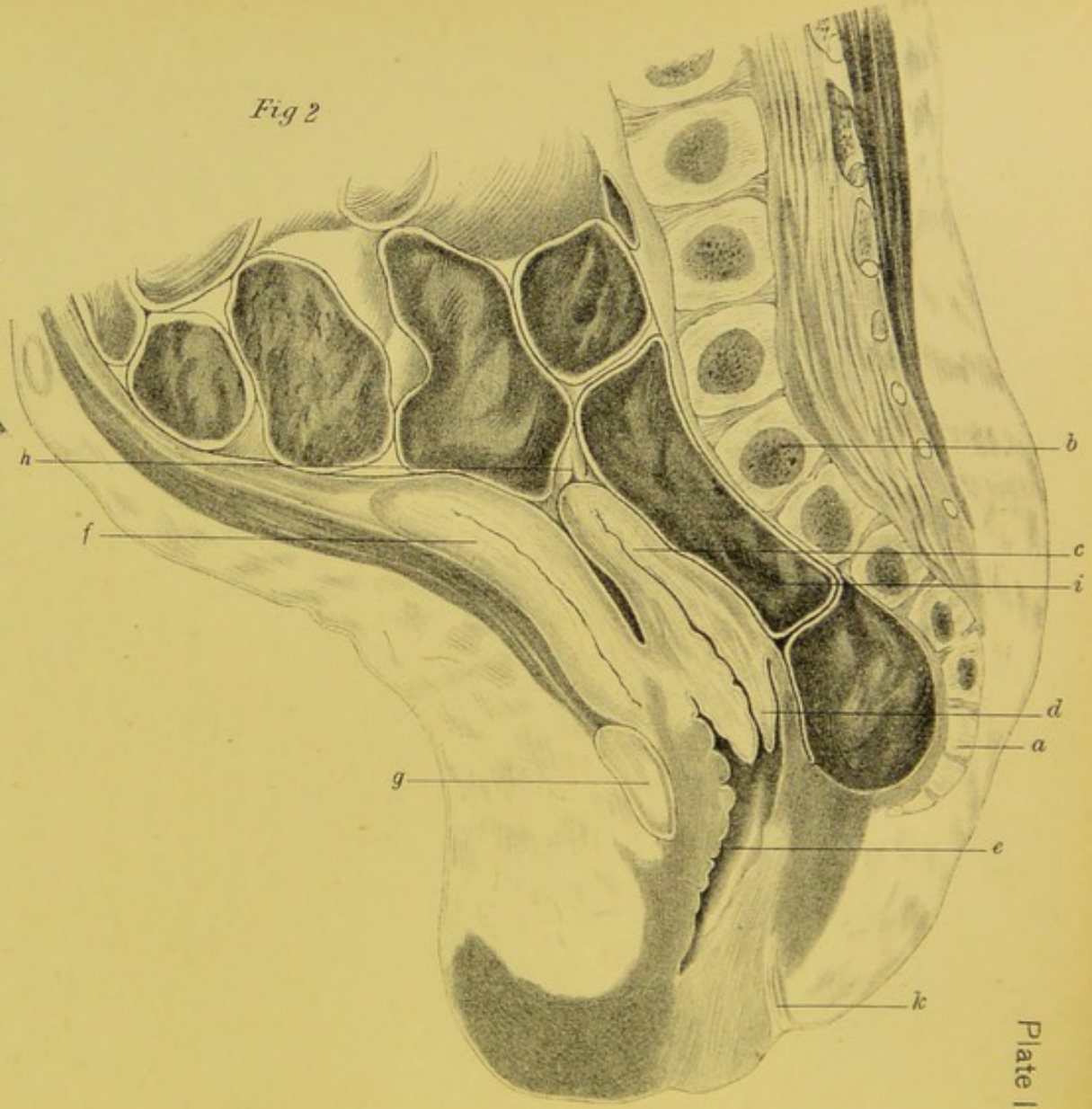


Plate IX.

W^m CATHIE DEL ET LITH.

PLATE IX.

FIG. 1.—Vertical Sagittal Section of Pelvic Region of full-time male Infant (still-born). Section is to the right side of the middle line.

a. Umbilical Cord.
b. Partially filled Bladder.
c. Cæcum and Ileo-cæcal Valve.
d. Loop of Sigmoid Flexure in Pelvic Cavity.
e. Pubic Bone.
f. Scrotum and Right Testicle.
g. Urachus.
h. Penis.

FIG. 2.—Vertical Sagittal Section of Pelvic Region of full-time female Infant (frozen in genu-pectoral position).

a. Coccyx.
b. First Sacral Vertebra.
c. Body of Uterus.
d. Cervix Uteri.
e. Vagina.
f. Empty Bladder.
g. Symphysis Pubis.
h. Right Ovary and Fallopian Tube.
i. Rectum.
k. Anal Aperture.

further, there was no loop of sigmoid flexure in the pelvis, the posterior vesical wall lying in contact with the rectum and the recto-vesical pouch being empty. If the pelvis contain in addition to the rectum a twist of sigmoid flexure, and more especially if the subject be a female, it is difficult to see where room can be found within the pelvis for fully half the bladder. In the case of male infants in whom no loop of sigmoid flexure exists in the pelvis, and in which the bladder is distended, that organ may be found lying to some extent below the plane of the brim; but in the female infant, where the uterus partly fills up the brim, and in male infants, where the sigmoid twist occupies the pelvic inlet, the above-described position of the bladder must be the usual one. The bladder is practically, therefore, entirely an abdominal organ at birth.

In my specimens the vesical orifice of the urethra lay very nearly at the level of the upper border of the symphysis pubis, and in all only a very small part of the vesical cavity lay behind a line dropt vertically through the orifice of the urethra. The position of the upper end of the bladder varies with the state of distension of the viscus. Of three cases in which the bladder was empty, in two its upper end lay 2·3 ctms. above the symphysis pubis, and in the other case (in which the infant was frozen in the genu-pectoral position) it lay 3 ctms. above the level of the symphysis. In one case in which the bladder contained a little urine, its upper end was 2·5 ctms. above the symphysis; and in another case in which the bladder was enormously distended, its upper margin was found 2 mms. above the umbilicus (4·5 ctms. above the symphysis). It is probable that the empty bladder in the infant reaches nearly half way to the umbilicus.

The Form of the Bladder.—The bladder of the infant is often described as pyriform in shape, with the larger end superior; but frozen sections have clearly shown that except in cases of over-distension this is not the normal form of the viscus. In the cases in which the bladder was quite empty, its cavity was seen to form a continuation of the urethral canal, and the anterior and posterior walls were in complete apposition (Plate IX. Fig. 2). In one of Symington's cases (fig. 27 in his *Atlas*) the bladder, which contained about 1 drachm of urine, is seen to have an egg shape, the larger end of the ovoid being directed downwards and backwards; and in one of my cases (Plate IX. Fig. 1), in which the bladder contained a few drops of urine, the viscus is seen to have a somewhat

triangular form, the base being below and the apex above. In this case there was a very small vesical cavity, but even with this small cavity it could be clearly seen that the larger portion was situated inferiorly and not superiorly. In the six months' fœtus the bladder, which was pretty well filled, had a somewhat ovoid form, but there was no great difference in the size of its two poles. In another case (Plate VIII. Fig. 2) the bladder was over-distended, reaching above the umbilicus, and in this solitary instance the upper end of the bladder cavity was larger than the lower. It may be concluded that the normal form of the partially distended bladder is ovoid, and that, as Symington states, the larger end is directed downwards and slightly backwards. The rugæ on the bladder walls are well seen in the empty bladder, and in the partially filled organ these are present only at the upper end, whilst in the fully distended viscus these are absent altogether. It is easy to conceive that as urine begins to dribble into the empty bladder, it will first accumulate at the lower end of the organ, and there separate the walls and smooth out the rugæ; and that as the distension becomes more marked, the upper part of the bladder will also become distended, and the rugæ will disappear both at the upper and lower extremities of the viscus. The important fact with regard to the form of the bladder in the infant is, that the broad end is directed downwards.

The Relations of the Bladder.—In the infant the anterior vesical wall is in close contact with the anterior abdominal wall, and there is no intervening pouch of peritoneum. The reflection of the peritoneum from the anterior abdominal wall on to the posterior bladder wall usually takes places a little below the level of the umbilicus, and from 2 to 3 ctms. above the upper border of the symphysis pubis. In one case in which the bladder was over-distended, the peritoneum passed to the posterior surface of the bladder about the level of the umbilicus. The anterior surface of the bladder, triangular in shape, is, therefore, entirely uncovered by peritoneum,—a fact of great importance to the surgeon who may be contemplating operative interference for stone. Posteriorly the peritoneum passes over the bladder wall, reaching in the male infant to a point immediately below the vesicle orifice, and here coming into relation with the small prostate gland, another fact which is of great importance surgically. In the female infant the peritoneum does not descend so low posteriorly, for its point of

reflection on to the anterior uterine wall lies above the level of the internal urethral orifice. In the infant the posterior relations of the bladder are less constant than are its anterior. In one male infant the bladder was related posteriorly to a loop of sigmoid flexure, and to the commencement of the rectum; in another the anterior surface of the cæcum was in relation with the posterior vesical wall, but in this case the cæcum lay mesially and was therefore abnormal in position; in a male fœtus of six months the bladder was related posteriorly to the rectum and to some coils of small intestine; and in yet another premature infant with dropsy, the posterior bladder wall was in contact with ascitic fluid which lay in the recto-vesical pouch of peritoneum. In the female infants the bladder lay in close relationship with the uterus posteriorly, but in one case there intervened a loop or two of small intestine, which lay in the utero-vesical pouch of peritoneum, and in this case also the right Fallopian tube lay behind and a little to the right side of the bladder, being also in the utero-vesical pouch. The hypogastric arteries run laterally to the bladder, converging towards the umbilicus.

The Size of the Bladder.—The bladder is relatively small in infants, and this fact is at least one of the causes of the frequency of micturition in infants and young children. When empty the cavity of the organ measures from 2 to 2·5 ctms. in length; but that the bladder can in exceptional circumstances be greatly distended with urine is proved by one of my cases, in which its upper wall reached to a point 1 or 2 millimetres above the umbilicus. It is rare for the bladder to contain more than 1 drachm or $1\frac{1}{2}$ drachms of urine at the time of birth.

The Urethra.—In the female infant the urethra is pelvic in position, and runs at first downwards parallel to the axis of the pelvic canal, it then turns slightly forwards, and ends at the meatus urinarius externus, about 1 ctm. in front of a line drawn vertically downwards from the lower border of the symphysis pubis. Symington has demonstrated that in the young female chimpanzee the meatus urinarius lies behind a line drawn vertically downwards from the symphysis. There is no approach to this condition seen in the human female infant. The length of the urethral canal alone is about 4 ctms. in the female, and a little more than 6 ctms. in the male infant. I have passed a No. 10 catheter with ease through the infantile urethra.

The Ureters.—In two cases I traced the course of the ureters by injecting them with quicksilver. They lie immediately internal to the external and internal iliac vessels at the brim of the pelvis, and in the female dip down under the broad ligaments close to the sides of the uterus, and rise again slightly to open into the bladder at or immediately above the plane of the brim.

The Rectum (Plates VIII. and IX.).—The relations of the rectum may now be considered. This part of the intestinal canal is relatively larger and more vertically placed in the infant than in the adult. Its large size and vertical position are taken advantage of by the physician, who often finds it useful to take the infant's temperature by means of the thermometer passed into the rectum. It is also probable that the rectum may come to be more generally employed in diseases of infancy for purposes of alimentation by nutritive enemata than it has hitherto been. The rectum in the infant may, as in the adult, be divided into three portions. The first part is nearly quite vertical, and passes down in front of the sacrum to the lower part of that bone, where it turns slightly forwards to become continuous with the second part. If the first part of the rectum be empty, as in one of my cases where the infant lived for six days, it frequently forms one or two lateral bends; but if it be distended with meconium, as in the other infants observed, this part of the bowel is nearly quite straight. The second part is very short in the infant, and runs downwards and forwards. The third part is relatively long, and passes downwards and slightly backwards to terminate at the anus. This part of the intestine is, therefore, more worthy of its name, *rectum*, in the infant than in the adult, where it is far from being a straight tube. Its straightness, large size, and vertical position, may have not a little effect in favouring the production of prolapsus recti, a common malady in the infant; and the rational treatment of this disease will, therefore, be to use palliative measures until the infantile disposition of the rectum becomes changed into the adult. The peritoneum descends in both male and female infants in front of the rectum to about the level of the 4th sacral vertebra posteriorly, and to that of the middle of the symphysis pubis anteriorly. Posteriorly the rectum is in contact with the anterior surface of the sacrum and coccyx, and has in the upper part of its course a meso-rectum.

The Sigmoid Flexure in the Pelvis (Plate VIII. Fig. 2, and Plate IX. Fig. 1).—It may be well here to restate the fact that in

several of the infants examined a loop of the sigmoid flexure formed one of the pelvic contents. In the male infants it lay in the middle line or a little to the right of it, between the rectum and bladder in the recto-vesical pouch; and in one female infant it lay in the right compartment of the pouch of Douglas behind the right broad ligament.

The Anus (Plate VIII. Fig. 2).—The anus in the infant is directed downwards and slightly backwards. On account of the small degree of development of the gluteal regions in the infant, the anus does not lie in a depression between the buttocks as it does in the adult. A recognition of this anatomical fact would tend to save many a one from the rather humiliating position of having failed to diagnose a breech presentation. A peculiarity pointed out by Symington is that a line dropped vertically from the tip of the coccyx will pass through the anal aperture, and this fact I was able to demonstrate in several of the sections made. In the infant, therefore, the anus is situated relatively posterior to the position it occupies in the adult.

The Uterus (Plate IX. Fig. 2).—The uterus differs in many points from that organ in the adult, and there also exists considerable difference of opinion as to what are the normal topographical relations of the infantile uterus. I have studied the uterus in the new-born infant in three cases by the frozen sectional method, and in many other cases by simple dissection, and have compared the results thus obtained with the conclusions of Boullard, Bandl, Klob, Kölliker, and Symington.

Position of the Uterus.—The uterus at birth is partly an abdominal and partly a pelvic organ. In the three full-time infants examined by the frozen sectional method, the proportion of the entire length of the uterus which lay above the pelvic brim varied from a little more than one-third to nearly a half. In one of Symington's sections (*Trans. Ed. Obst. Soc.*, vol. xi. p. 36), the proportion of uterus lying above the pelvic inlet is less than one-third. It is probable that the proportion of the uterine mass which lies in the abdomen varies considerably in different cases, and is influenced to some extent by the condition of the adjacent intestine. In the new-born infant the rectum and sigmoid flexure are distended with meconium, and this may serve partly to explain the high position of the uterus in the cases which are noted above.

With regard to the relation of the uterus to the horizon, and of

the body of the uterus to the cervix, authorities are at variance. Most writers assert that the uterus is normally anteverted, and some hold that it is also slightly anteflexed, whilst others believe that it is sometimes straight. I do not think that one position can be assigned to the infantile uterus as the normal; in my three cases, in all of which the rectum was distended and the bladder empty, the uterus lay in an anteverted position; but had the conditions been different—had the bladder been distended and the rectum been empty—the uterus would, no doubt, have occupied a nearly vertical position. I have not seen the organ anteflexed, although it may occur; and with regard to retroflexion there seems to be no doubt that such a position is in the infant always pathological; and, indeed, its occurrence is very rare, almost the only cases recorded being two noted by Ruge ("Zwei Fälle von Retroflexio Uteri bei Neugebornen," *Zeitschr. f. Geburtsh. und Gyn.*, Bd. ii. p. 24), in both of which the uterus was abnormal in structure. The presence of the rectum filled with meconium, and of the loop of sigmoid flexure, will tend very much to keep the uterus in a position of anteversion; and, as above stated, I look upon the vertical position and the position of anteversion as representing the normal lie of the uterus in the new-born infant. If the bladder be distended, the uterus will be more or less vertical; if undistended, it will be anteverted in position.

In one of the cases examined there was, in addition to the anteversion, a slight degree of torsion of the uterus. The anterior surface faced towards the front and the left in such a manner that the uterine end of the right Fallopian tube lay anterior to the uterine end of the left tube. In this case a loop of sigmoid flexure occupied the right compartment of the pouch of Douglas, and being distended with meconium, may by its pressure have caused the torsion of the uterus.

Size of the Uterus.—In the infant, as is well known, the cervix uteri is relatively much larger, both in length and thickness, than the body of the organ. The average length of the uterus in the new-born infant is usually placed at 2·5 ctms., but in nearly all the cases I have examined I found this measurement exceeded. In one case the uterus measured 3·2 ctms. in length; in another infant the measurement was as much as 4·1 ctms., and even in a seven and a half months' infant the uterus was found to be 2·7 ctms. in length. In the case of four uteri from new-born infants measured by

Symington, in two the length was 2·5 ctms., in one it was 2·6 ctms., and in one it was 3·0 ctms. In the following table are given the average measurements obtained from the examination of the uterus in four infants :—

Length of uterus from anterior lip of cervix to fundus,	3·4 ctms.
Sound passes in to a distance of	3·2 ,,
Transverse diameter at fundus uteri, . . .	1·1 ,,
Antero-posterior ,, ,, ,, ,, . . .	0·8 ,,
Thickness of wall ,, ,, ,, . . .	0·2 ,,
Antero-posterior diameter of cervix uteri, . .	0·9 ,,
Transverse ,, ,, ,, . .	1·25 ,,

The above table shows that in these infants the cervix uteri was larger both in the antero-posterior and in the transverse direction than was the fundus uteri, but the difference was not so large as might have been expected from the statements made by some authors. No doubt there are considerable individual differences depending upon the size of the infant, etc. It was also noted that, as a rule, the anterior lip of the cervix was very slightly longer than the posterior; but in one case the two lips were of practically the same length. The gaping condition of the os uteri was a notable character of all the uteri I examined, and in all of them the folds of the arbor vitæ were prolonged to the fundus. There was one longitudinal fold on the posterior wall which extended from os externum uteri to fundus; in the lower part of the uterus there were also many transverse folds, while near the fundus the folds ran in an oblique direction. On the vaginal aspect of the cervix some rugæ were usually seen, but only on the anterior lip. Posteriorly the peritoneum descended behind the uterus to a level one or two millimeters below that of the os externum, whilst anteriorly it descended to a point almost exactly half-way between fundus and os externum uteri.

The Fallopian Tubes.—The Fallopian tubes in the new-born infant have an average length of from 2 to 3 ctms., and the right tube is usually a little longer than the left. There are at birth from three to five sinuosities on each tube, but in the fœtus at an earlier period of intra-uterine life these are more numerous, and are found at the uterine end of the tube as well as more peripherally (Plate VIII. Fig. 3). Freund points out how the sinuosities disappear from the uterine end of the tube first, and he attaches considerable importance to their presence in adult life as an etiological factor in the production of hydro- or hæmato-salpinx.

The position and direction of the Fallopian tubes were ascertained by allowing the frozen sections to thaw partially, and by then removing the coils of small intestine which lay in front of the uterine appendages. In two cases which were treated in this way the tubes were seen to have a general direction outwards, backwards, and downwards. The downward direction of the tubes is due to the fact that the uterine fundus lies above the plane of the brim. The uterine end and inner third of the tube lie at the level of the fifth lumbar vertebra above the brim of the pelvis, whilst the fimbriated end lies at or below the plane of the brim. In one case there was peritonitis in the new-born infant, and in this case the tubes and ovaries were both firmly adherent to intestinal coils, to the cæcum on the right side, and to the sigmoid flexure on the left; in this case the tubes had a general upward direction, the result evidently of the peritonitic adhesions.

The Ovaries (Plate VIII. Fig. 3).—In the infant the ovaries lie in a somewhat vertical position, near to the uterine fundus and behind the Fallopian tube of that side. What is usually described as the outer end of the ovary is seen projecting upwards above the Fallopian tube, and the long axis of the ovary runs from above downwards and inwards. The surfaces of the ovary usually termed anterior and posterior are internal and external in the infant, and the borders are anterior and posterior. In one case, that in which there was a degree of lateral twisting of the uterus, the right ovary lay anterior to the uterus, and the left in a plane somewhat posterior to it; but as to the frequency of this arrangement I can make no definite statement. Since the ovaries lie above the plane of the brim, and since the broad ligaments are not at all tense in the infant, it is probable that both ovary and tube may occupy positions other than those described. It is difficult to lay down with any degree of definiteness their normal position at birth.

The Vagina (Plate IX. Fig. 2).—In the new-born infant the vaginal canal is relatively long, and in the first part of its course it runs almost vertically downwards; it then changes its direction, and passes downwards and slightly forwards to end at the hymen. It does not, therefore, as in the adult, run upwards and backwards in a direction nearly parallel to the plane of the brim, but is in the infant more nearly parallel to the axes of the rectum and urethra. It forms with the uterus a very obtuse angle. The vagina varies in length from 2·5 to 3·5 ctms., and I have not

noted any difference in the depth of anterior and posterior fornices. Its form on section somewhat resembles an H, the anterior and posterior walls being nearly in close contact in the middle line. The vaginal walls are covered with numerous transverse rugæ.

External Genital Organs.—In infants of either sex the external genital organs are somewhat imperfectly developed. In female infants, for example, the labia majora are relatively smaller than in adults, and, therefore, the labia minora or nymphæ are not so completely hidden from view in infancy as in later life. In children it can also usually be seen that the labia minora do not blend posteriorly with the labia majora, but are united behind the vaginal aperture by means of the fold known as the fourchette. Most authorities now admit that the labia minora as well as the labia majora are histologically skin and not mucous membrane; and evidence in support of this view is obtained from the study of both the naked eye and minute anatomy of the labia, and from the consideration of embryology and the facts of pathology (*vide* "Labia Minora and Hymen," Ballantyne, *Edin. Med. Jour.*, Nov. 1888). In female infants

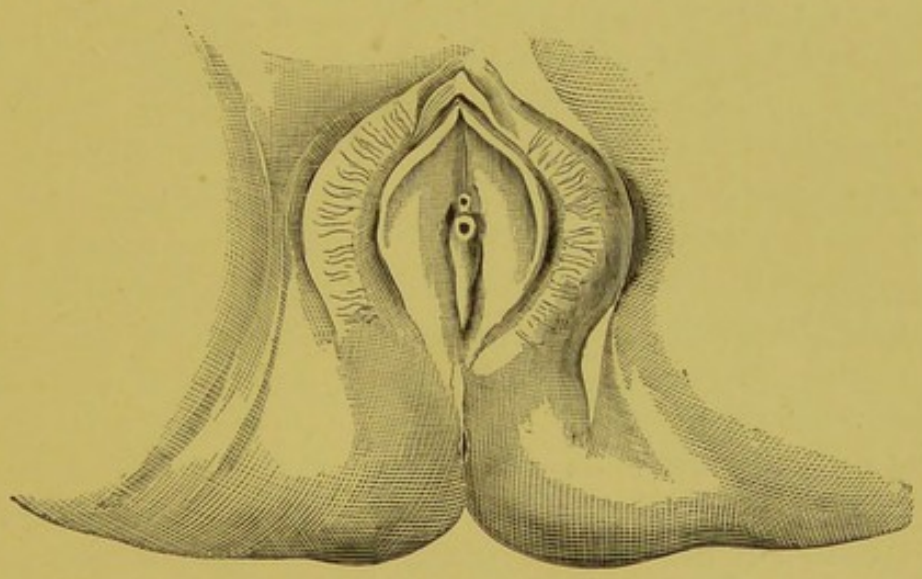


Fig. 4.—External Genitals of Female Infant, showing projecting hymen.

there is sometimes seen in the middle line of the vestibule a band which Pozzi (*Ann. de Gyn.*, vol. xxi.) has called the "male vestibular band in the female." This structure, which stretches from the base of the clitoris downwards in the middle line to the base of the triangular vestibule, there encircling the meatus urinarius and becoming continuous with the hymen, is rarely seen in the adult woman, but

is not uncommon in the infant. The band is regarded by Pozzi as homologous with the corpus spongiosum in the male. The hymen in the infant not unusually has a form differing more or less markedly from the crescent which is normal in the adult virgin; for instance, I have found it in some cases annular, and in others projecting like the everted finger of a glove (Fig. 4).

Clinical Examination of the Pelvic Viscera.

It is not very often necessary to carry out a systematic examination of the pelvic viscera in the case of the infant; but it is always wise to inspect the external parts at the time of birth, both in order to ascertain the sex of the child, and to detect any malformation of the organs which may be present. Certain vices in the conformation of the external genital organs in the male may be detected; for example, the testicles may not yet have descended into the scrotum (cryptorchism), or there may be either epispadias (often associated with ectopia vesicæ) or hypospadias, or again the common defect known as phimosis may be present. The male infant may at birth be the subject of inguinal hernia, or of any one of the varieties of hydrocele—conditions for the differentiation of which careful inspection and palpation will be necessary. The female external generative organs, also, may be malformed in various ways: thus there may be a complete closure of the vaginal orifice from an imperforate hymen,—a condition which will lead to trouble at the time of puberty when the menstrual function is established; or there may be congenital cystic growths in the hymen, or other minor deformities. Simple inspection is usually sufficient to reveal these defects; but should the abnormalities be so marked as to throw doubt upon the determination of the sex of the infant, it may then be necessary by rectal touch and by the sounding of the bladder to investigate fully the condition of the internal organs of generation. Even with the fullest possible examination of parts, the question of the sex of the infant may still remain uncertain, and it is then a wise plan to consider the child as a male until the establishment of the sexual functions finally remove all doubt. Inspection of the vulva in infants may reveal the existence of a vulvitis, which is usually of a simple character, but which may be in some cases undoubtedly gonorrhœal in nature; sometimes it has almost seemed as if infantile vulvo-vaginitis has been present in an epidemic form.

If during the first twenty-four hours after birth there has been no meconium expelled from the infant's bowel, it will be necessary carefully to examine the anus. Inspection may in some cases reveal an imperforate condition of the anus, or, in other cases, palpation may be necessary to detect some narrowing or obliteration of the rectum at a level higher than that of the anal aperture.

Early diagnosis is very important in the treatment of this abnormality, for every hour lessens the hope of successful surgical interference. Inspection of the anus may disclose other pathological conditions. For instance, the infant may suffer from prolapsus recti, a malady relatively common in early life; or there may be various skin eruptions in the neighbourhood of the anus, such as roseola syphilitica or erythema intertrigo; or from the presence of the marks of scratching, it may be evident that there has been irritation round the anus which may point to the existence of thread worms.

In the female infant, vaginal palpation is not often practicable; but in the rectal touch is found a means of examining the uterus and annexa, organs which are occasionally the seat of disease in infancy; and when the rectal touch is combined with abdominal palpation, it becomes possible very thoroughly to map out any cystic growth or abnormal intra-pelvic condition. The presence of symptoms suggestive of stone, such as painful and frequent micturition, should always lead to the careful sounding of the bladder; for vesical calculus, although hardly ever met with in female infants, is not uncommon in the male.

The subject of pelvic deformity in infancy has not yet had that attention paid to it that the condition demands, and the measurement of the pelvic diameters ought not to be omitted in any case in which there are evident irregularities in the osseous system.

The Extremities.

The limbs of the new-born infant are relatively small. The bones which form this framework are partly cartilaginous and partly osseous, and the muscles which clothe the bones are softer and less powerful than they are in later childhood and in adult life.

The ossification of the long bones is very incomplete at birth, and remains so during the whole term of infancy. For example, in the case of the humerus, the shaft alone is osseous at birth, the two ends being entirely cartilaginous; and it is not until the beginning of the

second year of life that the ossific nucleus of the head of the bone appears, and not till the third year that the nucleus for the great tuberosity can be seen, whilst the humeral epiphysis formed by the union of these two nuclei is not united to the diaphysis until both childhood and youth are past. The ossification of the femur is only a degree further advanced at birth than that of the upper arm-bone; for in the lower end of the bone of the thigh there is found in the new-born infant an ossific centre, to which some importance has been attached as a sign that the fœtus has completed the full term of nine months' intra-uterine life. The ossific nucleus for the head of the femur appears during the first year of life. In the case of the tibia there is occasionally present at birth a nucleus for the upper end of the bone; but the fibula, the radius, and the ulna, show extremities which are entirely composed of cartilage in the new-born infant. The carpal bones also are cartilaginous at birth; but of the bones of the tarsus, the os calcis, astragalus, and cuboid, already show ossific centres at this age. The shafts of the metacarpal and metatarsal bones and of the phalanges are osseous at birth; but the nuclei for the epiphyses of these bones do not begin to appear till the third year of life. The bones of the limbs of an infant are, therefore, in a transition stage: ossification is advancing rapidly, both at their extremities and also on the surface of the shafts under the thick and somewhat loosely attached periosteal membrane; and there is great vascularity in the osseous tissue, in the cartilage, and in the bone producing periosteum. It follows that in infancy diseases of the skeleton are common, and have characters quite peculiar to this time of life. Rickets, for example, is essentially a disease of early life; and the effects produced upon the manifestations of this affection by the highly vascular condition of the bones, and by the astonishingly deep-seated and complex changes connected with bone formation, are evident in that interesting series of osseous hypertrophies, and of contorted, deformed, and twisted conditions of the bones, which go to make up the clinical picture of rachitis. Infantile syphilis, also, is accompanied by changes in the bones scarcely less interesting than those associated with rickets,—changes, further, which are so closely allied to the rachitic as to have led some observers, and notably Parrot, to regard rickets as the ultimate manifestation of hereditary syphilis. In the conditions of the osseous system normally present in the infant may also be found the explanation of the peculiar forms of fracture and dislo-

cation which occur in the early years of life. Through the incomplete ossification of the long bones the separation of epiphysis from diaphysis becomes a possible accident; and on account of the thick, vascular, and loosely attached periosteum, the so-called green stick or incomplete fracture is comparatively common in infancy and childhood. The surgeon, also, when operating for genu valgum or genu varum, has to keep in mind and avoid interference with the rapidly proliferating zone of growing cartilage which intervenes between shaft of long bone and epiphysis, for upon this zone depends the future complete growth of the bone.

Both the upper and the lower extremities grow very rapidly in length and in circumference during infancy; but the lower limbs increase at a more rapid rate, for whilst the upper limb has doubled its length by the age of four or five years, the lower has doubled its measurement before the end of the third year of life. Growth in height is indeed principally due to increase in the length of the lower limbs.

Clinical Examination of the Limbs.

The infant may at the time of birth exhibit various congenital anomalies of the extremities; thus he may be the subject of the different varieties of deformity collectively designated club-foot, or he may present the condition known as webbed fingers. Rarer malformations are hypertrophy, atrophy, or complete absence of certain digits, club-hand, and the so-called intra-uterine amputations. The little understood condition known as congenital dislocation of the hip may be present; and in some cases instrumental or digital interference on the part of the accoucheur may have resulted in the production of fractures of certain of the limb bones, or of luxations of certain of the joints. Whilst the congenital deformities of the limbs are usually easily diagnosed, such conditions as fractures of the humerus or femur are often apt to be overlooked; and infants who are the subjects of such fractures have in some cases been wrongly treated for various internal disorders, through the failure of the physician's diagnostic skill. It is, indeed, often extremely difficult to diagnose morbid conditions of the extremities in infancy; the presence of pain in a joint or limb is always a difficult symptom to elicit, and the absence of regular voluntary movements of the limbs often masks the presence of powerlessness. Careful inspection and palpation of the limb are always necessary in

cases in which disease is suspected ; and it is a wise rule to examine first the limb which it is supposed is healthy, in order that the infant may be accustomed to the methods of investigation before the affected member is handled. If the infant be able to walk, any peculiarity in the method of locomotion, such as the presence of a limp, should be carefully noted, as should also the manner in which the child stands or raises himself from the ground. The physician ought also to remember that joint inflammations in early life have a tendency rapidly to spread to all the structures composing the joint, and are more apt to change their type than in the adult. The above-named characteristics are well illustrated in the disease known as acute arthritis of infants, which, commencing often as an epiphysitis, rapidly involves all the structures in the articulation affected, soon becomes purulent in type, and most commonly leaves a useless joint, if indeed it does not kill the little patient. The appearances of the limbs in cases of infantile paralysis, and of pseudo-hypertrophic paralysis, are usually so distinctive as to render diagnosis easy.

CHAPTER VII.

THE PHYSIOLOGY OF INFANCY.

THE PHYSIOLOGY OF THE DIGESTIVE SYSTEM — THE BUCCAL, GASTRIC, HEPATIC, PANCREATIC, AND INTESTINAL SECRETIONS—THE FÆCES—THE FEEDING OF INFANTS—METHODS, MATERNAL AND MERCENARY.

The phenomena of digestion in infancy differ in many important details from those observed in later life, and so great are these physiological differences, that the proper feeding of infants becomes a problem of no little difficulty. It is also matter for regret that we are not yet in possession of that complete account of the chemistry of digestion in early life which is absolutely necessary for the regulation of the diet of infants, and for the comprehension of the frequently occurring attacks of gastric and intestinal disorder so common during the first few years of life. Much has, however, been already accomplished in the domain of infantile physiological chemistry ; and it is to be hoped that during the next few years much may be added to the store of accumulated facts relating to digestive processes in infancy, with the resulting elucidation of the dietetic laws of this period of life. The absence of the knowledge of some of the stages in the conversion of the food into material suitable for absorption and assimilation is not, however, an excuse for the many erroneous conceptions concerning infant diet which prevail, not only in the popular mind but also to some extent in the practice of the medical profession. When it is remembered that young infants are not infrequently fed upon the food of their parents, there is no cause for wonder that so many children succumb to diseases of the digestive system, or grow up weakly, puny, and ricketty. The natural food of a baby for the first year of life is the mother's milk. This remark may be counted trite and stale; but it is a remark which it will be necessary to reiterate, and to reiterate with force, until such time as the principle which underlies it is universally acted upon. Then, and only then, can it be reasonably hoped that there will be

a diminution in that distressing infantile mortality which is due to dietetic disorders.

It will be convenient to study in order the digestive processes which take place in the mouth, stomach, and intestines, and thereafter to formulate the laws which must regulate the feeding of infants, if such infants are to be preserved in bodily health and strength.

Buccal Digestion in Infancy.

During the first six or seven months of life the food is not much altered whilst in the mouth. There are no teeth, and, therefore, it can scarcely be stated that any mastication of the food takes place; but if the food consist, as it should do, of the mother's milk alone, no bad effects will result from the absence of the teeth. The buccal secretions are present in but small amount during the first weeks of life, and, therefore, the baby's mouth is relatively dry; but when the third month of life is reached the saliva is secreted in larger quantities, and when the dentition period is arrived at the glands of the mouth pour out such a large quantity of fluid as to cause dribbling or drooling. It has sometimes been stated that the saliva of the new-born infant has no effect upon starch; but the experiments of Zweifel and others make the entire acceptance of this statement impossible. It has been demonstrated that, in the case of a healthy full-time infant, the buccal secretion possesses, even in the first weeks of life, a distinct although slight diastatic effect, and that this effect steadily increases as the infant grows in age. Zweifel's experiments with the infusions of the salivary glands prepared after the death of the infant are of interest in this connexion. He found that whilst infusions of the sub-maxillary glands of an infant seemed to have no converting action upon starch, infusions of the parotids of a seven days old baby produced a diastatic effect in a few minutes. The hydrolytic ferment, ptyalin, must, therefore, be present from the very first in the parotid secretion, if not in that from the sub-maxillary gland. Zweifel also found that infusions of the parotid glands of premature infants, or of infants that had succumbed to diarrhœa and infantile atrophy, had no diastatic effect upon starchy matters. It is safe to conclude that there is not in the early months of life that supply of ptyalin necessary for the proper conversion of starchy articles of diet into dextrin and glucose; but it is necessary also

to remember that probably the action of the ptyalin upon starch proceeds for some time in the stomach after the food has been swallowed. As the infant grows older the diastatic effect of the salivary secretions becomes more marked; and after the eruption of the teeth has taken place, the mastication and insalivation of food in the mouth soon become nearly as complete as in adult life. In the infant, as in the full-grown individual, all varieties of starch are not equally affected by the diastatic ferment; but the experiments of different observers do not, unfortunately, give identical results in this relation; for, whilst some state that potato starch requires one or two hours for its conversion into glucose, others are of opinion that it is very rapidly acted upon by the saliva. More observations are required to clear up this very important matter.

Gastric Digestion in Infancy.

The food having been swallowed, remains for a time in the stomach, therein undergoing further chemical and mechanical changes to fit it for absorption into the system. The form, position, and relations of the stomach in the infant have been already considered in a former chapter; but it may be well here to state certain facts relating to gastric capacity which have an immediate bearing upon the feeding of young infants. All observers are agreed that during the first two months of life there is a very rapid increase in stomach capacity, but that thereafter the rate of growth is much less. Frowlowsky (St Petersburg, *Inaug. Diss.*, 1876) states that the ratio of stomach growth may be represented as one for the first week, to two and a half for the fourth week, and three and one-fifth for the eighth week, but only as three and a third for the twelfth week, three and four-sevenths for the sixteenth week, and three and three-fifths for the twentieth week. Since the gastric capacity at birth may be taken as a little more than one ounce, the following table, showing the normal size of the stomach at different periods during the first five months of life, can easily be constructed :—

In 1st week, stomach capacity is 1 oz.		
,, 4th ,, ,, ,,	2½ oz.	Period of rapid increase.
,, 8th ,, ,, ,,	3⅕ oz.	
,, 12th ,, ,, ,,	3⅓ oz.	Period of slow increase.
,, 16th ,, ,, ,,	3⅘ oz.	
,, 20th ,, ,, ,,	3⅗ oz.	

Beneke's observations give a greater and more rapid increase in gastric capacity in the first weeks of life than do those of Frowlowsky; but the very careful post-mortem measurements made by L. Emmett Holt (*Archives of Pediatrics*, Dec. 1890) in the main support the conclusions found in the above table. Holt found that, taking the cubic capacity of the stomach at birth as one ounce, the stomach increased at the rate of one ounce a month during the first three months; that from the third to the eighth month the rate of growth was less, being about half an ounce a month; and that from the eighth to the fourteenth month there was a still smaller increase in capacity, about one-third of an ounce a month. Ssnitkin (Reitz, *Physiol. des Kindesalt.*, S. 40) has endeavoured to show that the greater the weight of the infant the greater the cubic capacity of the stomach; and, although Holt has been unable to find any such correspondence, yet Ssnitkin's rule for estimating the amount of food necessary for an infant of any given age, which is based upon the above statement, is found in practice to be approximately correct. He states that, taking one-hundredth of the initial body-weight as the amount of food to be given on the first day of life, one gramme (15½ grs.) ought to be added for each day. The rule to be hereafter stated to serve as a guide in computing the amount of food necessary for a healthy infant has been founded upon the results obtained by Frowlowsky and Holt.

Such being the gastric capacity in infancy, it is now necessary to consider the digestive processes which occur in the stomach at this time of life. As regards the part played in digestion by the contractions of the muscular wall of the stomach, it may be stated as more than probable that the gastric muscles, on account of their feeble development, do not take such a prominent part in the admixture and circulation of the stomach contents in infancy as in later life. The absence of the thorough mechanical compression and trituration of the food in the infant's stomach is but one among many reasons for the avoidance of the administration of solid foods to young infants.

If starchy matters be present in the infants' food, the diastatic action of the saliva swallowed with the food continues in the stomach until such time as the secretion of hydrochloric acid commences. In this way the imperfect buccal digestion of starchy matters is supplemented to some degree in the gastric cavity; but even after making allowance for this, it must be conceded that farinaceous

foods are not well suited for the dietary of the infant during the early months of life. Hydrochloric acid and the hydrolytic ferment known as pepsin are the ingredients of the gastric juice, whose action upon albuminoids results in the conversion of these insoluble proteids into soluble peptones. The hydrochloric acid is not found in the stomach immediately after the ingestion of food, and may not appear for a time varying from half an hour to an hour. In the absence of hydrochloric acid, other acids which are organic in their nature, and of which the most important is lactic acid, are present. This acid is produced in large amount when infants are fed upon their proper food, namely, upon milk; and its presence is probably due to the action in the infant's stomach of a special ferment, the rennet ferment or *lab-ferment* of Hammersten. This ferment throws down the casein of the milk as a curd, probably on account of its power of developing lactic acid out of sugar of milk or lactose. Reichmann has shown, in a very interesting series of experimental investigations upon the digestion of milk in the human stomach (*Jahrb. f. Kinderh.*, Bd. xxvi. H. 3 u. 4), that in a very few minutes after the introduction of the milk into the stomach there are found in it curdy lumps of casein, some parapeptones, and traces of lactic acid; and that as time goes on the amount of lactic acid increases, and there appear hydrochloric acid and peptone, the lumps of casein and the parapeptone disappearing as digestion approaches completion. Reichmann, further, has found that the appearance of the peptones and the completion of the digestive process are hastened when boiled milk is given. It may also be stated that the peptonizing effect of the pepsin is greatly hindered if a large amount of water be not present in the stomach; and it is for this, if for no other reason, that it becomes necessary to add water to the dietary of infancy. Such are, stated briefly, the probable changes which food undergoes in the infant's stomach; and the result is the production of chyme, a creamy acid fluid containing, in addition to the products of gastric digestion, the fats and fatty acids which have not yet been acted upon.

There is yet one other question concerned with gastric digestion in infancy which calls for some attention, and that is the presence in the stomach of various forms of bacteria. Van Puteren (*St Petersburg Vrach*, Nos. 21, 22, 1888) examined the contents of the stomach in forty infants between the ages of four and seventy days, these infants having been fed either with breast-milk or with a

mixture of cow's milk and water. In infants fed upon the breast-milk, who were perfectly healthy, few bacteria of any kind were found in the stomach contents. In the case of those that were artificially fed considerable numbers of micro-organisms were present, and in the infants that were suffering from thrush (even if breast fed) there were multitudes of bacteria in the stomach. Cleansing of the mouths of the infants with thrush greatly diminished the number of the bacteria found in the stomach contents. The microbes discovered were of several kinds—the bacillus lactis aërogenes, the staphylococcus pyogenes aureus, the bacillus subtilis, the bacillus butyricus, and the oidium albicans. The oidium albicans was only found in the case of children suffering from thrush. Van Puteren drew the conclusion that no single variety of bacteria was found so constantly or in such numbers as to give rise to the belief that it exercised any effect upon the digestive functions.

The fact that infants vomit with great apparent ease has been already mentioned, and the probable causes of this facility discussed in a former part of this work (*vide* p. 82); but it may be well here to state that in cases of infantile vomiting the examination, both by the naked eye and microscopically, of the vomited matters ought not to be omitted. Vomiting in infancy is not infrequently a symptom of diseases other than those of the digestive system. For example, emesis is common at the commencement of fevers and during the progress of meningitis, and it is very necessary that the cause of the vomiting in such cases be early recognised. With this end in view, therefore, it is wise in all cases to examine the vomited matters.

The Hepatic Secretion in Infancy.

The chyme having passed from the stomach through the pylorus into the duodenum, is acted upon by the hepatic and pancreatic secretions, which further modify its composition. That the liver has an important part to play in the physiology of fœtal and infantile life is evident from the large size of the organ, and from the fact that it contains more than a quarter of the volume of blood in the body. It can also be readily understood that the stoppage of the placental circulation at the time of birth must be the cause of profound changes in the supply of blood to the liver, for now the blood current is altered and the umbilical vein and ductus venosus are

closed. These circulatory changes in the liver at the time of birth show themselves in the development of a benign form of icterus or jaundice; and the probable explanation of this icterus neonatorum is found in the diminution of blood pressure in the portal capillaries, with the corresponding increase of pressure in the bile capillaries, effusion of bile, and absorption of the same into the lymphatics or veins of the liver and of the body generally. Whilst, however, it is admitted that the liver must have important functions in early infancy, it must also be granted that its physiology is yet but imperfectly understood. Jacubowitsch has made a useful addition to the subject of the hepatic function in infancy by his careful analyses of the bile in early life, and it is probable that further researches in this direction may serve to explain many problems hitherto unsolved. Jacubowitsch found that the bile in children was relatively poor in cholesterine, lecithin, fat, and in inorganic salts with the exception of those of iron, and that it also contains a smaller percentage quantity of glycocholic and taurocholic acids. The bile acids are present in the bile in the form of glycocholate and taurocholate of sodium. The biliary colouring matters—bilirubin and biliverdin—are abundantly present in infantile bile. It is probable that as in the adult so in the infant, the bile has a complex action in digestion: that it stimulates peristalsis and intestinal secretion, that it acts as an antiseptic, and that it renders possible the passage of emulsions of fat through the walls of the intestine into the vascular system. The bile may have a slight converting action upon starch also, for a diastatic ferment is sometimes found, and it may also aid in the emulsification of fats.

The Pancreatic Secretion in Infancy.

The pancreatic secretion no doubt plays an important rôle in the process of digestion in infancy, for it contains three hydrolitic ferments: a peptone-forming ferment, trypsin; a fat-emulsifying and fat-decomposing ferment, steapsin; and a diastatic ferment, amylopsin. Steapsin is probably operative from the very earliest days of life, and plays an important part in the digestion of milk; but the full action of the trypsin and of the diastatic ferment is not witnessed for some months after birth. Korowin's experiments would seem to show that the starch-converting powers of the pancreatic juice are feebly marked until the end of the first year of life,

although there is a distinct trace of amylopsin to be found as early as the second month. In these facts is found further evidence in proof of the inadvisability of supplying infants of less than one year of age with starchy foods.

Digestion in the Intestine in Infancy.

As the chyme passes through the small intestine it is acted upon, as has been above described, by the hepatic and pancreatic secretions; but in addition it has its chemical composition altered by the secretions from Brünner's and Lieberkühn's glands. The glands of Brünner, which are found in the duodenum, and the follicles of Lieberkühn, which are present throughout the small intestine, are but imperfectly developed during the first months of life, and, therefore, the physiological effects of their secretions upon the intestinal contents are probably not great. On the other hand, it must be remembered that the alimentary tract is relatively long in infancy as compared with later life, and that on this account, and by reason of the feeble peristalsis, the action of the intestinal secretions upon the food is prolonged. The secretions of Brünner's and of Lieberkühn's glands act upon the food in a manner which is probably very similar to that of the pancreatic juice. As a result of the action upon the chyme of the biliary, pancreatic, and intestinal secretions, that substance is converted into the absorbable chyle, and this nutritive fluid passes readily into the system of the infant through the vascular connexions of the small and large intestines. Peptones, sugars, and fats thus pass from the intestine into the circulatory apparatus; and it may be that the large quantity of lymphoid tissue present in the solitary and agminate glands of the intestinal walls accounts for the readiness with which healthy infants absorb fats. The valvulæ conniventes also aid absorption by increasing the absorptive surface over which the chyle must pass. The absorption of the mineral constituents of the chyle in infants is but small in amount, by far the greater part of the lime, etc., being excreted in the fæces. The proteids of the food, on the other hand, are so thoroughly peptonised and absorbed, that only traces of them are found in the excreta.

Rectal Absorption in Infancy.

No digestion of food takes place in the rectum, but absorption of food materials dissolved and more or less peptonised occurs in

this portion of the alimentary tract. Albuminoids, and even fats, may be to some extent absorbed into the system through the rectal mucous membrane; but it is necessary to remember that by means of rectal feeding only about one quarter of the amount of food necessary for health can be taken into the system.

The Fæces in Infancy.—Defæcation.

Defæcation, or the discharge of the fæces from the anus, takes place more frequently in infancy than in childhood or adult life. During the first six or eight weeks of life it is normal for the infant to have three or four stools daily, and up to the end of the second year of life two motions each day usually occur; but after this age the child has only one stool in the twenty-four hours. In deciding the question, therefore, of the existence of diarrhœa or of constipation in an infant, one must keep constantly in mind the number of stools that are normal at the stated age.

The appearances and composition also of the fæces vary at different ages in infancy. In the new-born infant during the first two or three days of life the fæces consist of the meconium. The meconium, with which the large intestine and often also the small intestine are packed at the time of birth, is a greenish, viscous, and nearly odourless material, which possesses a slightly acid reaction. This substance, which owes its leading characteristics to the action of the fœtal bile upon the intestinal contents, is made up of the pancreatic, intestinal, and hepatic secretions, along with the shed intestinal epithelium, and such matters as may have entered the intestinal tract through the stomach, namely, the liquor amnii, lanugo hairs, and some of the vernix caseosa. It is, however, free from the products of putrefaction (as phenol and indol) in all healthy infants; and at first it is also free from bacteria, but these soon appear in great numbers after the birth of the child. The bacteria of the meconium consist chiefly of spore-bearing bacilli and of various kinds of micrococci, and differ entirely from the bacteria of milk fæces; indeed, they disappear from the intestinal contents as soon as the ingestion and digestion of milk commence.

In infants that are fed entirely upon milk the fæces during the first two months of life are usually pale yellow or orange-yellow in colour, have a consistence like that of thick soup, and have a somewhat sour but not markedly fæcal odour. During the

course of the first two years of life the fæces in such infants become brownish-yellow in colour, have a consistence resembling that of porridge or soft lard, and give off a more distinctly fæcal odour. After the second year the motions are formed, and resemble in all points those of adult life.

The fæces of milk-fed infants contain from 84 to 86 per cent. of water, fat, lactic and fatty acids in combination with lime, some proteids, intestinal epithelium, mucus, and traces of cholesterin and bilirubin. In the healthy infant there is no tyrosin, indol, phenol, or skatol; but there are numerous bacteria which have been specially studied by Escherich,* and found to consist principally of the bacterium lactis aërogenes and the bacterium coli commune. If the food be other than milk, or if there be any diseased condition present, multitudes of other kinds of bacteria appear; but the exact investigation of these pathological micro-organisms has not yet been completed, although Baginsky,† Nothnagel,‡ Brieger,§ Miller,‖ Macfadyen,¶ Booker,** and many others, have made most material additions to the existing knowledge upon this subject.†† Very various statements have been made by these observers as to the kinds of bacteria present in the intestine in such diseases as summer diarrhœa, cholera infantum, and the like; and although there are great diagnostic possibilities in the bacteriological examination of the fæces in these diseases, there is as yet such a want of unanimity amongst the results obtained by the workers at this subject, as to prevent much use being made of the information already gathered together.

There are other questions concerning the fæces in infancy in regard to which information is much required; for example, it is very desirable that the cause of the green coloured stools so common in weakly infants be discovered. It was supposed that the green colour was due to some acid condition of the intestinal contents,

* *Die Darmbakterien des Säuglings und ihre Beziehungen zur Physiologie der Verdauung*, 1886.

† *Verdauung-krankheiten der Kinder.*, 1884.

‡ *Zeitschr. f. Klin. Med.*, 1881, Bd. iii.

§ *Zeitschr. f. Physiol. Chemie.*, Bd. viii.

‖ *Deutsch. Med. Wochenschr.*, 1884, 1885, 1886.

¶ *Journ. of Anat. and Physiol.*, xxi. pp. 227, 413.

** *Trans. Internat. Med. Congress*, 1887, iii. p. 598.

†† Booker gives a very complete *résumé* of the observations that have been made upon the intestinal bacteria of children in the third volume of Keating's *Cyclopædia of the Diseases of Children*, pp. 170–190.

and Biedert believed that in the conversion of bilirubin into biliverdin by means of organic acids lay the explanation of the phenomenon; but these acids added to yellow fæces outside the body increased their yellowness, and did not turn them green. It is more probable, as Pfeiffer believes (*Jahrb. f. Kinderh.* xxviii. 2), that the green colour is due to alkalinity somewhere in the gastro-intestinal tract, for soda or potash added to yellow stools outside the body turns them first brown and then bright green, and it is probable that the bile on entering the intestine finds the alkalinity of the contents so great as to cause the conversion of the bilirubin into biliverdin. This alkalinity is abnormal, and may be due to the insufficiency of the hydrochloric acid of the gastric juice to neutralize the alkalies of the mother's milk.

Many important conclusions concerning the digestion of milk, and the appearances of the stools in infancy, have recently been arrived at by Biedert (*Jahrb. f. Kinderh.*, xxviii. 3 and 4), amongst which may be mentioned the facts that the fæces of infants fed upon cow's milk are more abundant and more offensive than those of breast fed infants, and have an alkaline reaction, and that cow casein is less digestible and therefore less valuable for infant nutrition than human casein. Upon these and upon many other questions relating to digestion in infancy it must, however, be confessed that further reliable information is greatly needed in order to found the laws of infantile diet and feeding upon a strong scientific and physiological basis.

The Feeding of Infants.

From the preceding statements it will be abundantly evident that the proper dieting of infants is a difficult matter; and when it is also remembered that many parents neglect to enforce even the most elementary rules of infant feeding, there will be little cause for wonder that digestive difficulties are the source of so many infantile maladies. For the sake of convenience it will be well to consider—first, infant feeding prior to the eruption of the milk teeth; and, second, the diet of infants after this period. There are three chief methods of infant feeding commonly employed during the first year of life, that is to say, before the establishment of the first dentition; and these methods may be termed the normal, the mercenary, and the artificial. These various procedures must now be considered seriatim.

The Normal, Natural, or Maternal Method of Infant Feeding.

The remark has been made by Starr, that "fortunate is the babe that in our day of advanced civilisation and city living can draw from the breast of a robust mother an abundant supply of pure, health-giving, tissue-forming food;" and it would, indeed, appear that one of the hardest tasks that falls to the medical man at the present time is to persuade a mother that the only natural food for an infant during the first eight or ten months of life is the mother's milk. There are reasons without number, both anatomical and physiological, to prove this contention; and the daily breaking of this law is the means of the carrying on upon a large scale of that pathological experiment, which whilst it demonstrates the inferiority of all other methods of infant feeding when compared with the maternal, does so, alas! at the cost of great infant suffering and many deaths. "The completion of delivery," says an old writer, "does not terminate the physical affinity or natural connexion between a mother and her infant." "Never," says another author, "have the lionesses or panthers refused their udders to their young; it is the reverse with woman,—not the poor woman, who is excusable on account of her misery, who acts so unnaturally, but the rich one, who is surrounded by all the advantages and blessings of life. What does it matter that her son should perish, provided that she may enjoy her pleasures? It is to the peasants that the vulgar cares of maternity appertain; the lady of fashion has other occupations" (Ryan). Whilst, however, mothers amongst the poor do not refuse to suckle their children, they often commit errors quite as grave in the feeding of their infants. It is, unfortunately, no uncommon sight to witness a mother giving her little baby whisky from a spoon, and should the infant cough and turn blue in the face with the strength of the fluid, she dips her finger in the spirit and rubs with it the inside of the child's mouth. On questioning dispensary patients as to the food supplied to their infants, I not infrequently elicit the reply, "Anything that we're taking ourselves." It is to be feared that amongst the poor as amongst the rich, errors in infant feeding are most alarmingly common, and it is the duty of the medical profession to diffuse among the laity correct views upon this all-important subject.

Commencement of Lactation.

For some hours after birth it is not necessary for the infant to be fed. The first one or two hours of life are occupied by the toilette of the infant: the umbilical cord has to be tied and divided, and its stump dressed; the cleansing of the skin from the vernix caseosa, blood, and liquor amnii has to be accomplished; and the infant has to be suitably dressed. After these offices have been performed the infant will usually sleep for some hours; and thus, in normal circumstances, it will not require the mother's breast till some six or eight hours after birth. There is no need to give a new-born infant sugar-and-water or gruel at the time of birth, all that is necessary is to wash out the mouth with a little water. It is well not to delay too long the application of the infant to the breast, for the milk that is thus obtained (the watery *colostrum*, as it is called) is a laxative for the child, and causes the evacuation from the bowels of the meconium; and, further, the act of suckling stimulates milk formation, draws out the nipples, and has a beneficial effect in keeping up uterine contractions. For the sake of mother and child alike, it is well that the infant be put to the breast not more than twelve hours after birth. The mother's milk secretion will probably not be free until the third or fourth day after the birth of her infant, but no other food than the colostrum is required by the child during these days; thereafter what may be termed regular nursing may be begun. Before considering the proper manner of nursing, it may be well to state the characters of mother's milk.

Characters of Human Milk.

In its physical characters the mammary secretion of the human female is bluish white in colour, of a thin, watery consistence, is persistently alkaline in reaction, has an average specific gravity of 1031, and possesses a slightly sweetish taste. The first milk secreted by the breast, the colostrum, is more mucilaginous than ordinary milk and has a slightly yellow colour. If the colostrum milk be examined under the microscope, there will be found in it many mulberry-like cells containing oil globules, and also some free drops of fat. The mulberry-like cells, the so-called colostrum corpuscles, are the epithelial cells of the mammary gland acini which have undergone fatty metamorphosis, but in which the oil globules

are still held together by the remains of the cell protoplasm. The colostrum and fat cells are seen floating in a fluid which is derived from the blood by transudation. If a microscopic examination be made of the fluid drawn from the breasts of a woman in whom lactation is fully established, it will be seen that the colostrum corpuscles have almost entirely disappeared, and that in their place are to be found oil drops of various sizes and in great numbers, which, mixing with the transudation from the blood, form an emulsion, which is the milk.

Such are the physical characters of human milk; the chemical composition of that fluid now demands consideration. Many analyses of milk have been made by different observers, and the results obtained have not always exactly agreed; but the composition represented in the following table, which is founded upon the observations of Leeds (*Medical News*, vol. xliii., Nov. 3), may be taken as giving as correct an average as can be obtained:—

Water,	86·766
Total solids,	13·234
Total solids not fat,	9·221
Milk sugar,	6·997
Albuminoids,	2·058
Ash,	0·21
Fat,	4·013

Human milk is a perfect food, one which contains in itself all the elements necessary for bodily growth and for the maintenance of heat; but it is by no means a fluid of constant composition, for the figures given in Leeds' table are only the average of the analyses of forty-three varying samples of milk. Individual specimens of milk obtained at different hours of the day, at different periods of lactation, and from different women, show marked variations in the percentage quantity of the constituent parts. The albuminoids vary much in amount (max. 4·80 per cent., min. 0·85 per cent.), the fat also varies considerably, the salts less so, whilst the milk sugar is nearly constant in quantity (7 per cent.). The composition of mother's milk is, therefore, very variable; but it must at the same time be remembered that the infant ceases to thrive perfectly if these variations are great. T. M. Rotch has shown (*Archives of Pediatrics*, Nov. 1890), that with infants that are thriving the range of variation in the constituents of the maternal milk is no greater than what is shown in the following table:—

	Normal average.	Range observed with thriving infants.
Fat, . . .	4	3 to 4
Albuminoids, . .	1 to 2	1 to 3
Sugar, . . .	7	6 to 7
Ash, . . .	0·2	0·1 to 0·2
Total solids, . .	12 to 13	10 to 14
Water, . . .	88 to 87	90 to 86

In the following table Rotch shows the variations which must be looked upon as abnormal, for the infants of mothers supplying such milk do not thrive. The variations are due to starvation in one set of observations, to rich living and insufficient exercise in another, and to the supervention of pregnancy or disease in a third group; and the result is a poor, an over rich, and a bad milk respectively.

	Normal.	Poor.	Over rich.	Bad.
Fat, . .	4·0	1·50	5·10	0·80
Albuminoids, .	1 to 2·0	2·40	3·50	4·50
Sugar, . .	7·0	4·00	7·50	5·00
Ash, . .	0·2	0·09	0 25	0·09
Total solids, .	12 to 13	7·99	16·35	10·39
Water, . .	88 to 87	92·01	83·65	89·61

It may be concluded from what has been said, that whilst human milk is the perfect infant food, it is at the same time a food which, when produced by a mother who is suffering from disease or who breaks the laws of hygiene, may very readily interfere with the health of the infant. It is, therefore, necessary not only that the mother nurse her infant, but also that she maintain her own health at a high level whilst doing so.

Hygiene of Lactation.

In order that the milk supplied by a mother to her babe may be of the best quality and be present in the most suitable quantity, she must observe certain hygienic laws. She ought carefully to preserve her system in perfect health, by taking sufficient exercise, by allowing abundant time for rest and sleep, by avoiding the exactions of modern society in the form of balls, dinners, theatres, and the like, and by taking a plentiful but not excessive supply of plain and digestible food. There is an old and deeply rooted popular belief that nursing women require malt liquors; but it is very doubtful whether alcohol can increase the secretion of milk if that be deficient,

and it seems to be certain that the administration of ale or porter to healthy mothers is quite unnecessary, if not actually prejudicial. If from anæmia, debility, or other cause, the maternal milk supply become insufficient, it seems far more rational to treat the causal conditions by the use of milk, animal broths, porridge, and the like, and by the exhibition of iron and quinine, than to dose the mother with malt liquors, part of which may actually find its way by the milk into the infant system. All that can safely be said in favour of the use of alcohol by nursing mothers is that, if taken in small quantities by a healthy woman, it may do no harm.

As regards the best manner of suckling, the mother ought to hold her infant on her right or left arm, according to the breast which is to be used, bending forward at the same time so as to permit of the easy passage of the nipple into the child's mouth; and she ought to support the nipple with the index and middle fingers of her disengaged hand, so as to control the flow of milk. The infant usually takes the breast best when lying on his right side, for this avoids the pressure of the liver on the stomach, and for this reason the left breast is apt to be the more used; but the best plan is to give the child each breast alternately, and to allow only one breast to be used at one time of nursing.

Irregularity in the hours and times of nursing is a very common error amongst mothers. Infants should be trained from their very earliest days to take their food at regular intervals; they are essentially creatures of habit, and if they are put to the breast at stated times from the very first much needless trouble will be avoided. Irregularity in the hours of feeding alters injuriously the composition of the milk, sometimes condensing it, at other times rendering it too watery, and it also gets the child into bad habits which are very difficult of correction. During the first week of life the infant ought to be put to the breast every two hours from 5 A.M. to 11 P.M. Up to the end of the second month the intervals of time between successive nursings should be increased to two and a half hours; and up to the date of weaning, the child should be fed every three hours. From 11 P.M. to 5 A.M. the infant ought not to be fed at all, and ought to be placed in a crib by the mother's bedside, or, what is perhaps better, in another room with the nurse. This practice is, no doubt, a little difficult of establishment, but if it be insisted upon from the very first, it will be found to be quite practicable. If these rules be followed, mothers will be able to obtain at least a six hours'

rest every night, and fathers will be spared those nocturnal disturbances which are so well known and so much dreaded. It is a very common but most erroneous practice to give the breast to a baby whenever that baby cries. Infants cry from hunger, it is true, and in such cases the giving of the breast is right enough if the proper time has elapsed since the last nursing; but hunger is not always the cause. Sometimes babies cry on account of the presence of an irritating pin; sometimes they cry from colic due to overloading of the stomach, or to intestinal disorder. In the one case nursing will certainly not lessen the pain; in the other case it will probably increase it. The cry of hunger is strong and healthy, not peevish, and it disappears when the child is fed, and does not recur for some time. By these and other signs it is easy for the mother to diagnose between the cry of hunger and that of colic or cramp.

As regards the proper amount of milk required by the infant, it is a safe rule for the mother to be guided by the child himself. When he has had enough he will throw out the nipple from his mouth, and will usually fall asleep. As he grows older, he will, of course, require more milk at each meal; but there is no need at this point to state exactly how many ounces will suffice. That question will be more suitably taken up when artificial feeding is under consideration.

The rules for the nursing of an infant by his mother have now been stated, and it is almost superfluous to point out the many advantages of the maternal plan of nursing. It may, however, be reaffirmed that human milk is not only the most suitable food for the infant, but that it is also obtained by the child free from all the impurities that are so often present in cow's milk or other artificial foods.

The Mercenary Method of Feeding.—Wet-Nursing.

Maternal nursing, however desirable, is not always possible, and it may reasonably be asked, What is to be done in those cases in which the mother, from illness or from some other *sufficient* cause, is unable to nurse her offspring? Before answering this question, it must be said, in the first place, that it is a serious matter for the infant if the mother be unable to nurse him; and in the second place, that the mother ought never to relinquish what is her first duty to her child without full consideration and without consulta-

tion with her medical attendant. If it has been decided that it is impossible for the child to receive his natural food, an answer must then be given to the question, What is the next best food with which to supply him? Wet-nursing is theoretically the next best method of bringing up a baby; but there are so many difficulties in the way of getting a suitable nurse, and so many disagreeable circumstances to be faced in the carrying out of the procedure, that it is not surprising that this method is seldom employed. Even when a thoroughly suitable wet-nurse has been obtained—an almost impossible thing to accomplish—it must never be forgotten that that nurse enters the household practically as an autocrat. During her residence in the family she is mistress of the situation. She can claim an exorbitant wage; her commands must be obeyed and her whims satisfied, else she takes her departure, and leaves chaos behind her; and she is a continual source of anxiety to the child's parents, and of annoyance to all those living in the house. If it be also borne in mind that wet-nursing almost necessarily entails the practical desertion of one child for another, it will be seen with how many difficulties and dangers the procedure is surrounded.

With all its inconvenience and difficulty, the mercenary method of infant feeding has yet often to be recommended; and upon the shoulders of the medical man rests the twofold responsibility of first deciding that wet-nursing is necessary, and of, in the second place, obtaining a suitable nurse for the purpose.

In deciding the primary question of the necessity for wet-nursing, the physician must take into account in the formation of his opinion both the health of the mother and the health of the infant. It will often be alleged by the mother that her health will not be able to bear the strain of nursing, and that, therefore, her infant must be brought up either by means of a wet-nurse or by hand; but in many cases the wish has been father to the thought in the mother's mind, and upon strict investigation it will be found that there are no sufficient reasons for supposing that nursing will be in any way prejudicial to her health. There are, however, cases in which it will be impossible for the mother to nurse her child. She may, for example, be suffering from a serious illness, such as typhoid fever, or she may be in the last stages of pulmonary phthisis. Under such conditions it will be the medical man's duty to pronounce against maternal nursing, or to advise premature weaning if lactation be already established. Local diseased conditions of the mammæ are often

brought forward as reasons for the stopping of maternal nursing; but these conditions are seldom sufficient in themselves to justify the engaging of a wet-nurse. Fissure of the nipple is a painful condition; but, if properly treated, it need interfere only temporarily with lactation; and even when it affects both breasts, the use of nipple shields and of astringent and protective applications will in most cases enable the mother to perform her maternal duties without great inconvenience. A retracted or imperfectly developed condition of the nipple may be a hindrance to lactation, but it need not prevent nursing altogether, for in the worst cases the milk can be drawn from the breast by a breast-pump and administered to the infant by means of a spoon. Mammary abscess is a more serious obstacle to lactation; and in the cases where it affects both breasts, it may be necessary to engage a wet-nurse to take on the maternal function. There is one other class of case in which it becomes essential that a wet-nurse be procured—that, namely, in which an infant that has been brought up by hand on cow's milk becomes the subject of infantile diarrhœa. In such a case the child's recovery may depend upon the speedy engagement of a suitable wet-nurse.

The medical man who has decided that it will be best for his patient not to undertake the nursing of her child will then in all probability be called upon to procure a suitable wet-nurse. He may have on his list the name of some recently delivered woman who may be willing to undertake the office, and who is personally known to him; if that be the case there will be no great difficulty in carrying out the arrangement satisfactorily. In many instances, however, the medical man knows of no suitable person, and then he will be forced to fall back upon other methods of hearing of a wet-nurse. He may, for example, apply at a Maternity Hospital, where often a list of suitable wet-nurses is kept; or failing this, it may be necessary to advertise in the newspapers. In whatever way a wet-nurse is obtained, it will always be essential that she undergo a thorough examination at the hands of the medical man.

The ideal wet-nurse ought to be neither intemperate nor bad tempered, for such qualities, if present, would injuriously affect the infant committed to her charge. She ought to be married; but as it is very difficult to obtain a married woman for this purpose, it will usually be necessary to be content with a primipara who has been unfortunate; a servant girl, for example, who has been seduced by

her lover, but who is not really dissolute. The wet-nurse ought to be a healthy woman, preferably from twenty-five to thirty-five years of age, and she ought to be neither menstruating nor pregnant. If there exist the slightest suspicion that she may be the subject of syphilis, she ought on no account to be employed in the capacity of a wet-nurse. To give a healthy infant to a syphilitic wet-nurse, or to give a syphilitic infant to a healthy wet-nurse, is most cruel, and ought to be considered as criminal. Not long ago, a wet-nurse at Marseilles, who had contracted syphilis from her nursling, was awarded damages against the child's father to the extent of 1500 francs. It goes without saying that a wet-nurse ought not to be the subject of any acute disease, fever, or grave diathetic taint. It will probably be unnecessary to insist upon her being a brunette; if she be suitable in other ways it may be considered as immaterial whether she is brunette or blonde. Much more important matters for decision are the condition of her breasts and the state of her genital organs. The medical man ought to insist upon an examination of both the mammæ and the internal genitals. The presence of diseased states of the uterus, ovaries, and tubes, if these pathological conditions be non-syphilitic, need not necessarily condemn the woman altogether as a wet-nurse; but it is preferable that her organs be free from inflammation, and be not the site of tumour growths. Her breasts ought to give signs of good glandular development, they ought to be entirely free from disease of any kind, and the nipples ought to be well formed and not retracted. The quantity as well as the quality of the milk ought to be tested; and whilst many elaborate methods have been employed for this purpose, it will probably be found that there is in the condition of the nurse's own child a most reliable index of the characters of the lacteal secretion. If her child is well nourished and healthy, there can remain little doubt but that her milk is satisfactory in character. It has sometimes been stated that the wet-nurse's child ought to be of the same age as the infant she is to nurse, but this is probably unnecessary; if her infant be not less than a month old, that will be sufficient. It may be necessary in doubtful cases to examine the milk chemically and microscopically, keeping in mind the normal composition of the lacteal secretion which has already been described. A milk that shows under the microscope a large number of good-sized oil globules may be considered as good in character.

All the hygienic rules laid down for the guidance of the nursing

mother apply also to the wet-nurse; and it may be added that she ought not to be allowed to pay visits to her own infant, for she might then be tempted to feed her own child at the expense of the one she is hired to nurse. It is, however, the very least that the parents whose infant she is nursing can do to see that her child is well looked after, and so prevent her feeling anxious about his condition. The conduct of the wet-nurse should be under strict supervision, for many cases are on record in which it was found that she was in the habit of giving opiates to quiet the child she was nursing. It may be interesting here to quote the rules laid down many years ago by St Marthe* for the choice and hygiene of a wet-nurse:—

"Choose one of middle age, nor old, nor young,
Nor plump, nor slim her make, but firm and strong;
Upon her cheek, let health refulgent glow
In vivid colours, that good humour show:
Long be her arms, and broad her ample chest;
Her neck be finely turned, and full her breast:
Let the twin hills be white as mountain-snow,
Their swelling veins with circling juices flow,
Each in a well-projecting nipple end,
And milk, in copious streams, from these descend:
This the delighted babe will instant chuse,
And he best knows what quantity to use.
Remember, too, the whitest milk you meet,
Of grateful flavour, pleasing taste and sweet,
Is always best; and if it strongly scent
The air, some latent ill the vessels vent:
Avoid what, on your nail, too ropy proves,
Adheres too fast, or thence too swiftly moves:
Remark that she, nor with a fœtus teem,
Nor to have borne her child too lately seem,
Nor yet too long; and, to nurse well your boy,
She must not quite forget the marriage-joy:
Yet be she chaste, nor sluttishly inclined;
A sightly dress denotes a cheerful mind."

It will be seen that, even in the time of St Marthe, the greatest care was exercised in the choice of a wet-nurse.

* Scevole de St Marthe, *Paedotrophia*. Trans. by Tytler, 1797.

CHAPTER VIII.

THE PHYSIOLOGY OF INFANCY—Continued.

THE FEEDING OF INFANTS, *continued*—ARTIFICIAL OR HAND FEEDING—WEANING—FOOD AFTER WEANING.

The Artificial Method of Infant Feeding.—Hand-Feeding.

It is necessary now to consider those cases in which the maternal milk-supply has failed, and in which it has been found either undesirable or impossible to procure a wet-nurse. In such cases it has to be decided in what manner and with what food the infant can be most satisfactorily nourished. It is difficult to find a food which will be a suitable substitute for human milk, and it is almost impossible so to administer this food as to eliminate all the risks associated with the use of the apparatus employed for artificial feeding. In order to avoid such risks it has sometimes been recommended that the infant be fed directly by some animal, such as the goat; but the difficulties in the way of carrying out this procedure are so great that it is seldom attempted. Many foods have been brought under the notice of the profession and of the public as substitutes for mother's milk; but it may safely be said that not one of them fulfils all the requirements of the case. It would, therefore, be unprofitable to discuss fully the various foods that have been in use at one time or another; but some notice must be taken of those that are most commonly employed at the present time.

It is only natural that a substitute for the maternal milk should be sought for in the milk of one of the lower animals, and from time immemorial the milk of the cow has been used for the feeding of infants. It is true that the milk of the ass resembles human milk more closely than does that of the cow; but there are many practical difficulties in the way of using ass's milk for infant consumption, and the same remark holds good for goat's milk and ewe's milk. In the great majority of cases in which an infant must be

fed artificially, cow's milk must be chosen as the means of nourishment. Now cow's milk differs from human milk in many particulars. In its physical characters it is more opaque than human milk, it has a lower specific gravity (1029), and unless it is absolutely fresh it is slightly acid instead of persistently alkaline as is woman's milk. The following analysis, when compared with that on page 126, will show the chemical differences between cow's and human milk:—

Cow's Milk.

Water,	87·7 per cent.
Total solids,	12·3 ,,
Total solids not fat,	8·48 ,,
Milk sugar,	4·42 ,,
Albuminoids,	3·42 ,,
Ash,	0·64 ,,
Fat,	3·75 ,,

—(*Leeds.*)

There are four chief chemical differences between cow's milk and the milk of the nursing woman: first, there is more nitrogenous material in the former than in the latter; second, there is less fat in cow's milk than in human milk; third, there is much smaller percentage of milk sugar in cow's milk; and fourth, the nitrogenous constituents of the milk of the cow are affected by rennet in a manner different from those of mother's milk. In order, therefore, to fit cow's milk for infant's use, these differences must be corrected, and the correction of them causes further differences which have in turn to be corrected; the process in consequence becomes a complicated one.

But before considering the means adopted to alter the chemical composition of cow's milk, some allusion must be made to the very common but fallacious belief, that milk from "one cow" is the best for infants' use. The principle that underlies this belief is a perfectly correct one,—it is that it is desirable to obtain a supply of milk of constant composition; but it has been found that the milk of the same cow varies in its composition within wide limits during the twenty four hours, and that it is in reality more likely that an admixture of the milk from several cows will show a more constant analytic result than that from any single animal. One other reason why "one cow" milk is to a great extent a mistake must be added, and that reason is, that in a great number of cases the "one cow" is entirely a fiction. I can remember in the case of one dairy, at any-

rate, seeing a special can come in for the milk from one special cow for infant use. When the dairyman was busy, as was often the case, this can was simply filled from the general mixed supply. The baby fed on that milk throve well! To return to the means employed in order to render the characters of cow's milk similar to those of human milk, it is necessary, in the first place, to reduce the amount of casein (nitrogenous matters) in cow's milk. This is usually done by diluting the milk with water; but sometimes lime water is used for a reason to be stated immediately. An equal part of water is usually added for this purpose.

Second, the proportion of fat in cow's milk is less than in human milk, and it has been still further reduced by the dilution; therefore it is necessary to add to it fat in some form or other, and this is most commonly done by adding cream.

Third, sugar must be added to the cow's milk in order to bring the lactose up to the proper level. It has by some been held that it is necessary to use milk sugar for this purpose; but there seems to be little doubt that in the great majority of cases cane sugar will serve the purpose quite well.

Then, in the fourth place, it is necessary to prevent as far as possible the great coagulating effect that the lab-ferment of the infant's gastric juice has upon the casein of cow's milk; and this is satisfactorily accomplished either by adding an alkali, such as lime water, or some mucilaginous material such as barley water or Mellin's Food. In this way the casein curd is rendered loose and flocculent, and more like that of human milk.

In order to meet the above-mentioned indications it has often been advised that the "top-milk" be reserved for infant use, as it contains more fat in the form of cream; but probably the plan that meets all the requirements of the case in the most satisfactory way is that first recommended by Dr Meigs of Philadelphia. This author advises the preparation of a mixture which shall have the following composition:—

Cream, ...	2 oz.
Milk, ...	1 ,,
Lime water, ...	2 ,,
Sugar water, ...	3 ,,

(The sugar water is made by dissolving about 2¼ oz. of milk sugar in a pint of water.)

The employment of such a mixture as the above gets rid of the

difficulties which are connected with the differences in chemical composition that exist between cow's milk and human milk; but there remain untouched other and more serious difficulties and dangers. It must be remembered that cow's milk before it can be used in the nursery must pass through various hands, and must necessarily be exposed to various sources of contamination. (*a.*) In the *first* place, an unhealthy condition of the cow may so affect the milk as to render it dangerous as an infant food. The cow may have been fed upon improper foods such as brewery grains or distillery refuse, or she may be the subject of tuberculosis; in either case her milk will not be suitable for infant use. It is true that there is still some difference of opinion as to the possibility of the transmission of tuberculosis by means of milk; but the fact that observers such as Koubassoff, Bollinger, and Nocard, see great danger in the use of milk from tuberculous cows is sufficient to warrant medical men in the employment of any means that may lessen or prevent this risk. (*b.*) In the *second* place, impurities may gain admission to the milk on its way from the cow-house to the nursery, and during transit certain chemical changes may also occur in the fluid. For example, milk that is allowed to stand for cooling purposes in the cow-house will there absorb the odours of the place, and such milk if given to infants may cause a chain of symptoms which are collectively known as those of tyrotoxicon poisoning. This form of poisoning is not yet well understood; but some indication of its nature may be obtained from the fact that the nitrate of potash sometimes added to milk which has been standing for some hours causes the formation of bodies which resemble nitroglycerine, and which give rise to symptoms very similar to those of tyrotoxicon poisoning. Again, there seems to be no doubt that milk may act as a carrier of scarlet fever, diphtheria, typhoid fever, etc.; and it is easy to understand that if there be in the dairy a person who is in the desquamation stage of scarlatina, the infective scales may easily pass into the milk which is being sent out for public consumption. It is also easy to see how typhoid fever may be carried in milk if the milkman be in the habit of adding to the milk water which has been drawn from an infected source. Still another mode of transmission of such diseases as scarlet fever by milk has been pointed out by Woodhead* in the following words:—"The milk-

* G. S. Woodhead, "Milk and Milk Supply," *Edinburgh Health Lectures*, 1890, p. 26.

man going from door to door receives a dish which may have been standing during the whole night in the room of a patient suffering from fever. It is hurriedly rinsed out when the milkman is heard, and is handed to him with the particles of dust adhering to it. The man fills up his measure, and then fills the vessel he has received, but in the process a few drops are sure to pass back into the milk-pail, with the result that some of the dust is carried on to the next houses at which the milk is to be delivered." (*c.*) In the *third* place, impurities may enter the milk in the nursery from the use of dirty feeding bottles and tubes, and in this way fermentative processes may be set up.

Attention must now be directed to the means at hand for the prevention or correction of the presence of the impurities just named in the domestic milk-supply. It is fortunate that in the method known as the STERILIZATION OF MILK a means has been found of purifying milk which may already contain the bacilli of disease, and of preventing the onset of fermentative changes in milk which may have to be kept for some hours before being used. Sterilization of milk is a process which has already been adopted to a very large extent in the United States, in Germany, and in other foreign countries; but its benefits are not yet fully appreciated in this land. Already, however, instances are not wanting in my own practice in which infants fed upon cow's milk, prepared in the usual way, did not thrive at all well, in fact, became seriously ill, but who recovered rapidly and got fat upon sterilized milk.

A rough and ready method of sterilization is found in the simple boiling of the milk in a pan upon an open fire; but this plan is imperfect, and does not fulfil all the requirements of the case. Better methods of sterilization consist either in the placing of corked bottles of milk in a can containing boiling water, there to be subjected to a high temperature for from half an hour to an hour, or in the treatment of similarly prepared bottles by steaming in a closed vessel. It is found that milk thus prepared and kept in hermetically closed bottles will remain unchanged, even in hot weather, for one or two days, some say even for one or two weeks. The apparatus commonly in use at present is that of Soxhlet, and the following are the rules given for the carrying out of the process of sterilization by his method:—

"1. The milk which is to be used can be procured from several cows, and is not to be allowed to stand long before being sterilized.

"2. The milk to be thinned according to the instructions of the physician, *before* being poured into the bottles or heated."

If Meig's cream mixture is used, it is best to add the lime water after the sterilization is complete, and after the milk has cooled.

"3. A quantity of milk, rather more than is necessary for one day, is to be poured into the bottles (each of which holds about half a pint), by means of the large bill-shaped glass jar, to within half an inch of the neck of the bottle, and the india-rubber stoppers pressed firmly into their mouths. The bottles are then to be placed in the bottle-frame, and deposited in the water-pan, which is to be filled with cold water as far as the neck of the bottles, and brought to the boiling point. After it has boiled for five minutes, the glass rods are to be placed into the rubber stoppers, having previously been dipped in boiling water so as to make them air-tight. The pan is then placed on the fire and kept boiling for forty minutes, after which the bottles may be taken out and allowed to cool.

"4. When the child is to be fed, one of the charged bottles is placed in the double-floored metal jar filled with cold or lukewarm water, and heated by means of a spirit lamp or kitchen range until it reaches the required temperature.

"5. When the milk has reached the proper temperature, and immediately before being used, the glass stopper is withdrawn, and the suctional (rubber-teat) part is slipped over the mouth of the bottle.

"6. Milk which has been left by the child, or a bottle which has been opened by mistake, must on no account be used or given to the child. On the other hand, bottles which have not been opened may be safely used on the second or third day.

"7. Immediately after use, the bottle and the several parts connected require thorough cleansing, and ought to be washed in water several times with the wire brush. The bottles are then placed in the bottle-stand upside down till required."

The apparatus of Soxhlet is at present a little cumbrous; but many simpler forms of sterilizer, of which those are the best in which the process is carried out by steam, are already in the market; and, no doubt, as the value of sterilization becomes better known, the methods will be still further simplified. Heidenhain has recently demonstrated* the possibility of sterilizing milk by means of peroxide of hydrogen, and if it be shown that the digestibility of the milk is not thus

* *Centralbl. f. Bakt. u. Parasitenk.*, Bd. viii. No. 16, Oct. 1890.

affected, there is found in this method a very easy way of rendering milk pure and harmless.

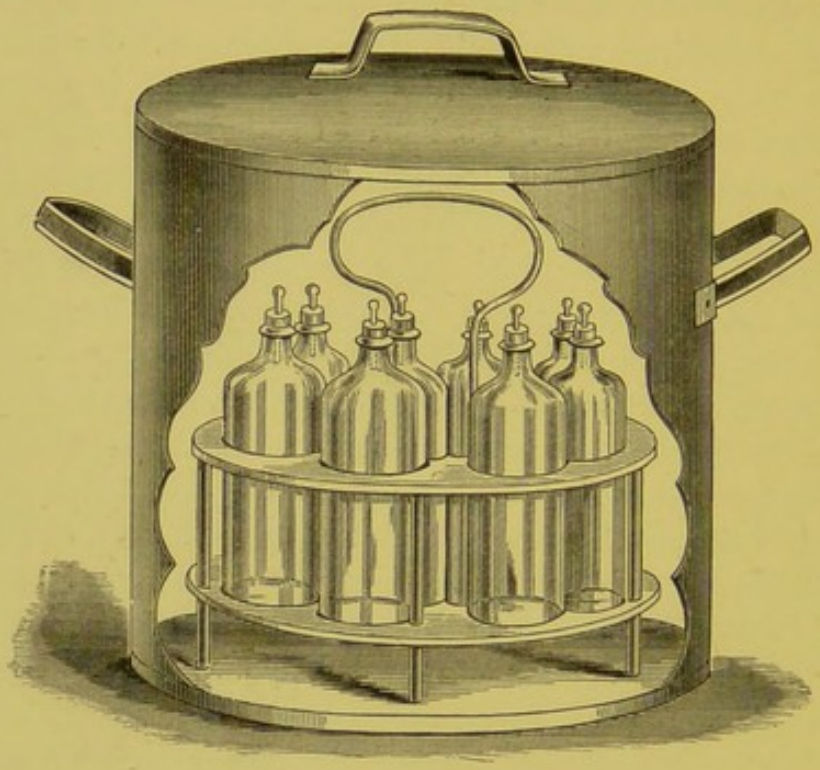


FIG. 5.—Soxhlet's Sterilization Apparatus. Pan containing bottles in bottle-frame ready for sterilization.

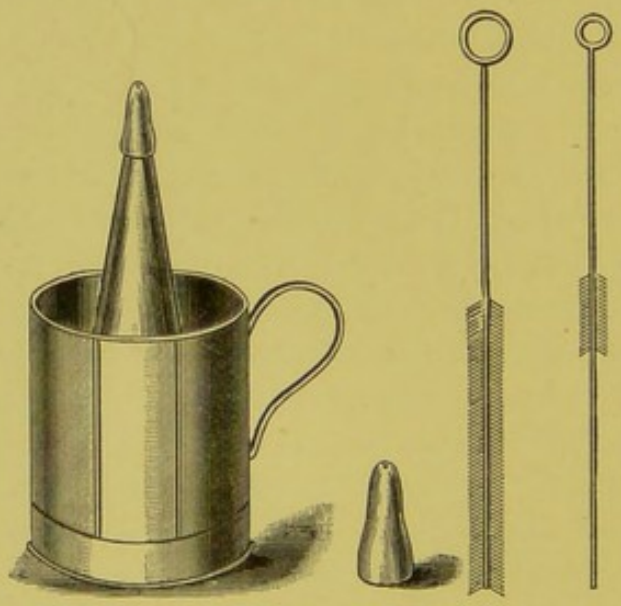


FIG. 6.—Soxhlet's Sterilization Apparatus. Bottle containing sterilized milk placed in double-floored jar ready for heating up. India-rubber tip and cleaners.

By the combination of the use of mixtures like Meig's cream food, and the practice of sterilization, most of the difficulties and dangers connected with the use of cow's milk can be removed; but there are other means which, if rationally employed, will greatly lessen the risks associated with the artificial feeding of infants. The sanitary inspection of cow-houses, the periodical medical examination of the cows, the careful supervision and isolation of any cases of infectious disease which may occur among the workers in the dairy, and the rigid enforcement of perfect cleanliness in the storage and conveyance of the milk to the customers, are all means which, if thoroughly carried out, would reduce almost to a minimum the dangers connected with the hand-feeding of infants.

It is now necessary to consider very shortly the means to be taken to avoid the third possible source of milk contamination, that due to the use of dirty feeding-bottles and tubes. All complicated feeding-bottles are a nuisance. They are simply traps for impurities and for germs of disease. It is extremely difficult to keep them clean. Mothers assure us that they clean them repeatedly, and the mothers in many cases speak only the truth; but still, with all care there are impurities, almost invisible it may be, which lodge in the angulations of the tube and around the fittings, and which influence injuriously the milk which is in the bottle. It is better to feed with a spoon than with a bottle that has a long india-rubber tube attached to it. A simple transparent flint-glass boat-shaped bottle, with no irregularities in the glass, and with no rubber tube, but with simply a black rubber tip or teat, is the least objectionable bottle that has been devised. The bottles used in the Soxhlet sterilizing apparatus answer to this description fairly well. The mother ought to be provided with several such bottles; and after one has been in use, it ought immediately to be thoroughly washed in scalding water, filled with a solution of bicarbonate of soda (℥ i. to a pint of water), and allowed to stand until again required. The india-rubber tip, of which there ought to be half a dozen or a dozen in use, ought also to be thoroughly cleansed, it should be inverted and scrubbed well with a nail-brush on both sides, and then carefully dried and kept in the open air in a box with numerous perforations. A feeding-bottle such as has been described has the advantage that it may be kept nearly if not absolutely perfectly clean; but it has in addition another advantage, for it entails the personal feeding of the infant by the mother or nurse. Such a bottle filled with prepared and sterilized

milk must be held in the nurse's hand, and she must, as the infant drinks, gradually tip it up so that the fluid can pass easily into the mouth. In this way that most convenient but most pernicious practice of putting the bottle into the crib or perambulator along with the baby comes to be impossible. This last-mentioned erroneous method of feeding has been and is still almost universally employed; it results, in too many instances, in the child sucking away at an empty bottle and thus distending the stomach with wind, and it is to be emphatically condemned.

In regard to the times of feeding and the amount of food required in infancy, something has been already said when maternal feeding was under consideration. It may be repeated here that the infant ought to be fed at intervals of two hours from 5 A.M. to 11 P.M. during the first two months of life; that up to the end of the sixth month two and a half hours ought to elapse between successive feedings; and that from the sixth month up to the time of weaning, food ought to be given every three hours. The quantity to be taken at each meal must be regulated by what is known of the stomach capacity at different ages. Under the subject of gastric digestion (page 115), allusion has been made to the stomach measurements in infancy; and, taking Frowlowsky's table as a guide, the following conclusions may be drawn as to the quantity of food necessary at each meal:—During the first week of life one ounce of Meig's cream food will suffice at intervals of two hours; up to the end of the sixth week about two ounces at each meal will be sufficient; up to the end of the sixth month from three to four ounces will form a meal; and up to the time of weaning, the quantity necessary will vary from six to eight or ten ounces. It is necessary to remember those quantities, for babies are very frequently overfed, and no doubt many cases of vomiting in early infancy are due to this and to no other cause.

There is one point in connexion with the feeding of infants which has not yet been mentioned, but which calls for a passing note, and that is the necessity of giving infants water to drink in addition to that which they receive mixed with the milk. Infants are often thirsty, and since milk does not quench thirst well, it is necessary to give water in small quantities occasionally, water that has been boiled is to be preferred.

Before passing to the consideration of the time and method of weaning, it is necessary to say something with regard to the almost

countless numbers of artificial foods for infants in common use at the present time. That these foods are all that is claimed for them by their vendors is more than doubtful; and it may be stated generally that, in the absence of the mother's milk, or that of a wet-nurse, sterilized cream food fulfils all the requirements prior to the time of weaning. It is, nevertheless, imperative that the medical men should be acquainted with the better known artificial foods in the market, for he is often asked by anxious mothers for advice in this matter. In making a reply to questions concerning the many varieties of artificial food-preparations it is very doubtful whether the physician should recommend any one of them, for that would be constituting himself an advertising agent for the manufacturers; but he ought to know so much of their chemical composition as will enable him to give a rational opinion upon the subject. Nearly all these artificial foods have as a basis cow's milk more or less altered, with, added to this, various starchy cereals, also more or less altered.

Condensed Milk has long held a high place in the opinion of the laity; but it must not be forgotten that there are several very different preparations grouped under this general name. There is, for instance, that form of condensed milk in which the cow's milk is simply evaporated to one-fourth of its volume and sterilized, nothing at all being added to it; and there is again that form in which the milk is not only condensed, but has also the addition made to it of about fifty per cent. of cane sugar. When it is also borne in mind that the composition of condensed milk varies with the season of the year and with the locality in which it is manufactured, it will be seen that great fluctuations must occur in its chemical constitution. Condensed milk also must be diluted with water before it is fit for use, and this dilution may entirely disarrange the proportions of the component parts of the fluid. For these and for other reasons it is found that even when infants appear to thrive well upon condensed milk, their apparent good health is due to an excessive deposit of fat, and not to a sufficient supply of albuminoids, and they are in the long run more prone to disease than babies fed at the breast or upon cow's milk properly prepared. The above remarks apply with less force to that variety of condensed milk which is made from the sterilized fluid and which is unsweetened; but even this preparation requires for digestibility to be diluted some ten times, and this reduces its nutritive value to a dangerous degree.

Peptonized milk, that is to say cow's milk which has been predigested by pancreatic extracts, is undoubtedly of great service in cases of gastric and intestinal disease in infants; but there is no reason why the stomach of the healthy child should be relieved from its digestive duties by any such artificial preparation of the food. The use of this food in the case of healthy infants will only serve to prevent the proper development of the gastric and intestinal digestive functions, and even in cases of disease it is well to discontinue its employment as soon as the stomach has begun to resume its natural power of digestion.

The next class of infants' foods contains those in which there is added to the cow's milk some ingredient such as wheat or barley-meal, and in whose chemical composition, therefore, there is a wide difference from either human or cows' milk. Of the many members of this class may be mentioned Mellin's Food, Nestlé's Food, Frame Food, Carnrick's Food, and Benger's Food, which are all foods greatly advertised and widely used by the laity. There may be no very important reason why such foods should not be used after the first year of life; but there is a sufficient reason why they should not be employed before the natural time of weaning, and that reason is that they contain a substance, starch, for the digestion of which, as physiology teaches, little preparation is made in the infantile alimentary tract. It is true that occasionally an infant seems to be able to digest starchy matters; but such cases form the exception and not the rule, they are probably of the nature of idiosyncracies. The analysis of Nestlé's food given by Rotch * is most instructive, and clearly demonstrates the difference in composition which exists between this food and human or even cow's milk:—

Fat,	1·91	
Albuminoids,	8·23	
Sugar,	38·92	1
Ash,	1·59	
Starch,	40·10	
Water,		10
		11

From a consideration of the chemical composition of this food, Rüger† agrees with Rotch, who says it "provides a larger amount of starch

* Rotch, "Infant Feeding," Keating's *Cyclopædia of Diseases of Children*, vol. i. p. 311.

† Rüger, *Gesundheit*, Nos. 11, 12, 1888.

for the infant's digestion than the other foods, almost one-third less total solids than woman's milk, practically no fat, too little albuminoids, one-half too little sugar, and a fair percentage of ash." It is claimed for another food (Mellin's) that the starch difficulty has been overcome by converting the starch into glucose; but it may reasonably be asked, *Cui bono?* Why add either starch or glucose? Nevertheless Mellin's Food in many of its characteristics is among the less objectionable forms.

But it is needless further to discuss the varieties of infant foods. The solution of the problem of infant feeding is, so far as our present knowledge goes, to be found in the use of cow's milk, so prepared as to resemble closely in composition mother's milk, and so protected from external influences, bacterial and otherwise, as to possess the same purity as human milk drawn directly from the mammary gland. These requirements are, in the present state of scientific knowledge, best attained by the use of the cream mixture and sterilization, with, as adjuncts, the sanitary supervision of cows, dairies, and milkmen, and the employment of simplified and thoroughly purified feeding-bottles.

Weaning.—Ablactation.

The physician's advice is often asked upon such subjects as the time of weaning and the manner in which that process is to be carried out. Many popular beliefs—one might almost say superstitions—prevail as to the determination of the date of weaning; and it is, therefore, very important that the medical profession should speak out clearly and emphatically on this point. There are not wanting mothers who have been taught by *their* mothers that the position of certain signs in the zodiac forms the solution of this difficulty; and there are other rules in use among the laity and also in the profession scarcely less ridiculous. It is a mistake to think that any hard and fast rule can be given for the time of weaning. The date of ablactation depends upon the condition and health of the mother, and upon the development of the infant—more especially as regards his dentition. In ordinary circumstances the mother may safely suckle her infant till from the tenth to the twelfth month, provided she retains her health and her infant continues to grow in weight. Weaning really depends not so much

upon the number of months the child has lived as upon the stage of teething arrived at. Nature affords a guide in the appearance of the teeth: and, other circumstances being normal, when teething is early, weaning ought to be early; and when teething is late, weaning also ought to be postponed. Every child is in this matter a law unto himself; and whilst ten to twelve months is the usual time, it is by no means always correct. The time for weaning most suitable for one child may be most unsuitable for another. The physician may as often have to advise late weaning as early.

With regard to premature weaning, the medical man should, before recommending that nursing be brought to an early close, take fully into consideration all the circumstances of the case, and be guided by the state both of the mother and of the child. Causes very similar to those which in the first instance prevent maternal lactation should determine premature ablactation. Amongst such causes are acute diseases of the mother; local diseased conditions of the mammæ, such as abscess; the recurrence of pregnancy or of menstruation, and the manifest signs of malnutrition of the infant as seen in the development of rachitis. If there be a suspicion that the mother's milk is not supplying sufficient nutriment for the infant, a chemical examination of it ought to be made before weaning, so as to determine its value; for it is possible that some cause other than the milk-supply may be injuriously affecting the infant's health. Mothers ought to be warned against the pernicious habit of continuing lactation in the hope of preventing conception. There is no foundation for the idea that nursing will prevent the occurrence of pregnancy, and the continued feeding of the infant with breast milk of poor quality may interfere with his natural growth. It is probably wise, however, to delay weaning for a little while in the summer months, for infants at that period of the year thrive best on the maternal milk. It is also advisable to choose for the time of weaning an interdental and not a dental period, for at the time when the eruption of a tooth is taking place the system is more apt to be thrown out of order by change in diet.

Weaning is a process which ought to be accomplished gradually and not suddenly. Gastric digestion does not all at once adapt itself to the change in food, and dyspeptic disorders may be set up by the sudden absolute withdrawal of the maternal milk. The

process ought to extend over a month; and should any abnormal symptoms arise during this time, a return to the original mode of feeding should be made for a while. It has been recommended, and the plan is a good one, that during the first week six lactations and one artificial feeding daily should be given; that during the second week there should be five of the former and two of the latter; in the third week three of the former and four of the latter; and that in the last week of the month the breast should be given once daily and artificial food six times. In this way the change in diet will be made without risk of starting digestive or other troubles in the infant.

Infant Feeding after Weaning.

Diet after weaning is nearly as little comprehended as diet before weaning. The baby of less than a year old cannot, it may be admitted, thrive upon the food of his parents; but it is equally true, although perhaps less generally known, that the child of two, three, or four years cannot enjoy good health unless fed upon articles of diet suitable to his age. With regard to the proper food for later infancy, the following letter from a mother may be adduced as evidence of the erroneous feeding in common use at this period of life. The letter appeared in a journal devoted to the health of children (*Babyhood*), and it runs as follows:— "I have a boy four years and three months, and a girl three years old, both much advanced for their years. They talk fluently, and are very bright children. Through their good-natured grandparents they are inclined to luxury, much to their father's and mother's protest. The children have both good appetites. At breakfast they have each a cup of gruel, followed by a chop (and often more), hashed potatoes, two small cups of milk (a drop of tea in it), and toast. For lunch, either beefsteak, cold roast meat, a chicken (plenty of it), with baked or hashed potatoes, and bread and butter and milk. Cake and candy between meals. At six o'clock (sometimes later) they come down to table, and partake of clear soup, oyster soup, etc., bread and butter, apple sauce, milk, and plenty of ice water, sometimes chicken, lots of ice-cream." The writer then goes on to ask, "Is this right?" Such a letter as the above may well drive one to despair. Nearly everything mentioned in the communication is wrong or unsuitable; and one

does not require to be gifted with prophetic vision to foresee a future of gastric and dyspeptic misery for these unhappy children.

During the process of weaning from the breast, and for some years afterwards, milk must still form the staple article of diet. During weaning the artificial food which has gradually replaced the maternal milk has been, if regard has been paid to health, cow's milk prepared in the way which has been already described; and during the first six months after ablactation cow's milk must still bulk largely in the infant dietary. From the twelfth to the eighteenth month of life a child ought to have some five meals a day; breakfast, consisting of a cupful of milk, with perhaps a lightly boiled egg, at 7 A.M.; another cupful of milk, with some bread and butter, at 10 or 11 A.M., will constitute lunch; dinner at 2 P.M., will consist of some beef-tea, potatoes, and a pudding of rice or tapioca; there will be a meal at 6 P.M. resembling the morning repast; and at 10 P.M. it will be necessary to give the child another cupful of milk with perhaps a little bread.

From one and a half to two and a half years of age children will usually require four meals a day, the cupful of milk at 10 P.M. being now omitted. There may be added to the dietary chicken soup, mutton broth, porridge, and underdone, finely divided beef or mutton. Fruits must be given with caution, although they are by no means to be forbidden. During this period the child will be admitted to the family table, but must on no account be allowed to partake of everything he sees there.

From the third year onwards a more varied and more extensive dietary is permissible; but still many articles of food must be denied, such as highly seasoned meats and sauces, strong tea and coffee, and indigestible sweets. No words strong enough can be found wherewith to condemn the iniquitous practice of allowing young children to sip the wines or beer found on their parents' table. This practice is a cruel one, and may lead to digestive troubles at the present time and to more incurable evils later on. The stuffing of children with sweetmeats, rich cakes, and pastry is also very injurious to complete health, and the giving of food of any sort between meals is a most objectionable practice. It must not be forgotten that water at meals is a necessary part of a child's dietary, and it must also be borne in mind that of the condiments salt alone is necessary in infancy.

CHAPTER IX.

THE PHYSIOLOGY OF INFANCY—Continued.

DENTITION OR TEETHING—PERIOD OF THE ERUPTION OF THE DECIDUOUS TEETH—SYMPTOMS OF DENTITION MANAGEMENT.

The process of dentition has been, and still is, the subject of much misconception. There are on the one side those who assert that dentition is as painless a process as the growing of the finger nails; and there are on the other side those who ascribe to teething all the ills that infants are heir to. In regard to the statement that dentition is a physiological process unattended with pain or discomfort, it is true that perfectly healthy infants may not suffer in any way from the eruption of the teeth; but it is also true that few infants are perfectly healthy at this period of life. The time of dentition is, as has just been stated, the period chosen for the weaning of the infant, for the substitution of a partly solid diet for the mother's milk or the liquid preparations of cow's milk; and on this account alone it is probable that gastric, intestinal, and other disorders may arise, which, occurring synchronously with the eruption of some of the teeth, may not only interfere with the normal process of dentition, but also themselves be aggravated by the changes then taking place in the mouth. Diseases other than those due to the erroneous notions common with regard to weaning may also be present at this time of life, and may both act upon healthy dentition and be reacted upon by that process. So that, whilst it may be quite true that a perfectly healthy infant does not suffer from dentition, it must also be admitted that few infants are free from disease whilst teething is going on.

As regards the statement that all the diseases occurring at or about the time of dentition are produced by the reaction of the system due to the purely local process going on in the gums, it is at once evident that this, to say the least of it, must be a greatly exaggerated view of the whole subject. It is, of course, next to impossible logically to prove that any disease that may affect a

young child may not be due to dentition: for if there are no teeth, the disease may be due to their tardy appearance; if there are teeth, they may yet be coming in wrongly; and if they are coming regularly but rather speedily, why, then, the child may be ill because of their premature eruption.* Physicians, therefore, as well as mothers, are tempted to find in teething an explanation of the origin of all infantile disease; and they too often adopt that maxim which tells the whist player when in doubt to play a trump, and, applying it to the pathology of infant life, say, "when in doubt as to diagnosis ascribe the state of things to teething." It is from reasoning such as the above that such names as tooth-rashes, dentition-convulsions, teething-colds, and teething-diarrhœas have arisen; and it is this belief in the malign influence of teething that has most prejudicially affected not only the treatment of all diseases occurring at dental periods, but also the management of the process of dentition itself. For if parents believe that teething is the cause of a diarrhœa or a skin eruption, then since the cause cannot be removed there is little benefit to be derived from attempting to cure the diseases produced by it. Nay, the argument is carried still further in some cases, and it is held that any attempt to treat the diseases occurring at dental periods is to be absolutely forbidden, as it may prevent or delay the proper eruption of the teeth. It is on account of this belief that mothers fear to "drive in a skin eruption" or to treat a diarrhœa which may occur at dentition time. In a very curious manner, also, the beliefs above mentioned are so twisted as to lead to the argument, that if an infant suffer from a diarrhœa or a cold, then the process of tooth-eruption must be going on, even if no sign of such a thing be present in the child's mouth.

Both the views of dentition which have been described are extreme, and are founded upon misconceptions. It is, as a rule, safe to assert that whilst there is nothing in the process of dentition itself which necessarily entails suffering in the infant, there is at the same time the very frequent association of various ailments with dentition, pointing to an unstable condition of the system at this period, and the possibility in some cases of demonstrating the

* It was a consideration of the many evils ascribed to dentition that led St Marthe to exclaim:—

"How great, alas! appears the wrath of Heav'n!
And is it thus our teeth must still be given?
Those useful instruments that cherish life,
And break our viands with unceasing strife."

causal relationship existing between dentition and a convulsive seizure, or between the eruption of the teeth and the disappearance of a diarrhœa. It is wise to adopt this middle course of belief, for there is a danger at present lest the old idea that teething is the source of all disease be replaced by the modern theory that dentition is a perfectly harmless process requiring no treatment and no special care. In order to illustrate the causal connexion which may exist between teething and certain diseases, it will be sufficient to cite the case of the so-called "teething-cough" or bronchitis of dentition. A "teething cold" is due in many cases to dentition, but not in the way that is usually supposed. The explanation of the frequency of colds at this time of life is to be found in the fact that teething is usually accompanied by an excessive secretion of saliva, and that unless this secretion be very carefully wiped away it will trickle on to the child's dress and soak it, thus leading almost inevitably to a cold in the chest. A bronchitis having been set up, it is easy now to understand how the inflammatory condition of the bronchi may weaken the general health, upset the digestive functions, and lead to an inflammatory state of the mouth, with all the attendant symptoms of stomatitis, gingivitis, feverishness, restlessness, disturbed sleep, digestive disorder, and the like. In some way such as this it will be found possible to explain the frequent association of various pathological conditions with the process of teething. I may conclude the discussion of this question by quoting the wise words of an old writer (Ryan, 1833) which are as follows:—"It would be inconsistent with the usual course of nature that the development of the teeth should be productive of more pain and danger than the growth of any other part of the body; and it would be contrary to the unbounded goodness of Divine Providence that so many tender infants should be doomed by dentition to the severest sufferings, nay, to death itself. The cause is mismanagement of physical education, and not the intention of the great and beneficent Author of all good."

The Eruption of the Teeth.

Dentition is a continuous physiological process commencing in early fœtal life, and terminating with the appearance of the wisdom teeth at the age of from eighteen to twenty-two or even twenty-five years; but, whilst dentition may be said to be continuous, the eruption of the teeth is an intermittent process, the teeth appearing

in groups and at certain intervals of time. The first great period of dental eruption is known as the time of the appearance of the milk, temporary, or deciduous teeth; and this period lasts from the sixth or seventh month of life to the end of the third year. There is then a period of rest, or an intermission, during which no new teeth appear in the mouth; and then at the sixth year begins the eruption of the permanent teeth, a process which can only be said to be completed when the wisdom teeth have appeared at the eighteenth or twentieth year. The milk teeth drop out to make way for the permanent set. It is with the teeth of infancy, or the deciduous set, that we are here specially concerned. These teeth are twenty in number, ten in each jaw, and they appear in groups. The time of eruption of each group is by no means constant, great individual differences being found; but as a rule the order of eruption may be stated as below. First there appear, at a time varying from the sixth to the eighth month, the two lower central incisors. Sometimes one appears before the other, but usually they appear simultaneously. Their eruption marks the first dental period. Then comes an interdental period, and then about the ninth month appear the two upper central incisors, and soon thereafter the two upper lateral incisors. Then, at a date varying from the twelfth to the fourteenth month, appears a third group consisting of the two upper anterior temporary molars, the two inferior lateral incisors, and the two inferior anterior deciduous molars. Between the sixteenth and the twenty-second month appear the four canine or eye teeth, which, it will be observed, are the only teeth which have to force their way between teeth that have previously appeared. Finally, at some time between the eighteenth month and the end of the third year, the four posterior deciduous molars force their way through the gum. Auvard's scheme of dental eruption (Fig. 7.), although partly artificial, will be found to be useful as an aid to memory.

The dates given above are approximately correct, and may be taken as normal; but variations are very common. The upper incisors may, for example, appear before the lower, or there may be either a delayed or a premature eruption of any or of all the teeth. Cases are on record in which infants have been born with teeth. Louis XIV. of France is said to have possessed four incisors at birth; and of Richard III. of England, Shakespeare has said, "He could gnaw a crust at two hours old." On the other hand, many instances of delay in the eruption of the teeth are to be found in

medical literature. It is not uncommon to hear of infants who showed no teeth till the fourteenth month, and cases are on record in which the first tooth appeared at a still later date. The association of rickets with delayed eruption of the teeth is a well-known clinical fact.

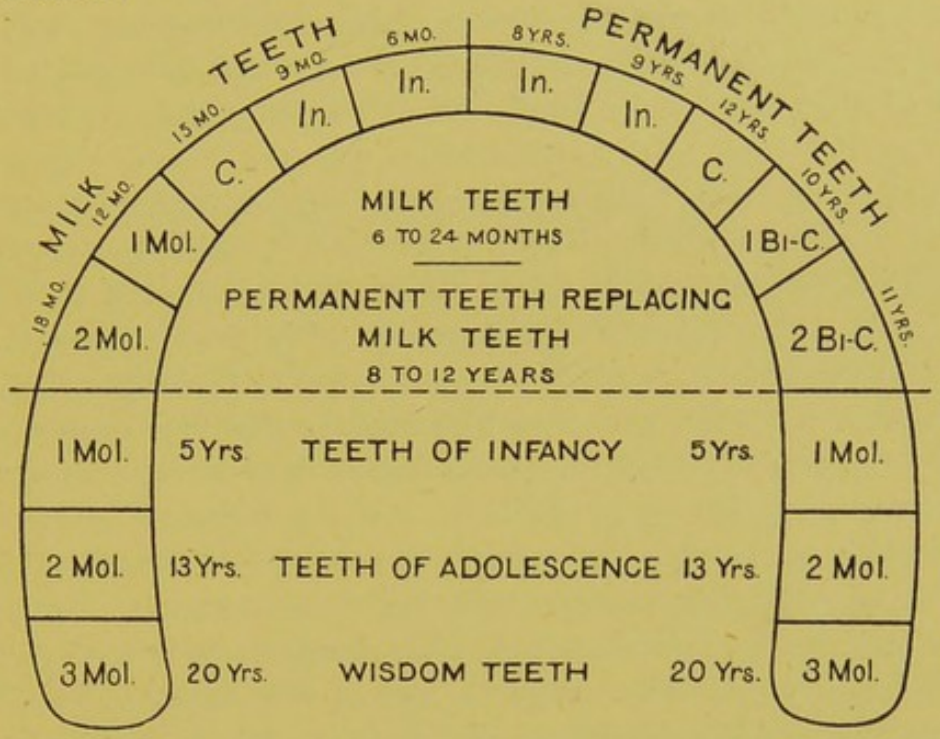


Fig. 7.—Scheme of Dental Eruption (after Auvard).

Symptomatology of Dental Eruption.

It will be readily understood from what has been said at the beginning of this chapter, that it becomes a matter of great difficulty to make any definite statements as to the clinical signs and symptoms of teething. Whilst some ascribe to teething a long series of well-marked clinical manifestations, others hold that the process is unaccompanied by any sign or symptom, local or general, save and except the appearance of the tooth itself. Without pledging one's self to either view, it may be stated that the infant at the time of teething usually exhibits some clinical features which, whilst they may not be immediately due to teething, are very constantly found associated with that process. Infants during dentition almost invariably exhibit signs of buccal discomfort. They are often discovered in the act of rubbing the gums with hard substances, such as crusts of bread, metallic rings, or their own fingers; and it is

usual to find that they dribble or "drool" a good deal. This "drooling" consists in the escape from the mouth of large quantities of saliva, and begins some weeks before the eruption of the first tooth. It may have little to do with teething, and may simply announce the fact that the salivary glands are passing from the comparatively inactive stage into an active one. Redness, swelling, and tenderness of the gums may be present; but it is difficult to say to what extent these manifestations are due, not to the eruptive process itself, but to the means taken with the hope of artificially aiding this process There may actually exist stomatitis and gingivitis, conditions which point to a markedly disordered state of the digestive system, and in the existence of these diseases it is not surprising that diarrhœa also appears. It is more reasonable to ascribe these disorders to errors in diet than to teething, especially since it is a matter of everyday observation that they occur much more frequently in hand-fed infants than in those brought up by the maternal method. The probable cause of the frequent occurrence of bronchitis at the time of dentition has been already stated (p. 151). With regard to convulsions occurring during teething, it must be admitted that convulsive seizures often disappear very soon after a tooth has cut its way through the gum or after the gum-lancet has been used, and it must be conceded that in a child prone to convulsions, an attack may at any rate be finally determined by the irritation in the mouth consequent upon the process of tooth eruption. It must always be borne in mind that convulsions are very easily excited in infants, that the nervous system is very delicately balanced, and that trivial causes may disturb this equilibrium, especially if the child be rachitic. Teething must, I think, be included among the minor causes of convulsive seizures in infancy; but, at the same time, convulsions cannot be said to be constant symptoms of dentition. Very similar remarks apply to the cutaneous eruptions common at the teething period of life; these affections, which are usually of an eczematous, lichenous, or urticarious character, are more probably directly caused by the digestive troubles common during dentition than by dentition itself. There seems to be no sufficient reason why such "breakings-out," as they are called, should not be treated during the period of teething just in the same way as at any other time of life. I have not met with a case in which their treatment had any disastrous results. From what has been said of the many disorders common during dentition, it may easily be conceived that

feverishness, restlessness, sleeplessness, and irritability, are symptoms which may be expected to be commonly met with; and every mother knows that this is the case, and it is far more likely that these concomitants of teething, and not the simple process of tooth extrusion, are to be looked upon as the causal factors. Other symptoms, such as those of eye and ear disease, have been attributed to dentition; but these are evidently so distantly related to that process as to demand no further notice here.

The Management of Dentition.

From a study of the symptomatology of dentition the medical man will be led to expect to find most confused notions prevalent among the laity as to the treatment of teething, and he will not be disappointed in his expectation. From the earliest times the whole process of dentition and its treatment has been surrounded with mystery and superstition. It is said that in Africa, at the present day, the Ibo people kill all the children who cut their upper teeth first; and at home here, there are practices scarcely less absurd, if not so dangerous. Amulets and charms, such as the anodyne amber necklace, and the brains of a hare, have been, and are still used as means of facilitating dentition and relieving its attendant pains; and whilst medical men do not recommend such things, they often tacitly allow the use of the more dangerous "soothing-syrup," and they not infrequently scarify the gums with the lancet both in season and out of season.

There are two great rules that ought to guide the physician in his treatment of infants during dentition. The *first* is that the process of tooth eruption requires little or no special treatment. If the health of the infant be kept at high-water mark, by careful regulation of the diet and by strict attention to the laws of hygiene, little else will be required, and the process may be safely left to Nature. The so-called "soothing-syrups" usually contain bromides and opiates, and are most dangerous preparations to give to infants. Teething-rings and "gum-sticks" made of metal, coral, ivory, or glass, are not only of most doubtful benefit, but may even intensify any inflammatory condition of the mouth which may be already present. The india-rubber ring is less objectionable, and there can be no harm in the use of a crust of bread as a gum-stick if such a thing be desired; but the much vaunted coral is too hard a

substance to be safely placed in an infant's mouth. It need scarcely be said that the so-called "sugar-teats" are not only abominable and disgusting, but are actually in many cases the direct cause of simple or of parasitic stomatitis. With regard to the use of the gum lancet, it is more difficult to lay down any absolute rule; but there seems to be little doubt that in normal teething this instrument is altogether unnecessary, and that even in difficult dentition it is seldom required. At the same time it must be admitted that the local bloodletting produced by judicious scarification of the gums may in some cases do good. The physician, however, ought not to allow himself to be induced to scarify the infant's gums simply in order to satisfy the demands of an anxious mother. He ought not to use his lancet simply in order to be "doing something."*

In the *second* place, diseases, such as skin eruptions, diarrhœas, and coughs, occurring during dentition ought to be treated. No harm can possibly result from their judicious treatment with the proper remedies; and they ought not to be regarded as the necessary concomitants of the teething process. To leave such ailments untreated is simply to pander to the superstitious notions of mothers and nurses. To summarize, the most rational treatment of teething is to make sure that infants at the time are put under the best hygienic conditions as regards food, clothing, ventilation, and exercise, and thereafter to leave the process to Nature, treating promptly, however, any complications in the form of diarrhœa, bronchitis, eczema, etc., which may arise.

The care of the deciduous teeth, after their eruption is complete, is a matter too often neglected. The systematic cleansing of the infant's teeth cannot be begun too early. Dentists are unanimous in stating that the children of the present day have seldom good teeth, and whilst many causes may be at work in producing early decay, there can be no doubt that neglect of the proper supervision of the milk teeth is at least one of these etiological factors.

* In one case of so-called difficult dentition I was very nearly led to scarify the gums, and I was very glad afterwards that I refrained; for on the next day the discharge of pus from the infant's ear made plain the cause of the child's sufferings.

CHAPTER X.

THE PHYSIOLOGY OF INFANCY—Continued.

PHYSIOLOGY OF THE CIRCULATION—THE PULSE—THE CHARACTERS OF THE BLOOD—THE PHYSIOLOGY OF RESPIRATION IN INFANCY—THE CHARACTERS OF RESPIRATION IN HEALTH AND IN DISEASE—THE COUGH—THE SPUTUM—THE CRY.

The Conversion of the Fœtal into the Infantile Circulation.

The circulation of the blood is not a function taken on for the first time at birth, for during the greater part of intra-uterine life the blood of the fœtus has been passing through the vascular system to and from the placenta; but at the moment of birth there takes place a wonderful rearrangement of the course of the blood-flow in immediate consequence of the stoppage of the placental circulation and of the commencement of pulmonary respiration.

It may be well briefly to trace the course of the circulating blood in the fœtus, in order to make more clear the changes which occur at birth. The umbilical vein receives the blood which has been purified by its proximity to the maternal blood in the placenta, and carries it to the under surface of the liver. Here the blood current breaks up into two streams, the greater part of it passing through the ductus venosus into the vena cava inferior, and the smaller passing directly to the liver itself. In the vena cava inferior, however, is found not only purified blood from the ductus venosus, but also the impure supply which is returning from the lower limbs along with that which has circulated in the substance of the liver. This mixed blood is poured into the right auricle of the heart, from which chamber by far the greater part of it passes through the patent foramen ovale directly into the left auricle, and thence into the left ventricle. The systole of the heart propels the blood contained in the left ventricle into the aorta and vessels of the head, neck, and arms—a small part, however, passing to the lower part of the body. The venous blood returning from the head, neck, and arms passes along the superior vena cava into the right auricle, crosses there the stream of blood coming from the inferior cava,

enters the right ventricle through the tricuspid opening, and is thence propelled into the pulmonary vessels. The lungs, however, are as yet unexpanded, and the greater part of the blood destined for them passes through the ductus arteriosus into the descending aorta. The blood in the descending aorta has thus come both from the left and from the right ventricle, and it now passes to the lower part of the body; but the greater part of it does not reach the lower limbs, for it is carried by the two hypogastric or umbilical arteries through the umbilical ring to the placenta, there to be changed from venous into pure arterial blood.

Such, briefly stated, is the course of the circulation in the unborn infant; at the time of birth, however, the conditions are entirely changed, for with the division of the umbilical cord, or the separation of the after-birth, the infant finds that the placental purification of the blood is no longer possible, and he has in consequence now to rely upon the establishment of an independent circulation, and the commencement of pulmonary respiration. The great circulatory changes associated with the establishment of the lung functions are marvellously quickly carried out, and this physiological revolution is very rapidly followed by structural alterations in the heart, in the ductus arteriosus, and in the umbilical vessels. To these organic modifications in the heart and great vessels full attention has been paid in a preceding chapter (*v.* p. 68); but a sentence or two must here be devoted to the physiological changes in the course of the circulation which lead to the closure of the foramen ovale, the ductus arteriosus, and the umbilical vessels. Air passes into the infant's lungs with the establishment of respiration, the organs are thus inflated, the pulmonary vessels dilated, and a large quantity of blood drawn into them from the right ventricle of the heart. More blood, therefore, passes directly from the right auricle into the left ventricle, and less through the foramen ovale into the left auricle; but, at the same time, a plentiful supply of arterialized blood returning from the lungs by the pulmonary veins now finds its way into the left auricle. In this way the vascular pressure in the two auricles comes to be equalized, and the closure of the foramen ovale is rendered possible. Blood also ceases to flow through the ductus arteriosus, and this vessel soon becomes impervious. Further, the ligature of the umbilical arteries prevents the passage of blood from the descending aorta to the placenta, and in consequence of this the current through the femoral arteries to the lower limbs is greatly

increased. In future the impure blood from the lower part of the body passes through the inferior vena cava into the right auricle, where it is joined by the venous blood from the head, neck, and arms; but where no longer is there any admixture with purified blood from the placenta, for the umbilical vein and ductus arteriosus are now closed. In this way the circulation of the fœtus, which supplies to the body a blood partly venous and partly arterial, is replaced by the more perfect circulation peculiar to extra-uterine life, which sends to all parts of the body a fluid which has been arterialized in its passage through the lungs. The centre of blood-purifying activity has thus been shifted from the placenta to the lungs.

In connexion with the circulatory changes which occur at birth there follow changes in the relative thickness of the walls of the chambers of the heart. The left ventricle has now more work to do, and its wall, therefore, hypertrophies, so that its weight, at the end of the first year, comes to be double that of the right ventricle. The right auricle has at first a thicker wall than the left; but from the second month after birth to the end of the first year the two auricles have walls which are practically equal in thickness. After that time, however, the right auricle increases in weight more quickly than the left, until at the time of puberty the former is about 5 per cent. heavier than the latter. This increase in the right auricle after the end of the first year of life is no doubt due to the commencement of the active muscular exertion connected with walking.

The Ligaturing of the Umbilical Cord.

It is not necessary that the umbilical cord should be tied in order that the extra-uterine circulation may be established—indeed, the change in the course of the blood current usually takes place before the cord is ligatured; but all writers are now agreed that, for many other reasons, it is advisable to tie the cord as soon after birth as is possible. The practice of leaving the placenta attached to the infant's body with the cord untied has now been universally abandoned in civilized countries, for it has been shown that the diseases of the infant (icterus, convulsions, etc.) formerly ascribed to ligature of the cord are due to totally different causes; but as to the time after birth most suitable for the application of the ligature

much difference of opinion still exists. It would seem that no rule can be safely laid down as to the exact number of minutes that should be allowed to elapse before the cord is tied and divided, for in some cases it has been demonstrated that it is wise to leave the cord untied for some time, whilst in others it has been shown that early ligaturing is demanded. It has, therefore, been stated that in pale still-born infants the cord should not be at once tied, so that blood may pass from the placenta into the child's body; whilst in cases of apoplectic infants the cord should not only be cut at once, but some blood ought to be allowed to escape before the ligature is applied. It is difficult in practice to apply these rules, and to discriminate between infants requiring early and those requiring late section of the cord, and no better rule of conduct has yet been found than that enunciated many centuries ago by Hippocrates. The father of Medicine laid down the principle that omphalotomy or section of the cord should be performed as soon as the infant had respired and cried, and at the present day no better guide to the proper time for the division of the cord can be found than that which is present in the establishment of respiration as shown by the child's breathing well or crying lustily.

Immediately after the infant is born, he ought to be drawn from under the bed-clothes, which should be tucked in around the mother to protect her from cold; but he ought not to be placed too far away from her so as to make undue traction upon the cord. In this way the mother's feelings of modesty are respected, and the danger of amputating a finger, a toe, or the penis of the infant are removed, for the attempt to tie and divide the cord with the infant concealed has in sundry cases resulted in such awkward occurrences. It having then been ascertained that the child is breathing satisfactorily, the root of the cord must be examined, in order to make certain no loop of intestine is contained therein, and thereafter the ligature may be applied. It has been recommended that the infant should, during this operation, be placed upon the right side, for such a posture, it is believed, aids the closure of the foramen ovale; but this advice is not of very great importance. The ligature may consist of a skein of fine threads or of elastic tape, and the latter material has the advantage of not becoming loose as the cord dries up and contracts; but in ordinary cases thread serves the purpose quite well. The ligature ought to be placed upon the cord about three finger-breadths from the infant's body, so as to allow room

for a second ligature should hæmorrhage from the stump occur, or should the first ligature slip. It is advisable now to place a second ligature round the cord at a point distal to the first ligature, for in this way hæmorrhage from the placenta in the case of a twin-birth is avoided. The cord having been constricted in these two places ought now to be divided midway between the ligatures by means of a pair of strong blunt-pointed scissors. The cut surface of the cord should be inspected, in order to be sure that all hæmorrhage has ceased, a piece of clean lint should be wrapped round the stump, and the abdominal binder applied. Desiccation of the cord will proceed rapidly, and in four or five days the stump will fall off, leaving a cicatrix—the umbilical scar. Various special methods of treating the umbilical cord have recently been recommended. These plans have been thought necessary in order to prevent the possible invasion of the infant's system by pathogenic bacteria from without, and consist in the application of various antiseptic dressings to the cut surface of the cord. Cholmogoroff (*Wien. Med. Woch.*, Aug. 10, 1889) has found that no micro-organisms exist naturally in the umbilical cord of the new-born infant; but that in certain cases, as during the occurrence of an epidemic of puerperal fever, pathogenic bacteria, such as the streptococcus pyogenes and various staphylococci (albus, aureus, and citreus), are all present upon the stump, and he, therefore, recommends plaster of Paris as a dressing for the cord. Fagonski (*Jahrb. f. Kinderh.*, xxix. 1), for similar reasons, counsels the disinfection of the navel stump with a 5 per cent. solution of carbolic acid in addition to the plaster dressing. Talc powder, salicylic acid, and starch, have also been employed; and although these applications may not be necessary in all cases, they certainly hinder the entrance of bacteria, and render more rapid the mummification of the cord.

Characters of the Pulse in Infancy.

a. Rapidity of the Pulse.—To return now to the characters of the infantile circulation, it must, in the first place, be stated that the heart beats more rapidly at this time of life than in either the child or adult; but its rate is less quick than in fœtal life. During intra-uterine life considerable variations exist in the rapidity of the heart's

contraction; in some cases it may be found that the heart beats 150 times a minute; in other cases the rate may be much less, falling not infrequently as low as 125 or 130 per minute. The rapidity of the fœtal pulse is influenced by the size, vitality, health, and perhaps the sex of the infant; and it is found that a small infant has a more rapid pulse than a large child. Since, therefore, a female fœtus is usually smaller than a male, it may be possible with some degree of accuracy to foretell the sex of the infant before birth. It is difficult at the time of birth and for some days afterwards to count the radial pulse in the infant; but the auscultation of the heart will always enable us to count the cardiac beats. Keating and Edwards (*Arch. of Ped.*, vol. v. p. 729) state that during the first eighth or quarter of a minute after birth the beats of the heart are not discernible; that they then commence slowly, having a rate of 10 or 12 per minute for the first half minute; and that they then quickly increase in rapidity, soon reaching the rate of from 136 to 150 a minute. This statement may probably explain the very varying opinions as to the pulse-rate at birth held by different observers,—for, whilst some, as Valleix and Trousseau, put it as low as 80, others place it at 160 or even 180 per minute. A pulse-rate varying from 120 to 150 may be regarded as normal during the first few weeks of life, we always bearing in mind that the heart beats less rapidly during sleep than in the waking hours. In young infants posture has little or no effect upon the pulse-rate; but in infants of more than nine or ten months of age, the position of the body begins to affect the rapidity of the heart's action in the same way as it does in adult life. Whilst posture affects but little the rate of the pulse in the young infant, other causes, apparently trivial, have an immediate effect upon the rapidity of the cardiac beats. Muscular movements, sucking, and crying, are all causes which greatly modify the rate of the pulse in infancy.

During the second year of life the rapidity of the pulse falls to from 120 to 100 beats per minute; in the third year the rate is usually a little more than 90 per minute, and this rate continues till the sixth year; but with the seventh year the heart contractions assume the adult character as regards rapidity (75 to 80 per minute). The most satisfactory theory that has been adduced to explain the rapidity of the infant's pulse is that which ascribes it to a want of development of physiological inhibition, for it has been found that stimulation of the vagus has not the same restraining influence upon

the heart-beats in infants that it has in adults. Pathological conditions seriously alter the pulse-rate in infancy—scarlatina and other fevers greatly accelerating the pulse, whilst jaundice causes considerable slowing of the rate, and tubercular meningitis in its early stage reduces the pulse-rate, and in its later stages quickens it.

b. Regularity and Strength of the Pulse.—An irregular or an intermittent pulse denotes some morbid condition of the circulatory system; but it must be borne in mind that the pulse in infancy is normally somewhat irregular in rate and variable in strength. This character of the infantile pulse has been with some degree of probability ascribed to instability of the nervous centres at this time of life. Trifling circumstances greatly modify the characters of the infant's pulse. The strength of the pulse is, nevertheless, its most reliable clinical feature, and it affords to the medical man his best means of estimating the general condition of the child. In drawing conclusions from the strength of the pulse it must also be borne in mind that in infancy the arterial tension is low, and that there is never that firm impact against the palpating finger which is in the adult regarded as a sign of health. This lowness of arterial tension is due to the relation which exists between the size of the heart and the width of the arteries. Beneke has pointed out that in the infant the volume of the heart is to the width of the ascending aorta as 25 : 20; that before the onset of puberty it is as 140 : 50; and that after puberty it is as 290 : 61. The width of the aorta is, therefore, greater in comparison with the volume of the heart in infancy than in later life, and the systemic arterial pressure is in consequence low at an early age.

c. Sphygmographic Appearances of the Pulse.—The low arterial tension, to which reference has just been made, is the most striking feature demonstrated by a sphygmographic tracing of an infant's pulse. The graphic study of the pulse in early life by the aid of the sphygmograph is, it may be here remarked, a means of which physicians have not yet widely availed themselves; and it may be confidently predicted that ere long the results of the use of the sphygmograph will throw much light upon the conditions of the circulatory system both in the healthy and in the diseased infant. In the case of the new-born infant the pulse-tracing consists simply of a line showing a series of slight undulations (Fig. 8), and it is not until the seventh or eighth year of life that an apex appears, and not until the tenth or fourteenth year that dicrotism can be

traced in the sphygmogram. Keating and Edwards (*loc. cit.*) have shown that the condition necessary for the production of the dicrotic

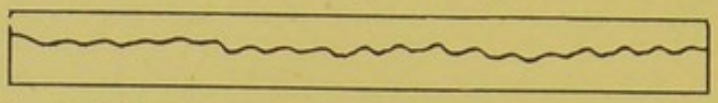


Fig. 8.—Pulse of the infant at the time of birth (after Ozanam).

pulse is absent in early life. This condition is elasticity of the great vessels combined with low tension of the peripheral circulation and a sharp contraction of the heart. Now in the infant, owing to the relatively less strong heart, the arteries are not distended to such an extent as to cause a thorough recoil, and further, there is a marked resistance to the peripheral circulation in the kidney. There is here, therefore, the probable explanation of the want of dicrotism in early life. The accompanying drawings (Figs. 9, 10, 11, 12),

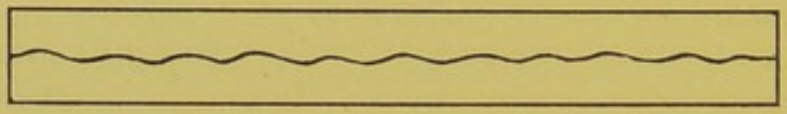


Fig. 9.—Pulse of a sleeping infant ten days old (after Ozanam).

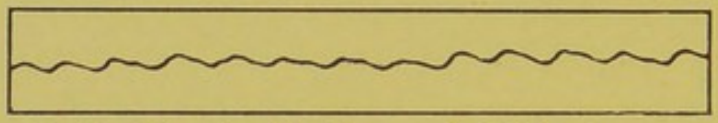


Fig. 10.—Pulse of an infant ten months old (after Ozanam).

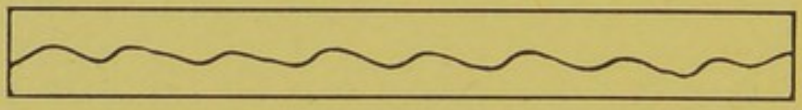


Fig. 11.—Pulse of a child two years old (after Ozanam).

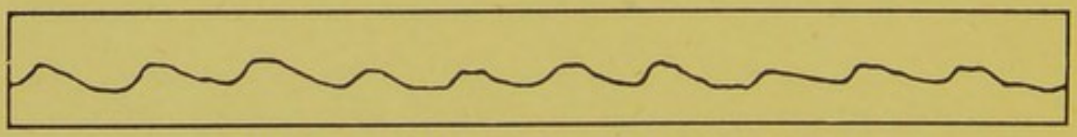


Fig. 12.—Pulse of a child three years of age (after Ozanam).

taken from Ozanam's work upon the Pulse, illustrate its sphygmographic characters at various ages in childhood, and may be

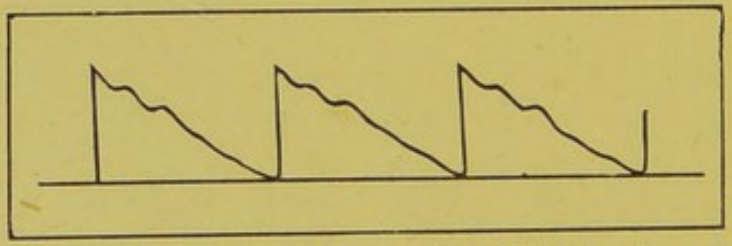


Fig. 13.—Sphygmographic tracing of normal pulse of adult (after Byrom Bramwell).

usefully compared with the tracing of the normal adult pulse (Fig. 13) taken from Bramwell's *Treatise on the Diseases of*

the Heart, in order to make more clear the statements which have just been made.

d. The Relation of the Pulse- and Respiration-Rates.—In the normal infant the relation of the pulse to the respirations is 3½ or 4 : 1. Any marked alteration in the relation of the pulse- and respiration-rates points to pulmonary disease; but, as Henoch has shown (*Lectures on Children's Diseases*, Transl. by Thomson, vol. i. p. 9), there are so many conditions other than diseases of the lungs which may affect these rates in children that comparatively little diagnostic importance need be attached to these characters when compared with those associated with the rhythm and strength of the pulse.

The Blood in Infancy.

Notwithstanding the appearance of many valuable monographs by reliable observers upon the blood in infancy, there still exist many differences of opinion both as to the formation and the characters of the blood in early life. It follows that the statements regarding the composition of the infantile blood which are found in the text-books are in many instances contradictory and often vague. With a multiplication of the number of careful observations upon the blood of the infant, it may be confidently anticipated that many of the vexed questions with regard to the pathology of blood diseases in early life may be cleared up, and the way opened for their successful treatment. All that can at present be done in the consideration of this section of the physiology of the infant is to state the views as to the physical and chemical characters of the blood which have been arrived at by the best investigators.

a. As regards the relation between the weight of the blood and the total body-weight at birth most authors are agreed that in infants there is a relatively smaller quantity of blood than in adults. In adults the proportion of blood-weight to total body-weight is as 1 : 13; but in infants it has been found to be only as 1 : 19·5. In the adult, therefore, the blood constitutes about 8 per cent. of the body-weight, in infants about 5 per cent. There is reason to believe, however, that at and immediately after birth it is rather more than 5 per cent. (Vierordt).

b. The specific gravity of the blood in the infant is usually stated to be lower than in the adult, being 1048 in the former and 1055 in the latter; but as regards its specific gravity in the new-born infant there does not exist the same unanimity of opinion. Keating and

Edwards (*Archives of Pediatrics*, iv. p. 715) state that at birth the specific gravity is high (1066), due to an excess of hæmoglobin in the blood at this time, and that it falls very low (1048 in boys, 1050 in girls) from the tenth week to the second year of life; but Scherenziss, on the other hand, holds that the blood of the new-born has a lower specific gravity than that of the adult, on account of the small proportion of hæmoglobin contained in it (*Centr. f. Gyn.*, Feb. 8, 1889). These two views differ, therefore, very markedly; and whilst Schmidt's statement that there is a larger proportion of solids in the blood at birth supports the former view, Krüger's researches (*Jahrb. f. Kinderheilk.*, xxvii. 4) into the quantity of hæmoglobin present in the blood of the new-born tend to confirm the latter. It is impossible in the present state of our knowledge to decide this question.

c. There is also divergence of opinion as to the COAGULABILITY of the infantile blood. Silbermann (*Jahrb. f. Kinderh.*, 1887) states that the blood of the infant is richer in the fibrin ferment than that of the adult, and proceeds on this account to explain the predisposition of infants to certain diseases; but Schmidt and Runge say that the fœtal blood is poor in fibrin as compared with the maternal blood, and that the coagulation of the blood of the infant is imperfect. Scherenziss states that the fibrin in the fœtal blood is to that in the adult blood as 2 : 7. Krüger says that the amount of fibrin in the fœtal blood distinctly diminishes at the time of birth, and tends also to diminish subsequently; but this author goes on to state that fœtal blood has the power of coagulating at birth, although the clot is slow in forming. This last-mentioned statement will go far to explain the divergence of opinion which has existed upon this subject, and it may also render intelligible the frequently noted fact that blood effusions in the new-born infant remain for a long time in a fluid condition. It is evident, however, that further investigations concerning the coagulability of the blood in the infant are much needed.

d. Most authors are agreed that there are more RED CORPUSCLES in the blood during the first few days of life than afterwards. The number on the first day has been estimated at from six to seven millions per cubic centimetre, whilst on the fourth and succeeding days it has fallen to from four to five millions. Keating and Edwards have pointed out that the number of red cells is increased if there has been any delay in the ligaturing of the cord, that it

remains stationary or gradually increases till the infant has reached its minimum weight on the third day of life, and that thereafter it falls. The red corpuscles are in infancy, as in adult life, circular, non-nucleated, yellow-coloured discs; but Hofmeier has pointed out that in the infant they are more spherical in shape than in the adult, that they vary in size within wide limits, and that they have no tendency to run into rouleaux.

e. In addition to the corpuscles just described there are present in the blood of the new-born infant NUCLEATED RED CELLS and also PALE-COLOURED DISCS of a small size. To these last-named cells Silbermann has given the name of "shadows," and has looked upon them as red corpuscles that have lost their colouring matter. The stroma of the corpuscle remains, but the hæmoglobin has disappeared and is dissolved in the plasma. Silbermann also noted that these "shadows" were more numerous during the first days of life if the infant's general health were much disturbed.

f. Keating and Edwards state that the WHITE BLOOD CORPUSCLES or LEUCOCYTES are present in the same proportion at birth as in adult life, and that their number gradually increases till the third day of life is reached. Hofmeier describes the white cells as more numerous in infancy than in adult life, and states that they have a marked tendency to accumulate in masses. Demme (*Jahrb. f. Kinderhk.*, 1882, 357) says that from the twelfth hour after birth to the end of the fifth month of life there are from 135 to 210 red cells to one white, and that thereafter the adult proportion of from 330 to 350 red to one white corpuscle is gradually arrived at. It would be interesting to know whether or not some observers have included the "shadows" amongst the white cells. The action of the white corpuscles as phagocytes has recently been described by Metschnikoff, who has founded upon this fact his theory to explain the immunity against certain infectious fevers which is possessed by some and acquired by nearly all individuals. The presence of leucocytes in large numbers in the blood of the infant is, therefore, an interesting phenomenon.

g. With regard to the amount of HÆMOGLOBIN in the blood of the infant conflicting statements have been made. Keating and Edwards state that there is as much colouring matter in the infant's blood as in that of the adult; Krüger believes that the quantity of hæmoglobin present in the blood at birth is about the same as in the adult, but that it increases in amount soon afterwards; and Scheren-

ziss says that the fœtal blood is deficient in hæmoglobin, the proportion of colouring matter in fœtal as compared with adult blood being as 76·8 : 100. The question of the relative amount of colouring matter present in infantile blood must for the present be left unsettled. There seems, however, to be little doubt that during the first few days of life there occurs a transference of hæmoglobin from the red corpuscles to the plasma of the blood. Hofmeier pointed out that this liberation of hæmoglobin occurred, and stated that the "shadows" were the corpuscles which had lost their colouring matter. This author has found in the condition of hæmoglobinæmia thus produced the explanation of the transient jaundice which is so often observed in the new-born infant, and he believes that in a few days the free hæmoglobin of the blood is converted by the liver into bile pigment.

h. It is usually stated that the blood of the infant contains a smaller proportion of salts than does that of the adult; but Scherenziss has found that fœtal blood is richer in salts than the blood of later life. He has also pointed out the marked preponderance of chlorides and salts in the serum, the small proportion of uncombined potash and soda, the relatively large quantity of sodium salts, and the relatively small amount of potassium salts in fœtal as compared with adult blood.

It has been stated that the blood of infants contains less soluble albumen than does that of adults; but the most important differences in composition are those which have been noted above.

From what has been said, and from the circumstance that so little is known of the functions of the spleen, the thyroid, and the thymus gland, it will be seen that in no department of infantile physiology is there a more pressing need for accurate investigation than in that which relates to blood and blood formation; and it may confidently be anticipated that reliable work in this field will yet yield good results in the elucidation of the problems of disease in the hæmopoietic system.

The Physiology of Respiration in Infancy.

The Establishment of Respiration.—The healthy full-time infant begins to breathe a very few moments after birth. The limbs of the fœtus, which have in the uterine cavity been tightly packed together, are now free to move; the head, which has been flexed upon the chest, is now extended; and it is probable that with

the extension of the head the epiglottis is raised and air permitted to enter the lungs. With the entrance of air into the lungs there takes place an opening out of the pulmonary air vesicles, and there ensue the changes in the course of the circulation of the blood which have been described in a previous section of this chapter. If there be a large quantity of stringy mucus in the mouth and air passages of the new-born infant, the establishment of the respiratory function may be interfered with; and it is, therefore, one of the first duties of the accoucheur to remove any such impediment to respiration. If the breathing is not set up within a few minutes after birth, then, even although the heart continues to beat, the infant is said to be still-born; and most vigorous means require to be employed in order to resuscitate the child. The consideration of the various means adopted to excite respiration in still-born infants is, however, beyond the scope of the present work.

The inquiry into the CAUSE OF THE FIRST INSPIRATION opens up a most interesting subject. Preyer, in his work on *The Physiology of the Embryo*, has very fully discussed this matter, and has criticised the views of Pflüger, Flint, Vierordt, Vulpian, Schwartz, Schultze, Lahs, and Kehrer. A detailed examination of the question cannot be entered into here; but it may be useful to state the two theories which have found the largest number of advocates. According to one view, the first respiration is brought about by external stimuli, such as cold and other cutaneous impressions, which, by exciting the centripetal nerves, stimulate the respiratory centres, which in turn transmit the impulse to the respiratory muscles. According to this theory, therefore, the infant begins to breathe on account of reflex excitement of the medullary respiratory centres by cutaneous stimulation; Preyer himself is inclined to adopt this as the most satisfactory explanation. Many other authors, however, consider that the first inspiration is caused by the stimulation of the respiratory centre by the venous condition of the blood of the infant consequent upon the stoppage of the placental circulation; but these writers are not agreed as to the *modus operandi* of the stimulation, some affirming it to be due to accumulation of carbonic acid in the blood, others to absence of a sufficient quantity of oxygen from that fluid. It would seem, however, that the latter theory must be held to be the correct one at any rate in some cases, even although its exact mode of action be unknown, for there is no doubt at all that inspiratory efforts are not infrequently made by the fœtus long before any external stimuli are brought to bear upon it. Cohnstein and Zuntz

have by their recent interesting observations upon the mammalian fœtus thrown some light upon this subject. From their experiments (*Arch. f. die gesammte Physiol.*, v. 42, p. 342) it has been shown that if the placental circulation be left intact, and the fœtus, enveloped in its membranes, be exposed to various forms of stimulation, no inspiratory movements can be produced; but that if the placental circulation be stopped, then the fœtus at once begins to breathe. These observers, therefore, believe that the direct action of the venous blood of the infant upon the respiratory centre in the medulla is the cause of the commencement of breathing. They also state that if the blood of the fœtus from any cause becomes so venous as to set up inspiratory efforts in utero, these will be immediately inhibited by the entrance of the liquor amnii into the nostrils. The entrance of fluid into the nostrils sets in action what is called the "diving-reflex," and there is, therefore, a self-regulating mechanism to prevent fœtal respiration.

There seems to be little doubt that both the internal stimulation of the respiratory centre by the venous condition of the blood, and its external excitement in a reflex manner by cutaneous stimuli, are operative in most cases; it may be that the former mode of action is the usual one, and that the latter is to be looked upon as supplementary. It is also probable that the respiratory centres in the newborn infant are in some cases remarkably tolerant of a venous condition of the blood, for many cases are on record in which an infant has begun for the first time to breathe ten, fifteen, or even twenty minutes after birth.

The Characters of Respiration in Infancy.—The first inspiration does not by any means inflate all the alveoli, and even some hours after birth portions of the lungs may be found in a state of atelectasis. This fact ought not to be lost sight of by the medical jurist who is called upon to decide the question of live-birth in a case of suspected infanticide. It is usually admitted that respiration is chiefly abdominal in type during the first three years of life. The diaphragm is the most important respiratory muscle in infancy. In later childhood the breathing becomes costo-inferior in type, as in the adult male. According to Sibson, the characteristic sexual respiratory type appears about the tenth year of life. It is costo-superior in the girl, costo-inferior in the boy. Depaul has stated that the respiratory type is abdominal in sleep, costal in waking hours. Dohrn (*Wien. Med. Press.*, June 30th, 1889) has

shown from spirometric experiments that the interchange of gases in the infantile lungs is much greater than in the adult organism. He found that during the first three days of life the volume of inspired air gradually increased; that on the fourth day it began to diminish; that it soon afterwards increased again, so that at the end of the first week the exchange of gases was about one-third greater than on the first day of life. It has also been stated by Von Pettenkofer that a child produces, in proportion to its body-weight, twice as much carbonic acid as does an adult. Although the lungs are relatively small compared with the length and weight of the body of a child, it will be seen, from what has been stated above, that they perform their functions in a very active manner. There is no physiological foundation for an argument that has been used in connexion with the ventilation of children's sleeping apartments and schools; this argument consisted in the statement that as a child's lungs were relatively small, a relatively small supply of pure air was all that was necessary for its health. The infantile lungs are small, it is true, but they excrete such a quantity of carbonic acid as to render a large air-space an absolute necessity in bed-rooms and nurseries.

As regards the RESPIRATION-RATE in infancy, it is difficult to state with any accuracy the normal rapidity of breathing at this period of life; for many apparently trivial causes affect very markedly the number of respirations per minute. The new-born infant makes from 30 to 50 respirations per minute; but towards the end of the first year the rapidity of breathing is less, having fallen to from 25 to 35 per minute. Even in children of 6 or 7 years, however, it is more rapid than in adults. Respiration in infancy and childhood is quicker than in adult life; and it is, as Henoch says, in inverse ratio to the age of the child. The adult makes from 16 to 18 respirations per minute. The respirations can be best counted by laying the hand gently upon the chest or abdomen, and the results will be especially reliable if this can be done without waking the infant.

In estimating the value of THE RESPIRATION-RATE AS AN INDEX OF DISEASE in infancy, it is necessary to bear in mind the fact that breathing is naturally quick at this time of life; and that it is also very easily influenced by nervous excitement, by sleep, teething, and even by sucking. A departure from the normal relationship between the pulse- and respiration-rates is a useful diagnostic indica-

tion; but even here it must be remembered that diseases other than those of the lungs may alter the relation of these rates; thus a rachitic infant always breathes more quickly than a healthy child. Nevertheless, if 40 respirations correspond to 120 instead of to 160 pulse-beats, disease of the lungs may be reasonably looked for.

Respiration in early infancy is very often IRREGULAR IN RATE and VARIABLE IN CHARACTER. Irregularity and variability may at this time of life point to no diseased condition; but after the first six months the characters of the respiration become more stable in health.

In DISEASE the respiration is much altered, and Bouchut has described four principal varieties of abnormal breathing:—

a. There is, first, the EXPIRATORY or PNEUMONIC respiration, in which each inspiration is accompanied by lateral narrowing of the base of the thorax, with projection of the abdomen, and with subclavicular and sternal depression. The inspiratory effort is preceded by a short, sharp nasal expiration. Closely allied to this form is the panting respiration of serious lung disease, concerning which Henoch has said, "If the breathing appear not only quicker and shallower, but at the same time more laboured, certain of the accessory muscles coming into play, and expiration becoming noisy, the presence of bronchitis, pneumonia, pleurisy, or other respiratory disease is indicated."

b. There is, second, the PLEURITIC respiration described by Bouchut, in which there occurs in the breathing a sudden arrest, due to the pain caused by the respiratory effort.

c. Third, there is the PERITONITIC respiration (R. SACCADÉE), which occurs in some abdominal affections, and in which the inspirations are short, jerky, and difficult, on account of the pain produced by the movement.

d. There is, fourth, the CEREBRAL form of respiration (R. SUSPIRIEUSE), which is characteristically short, incomplete, intermittent, and sighing, and which is indicative of acute brain disease, such as meningitis. This form also may take on the characters of the Cheyne-Stokes breathing; but this peculiar variety of respiration is not pathognomonic of meningitis, typhoid, or of scarlet fever.

Infants also are particularly liable to attacks of dyspnœa, and these attacks may point to various diseases, in some cases to laryngismus stridulus (the "inward fits" of the laity), in other cases to croup or diphtheria.

Cough is a modified expiratory effort, which when present may point very clearly to some definite malady; but its absence in infancy does not necessarily mean the absence of respiratory disease. The infant may be too weak to cough, or the phenomenon may be obscured in one way or another. The convulsive cough of pertussis is of great diagnostic value; as is also the hoarse, harsh cough of croup, and the suppressed, painful expiratory efforts of an early pneumonia.

The absence of expectoration is of common occurrence in respiratory affections in infancy. It is probable that, even in cases where there is a free secretion of mucus in the air passages, the whole or a great part of the sputum is swallowed. This fact must be constantly borne in mind when we inquire into the symptoms of lung disease in infants under four or five years of age.

The cry is a sign of respiratory activity, which, although welcome to the obstetrician, is often most disconcerting to the pediatric physician. The medical man must not, however, look upon the crying of the child as a bar to progress in the formation of a rational diagnosis; for, in many cases, he will obtain the most valuable diagnostic and prognostic indications from the careful study of the cry. It has by some been stated that the cry, like the facial expression, may enable the physician to say at once whether the disease affect the head, the chest, or the abdomen; but this means of diagnosis, whilst often valuable, is not always reliable. The cry consists of two parts, the inspiratory and the expiratory; and either part may be modified in disease. The former part has been called by Billard "la reprise," and the latter part forms the cry proper. It has been stated that, if there be in any case the loud inspiratory part as well as the expiratory cry or moan, disease of the lungs is unlikely in the extreme, although it is not absolutely excluded. It may also be accepted as almost invariably true, that if a prolonged fit of crying does not end in an attack of coughing there exists no serious disease of the lungs or throat.

During crying the skin of the infant's face becomes turgescent, the veins of the head and neck swell, and any cutaneous eruption which may be present becomes darker in colour. A vaccination mark, for example, will often become very evident when the infant cries. The coloration is due to the obstacle placed in the way of the return of the venous blood to the heart. The shedding of tears, which is in the adult and child an almost invariable accompaniment

of crying, is normally absent in the infant until the age of four or five months is reached. Probably every one has heard it said, "Look at that baby, he is not crying, it is only anger; there is not a tear coming." This illogical reasoning is explained by the above physiological peculiarity of the infant.

THE CRY of the HEALTHY INFANT is full and strong, and may be due to various conditions. It may, for example, be caused by hunger, by fear, by anger, or by joy; and it may also be due to the irritation caused by a flea or a pin, or may simply be produced by the sight of a strange face, or the hearing of an unfamiliar voice. Thirst is another cause of infantile crying, which has been much overlooked.

The CRY in DISEASE is very different from what it is in health, and it differs also in various affections. The colicky cry, which is accompanied by jerking movements of the legs and pelvis, is usually indicative of intestinal, renal, or vesical pain, and is easy of recognition. The cerebral cry (cri hydrencephalique) has long been described in connexion with cerebral disease, but it is in all probability not so pathognomonic as has been supposed; it consists of loud, piercing shrieks, with intervals of silence between the successive cries. The feeble whimpering or whining cry of the atrophic or partly asphyxiated infant is very characteristic, as is also the hoarse or aphonic cry of croup. In many cases, therefore, the character of the cry is a most important aid in the diagnosis of the disease. Earache in infants is associated with continuous crying and screaming, and it is always wise in cases of such prolonged crying to suspect ear disease; the suspicion is often converted into a certainty by the discharge of pus from the external auditory meatus.

The presence of a cry may be characteristic of disease; but its absence also may point to some serious pathological state. As Finlayson has said:—"The absence of crying is often of graver import than its presence. The sick child, ill and exhausted beyond endurance, may only wrinkle up the lips, as if to cry, without any sound; or in bad pulmonary cases, or even in rickets, the child may not be able to spare the breath required for the cry; or in the sopor and coma of brain disease the child is only too quiet."

CHAPTER XI.

THE PHYSIOLOGY OF INFANCY—Continued.

THE PHYSIOLOGY OF THE URINARY SYSTEM—MICTURITION—THE CHARACTERS OF THE URINE—THE PHYSIOLOGY OF THE CUTANEOUS SYSTEM—TEMPERATURE.

One of the most useful and most widely employed means of physical diagnosis in the case of disease in the adult is the examination of the physical and chemical characters of the urine; but in the case of infantile maladies this aid to diagnosis is but seldom made use of. The reason is twofold. In the first place, it is a difficult matter to obtain the urine of an infant for examination; and, in the second place, the characters of the normal urine in infancy are not generally known, and the significance of pathological variations in its composition and appearances is not, therefore, fully appreciated by the great majority of practitioners. It is, therefore, necessary to devote some space to a consideration of the normal characters of the infant's urine so far as these have been ascertained, and to the deductions which may be reasonably drawn from the discovery of various pathological changes in the appearance and constitution of the urinary secretion at this time of life.

The act of micturition is, in the young infant, performed quite involuntarily, the urine usually passing away at the time when the bowels move. The emptying of the bladder may, however, occur quite independently of the action of the bowels. This incontinence of urine which is normal in infancy is probably due both to infantile weakness of the sphincter of the bladder, and to increased reflex excitability of the spinal centres which preside over micturition. Very soon after the sixth month of life it becomes possible for the infant to retain his water; but great individual differences in this respect are found, and no doubt a very great deal depends on the training of the child by the nurse. Some nurses, by attention to this matter and by the regular "holding out" of the infant at stated times, are able to train the child to habits of cleanliness at a very

early age; whilst others, by the neglect of these precautions, allow the infants under their charge to continue wearing diapers till far on in the second year of life.

The normal infantile incontinence may persist, or may reappear during later infancy and childhood, and then it becomes pathological and constitutes the condition known as ENURESIS, or "bed-wetting." The more common form of enuresis in infants is the nocturnal, but the diurnal variety may also occur. J. L. Petit has classified infants that wet the bed at night in three groups: first, the sleepers, those who pass water in deep sleep; second, the dreamers, those who dream of micturition, and convert the dream into a reality; and third, the lazy, or those who, from idle or dirty habits, pass water in bed to save themselves the trouble of rising to urinate. The causes of this distressing complaint are, however, many and various; and a consideration of them would lead me beyond the sphere of the present work.

The COLLECTION OF THE URINE for the purposes of examination and analysis is always, in the case of young infants, a difficult matter; for the secretion is passed into the diapers, and it is, therefore, very difficult either to examine its quality or to estimate its quantity. Nurses, in a rough and ready way, estimate the amount of urine passed by the degree to which the diapers are wetted, and from the appearance of the cloth endeavour to gain some ideas as to the physical characters of the fluid. A more satisfactory method is found in the collection of the urine in clean sponges, which are wrung out into a vessel, and the secretion is then examined; but, certainly, the only entirely reliable method is the drawing off of the urine from the bladder by means of a clean catheter. In older infants who have been taught to pass the water into a vessel these difficulties are not, of course, met with. In the case of several newborn infants of whom frozen sections were made, I was able to remove from the bladder the frozen urine and to examine its physical and chemical characters.

The statements concerning the CHARACTERS OF NORMAL INFANTILE URINE to be found in the majority of text-books are distressingly vague and contradictory; but some very important monographs by Parrot and Robin;* Martin, Ruge, Biedermann;† Schabanowa,‡

* *Archives Gén. de Méd.*, vol. i., 1876, p. 129.

† *Centr. f. Med. Wissensch.*, No. 24, 1875.

‡ *Jahrb. f. Kinderheilk.*, xiv., 4.

Baginsky,* and many others have added much to our reliable knowledge of the urine in infancy.

In its PHYSICAL CHARACTERS normal infantile urine presents certain differences when compared with the renal secretion in the adult.

a. COLOUR.—The urine in early infancy is a colourless, clear, and limpid fluid. Parrot and Robin found that in two-thirds of their cases the urine at the time of emission was absolutely aqueous, and that in the remaining third it was tinted like Chablis wine. During the first two or three days of life the colour of the urine may be darker and may have appearances similar to those found in the adult; but this dark coloration is probably due to the fact that micturition is often delayed during the first and second days of life, for it has been found that urine passed immediately after birth is quite pale and clear. In the case of a seven and a half months' fœtus of which frozen sections were made, I found that the bladder was filled with perfectly clear and colourless urine; but in the case of a full-time infant with an over-distended bladder, the urine, as revealed in a frozen section, was darker in colour. No doubt the colour of the urine becomes darker if the fluid remain long in the bladder. In infants nursed by the mother or a wet-nurse the urine has a paler tint than in those brought up artificially on cow's milk or other food. Occasionally the urine of the infant has an opalescent appearance; and this opalescence may be present at the time of emission, and may point to the presence of epithelial cells from a vulvitis or vaginitis; or it may appear later and be caused by uric acid. The urine is sometimes greenish in colour during infancy.

b. ODOUR.—When the urine is colourless it is also odourless; but after weaning, when the renal secretion has a darker colour, there is also developed the distinct urinous smell, a smell which is intensified by boiling the urine.

c. SPECIFIC GRAVITY.—Martin, Ruge, and Biedermann ("Untersuchungen des Harns während der ersten 10 Lebenstage," *Centr. f. die Med. Wissensch.*, xiii., 387) give the average specific gravity of the urine in the first ten days of life as follows:—

1st day, ...	1010·0
2nd ,, ...	1010·0
3rd ,, ...	1009·0
4th ,, ...	1004·5

* *Archiv f. Kinderh.*, Bd. ix. H. 1.

5th day,	1006·0
6th ,,	1004·8
7th ,,	1005·5
8th ,,	1003·7
9th ,,	1002·4
10th ,,	1002·7

The statements of other authors do not agree with those given above: for some state that the specific gravity increases from the fifth to the tenth day of life and then decreases; others again give the density of the urine passed at the first micturition as 1005 or 1006. Parrot and Robin state that from the fifth to the thirtieth day of life the specific gravity varies from 1003 to 1004, and that from the first to the fourth month it is from 1004 to 1005. Whilst it is evident that the whole subject will bear re-investigation, it may be stated generally that in infancy the specific gravity of the urine is low.

d. Quantity.—It has been mentioned in a former chapter that the kidneys of the new-born infant are relatively large; it has now to be stated that the renal functions also are well developed at birth. So active is the secretion of the urinary constituents at the time of birth, that many of the renal tubules are found blocked with crystals of urates, the so-called uric acid infarcts. Since the kidneys are relatively large at birth (Longet has stated that in the infant the weight of the kidneys is to the total body-weight as 1 to 120, whilst in the adult the proportion is only as 1 to 240), and since the power of secreting the urine is well established at this time, it is to be expected that the amount of urine secreted will also be relatively large in infancy as compared with adult life. This expectation is fulfilled by the results which have been obtained by various observers. Parrot and Robin, for instance, found that the infant excretes four or five times as much urine per kilogram of body-weight as does the adult. As regards the exact quantity of urine passed in the twenty-four hours, investigators differ somewhat in the results they have obtained; but the statement of Parrot and Robin may be taken as generally correct. According to these writers the daily quantity varies from 150 to 300 cb. cent. during the period extending from the sixth to the thirtieth day of life. During the first year the quantity rises to from 400 to 500 cb. cent. daily, in the second year it varies from 500 to 600, and in the fourth year it rises to from 1000 to 1200 cb. cent. per diem. No doubt considerable individual differences are to be expected. Parrot and Robin have shown that the quantity passed at one

micturition varies but slightly in early infancy, and this they attribute to the fact that infants are fed regularly and at short intervals of time. These observers have estimated the quantity of urine passed at the morning micturition during the early days of life, and the results they have thus obtained are embodied in the following table :—

From the 1st	to the	5th	day,	morning	micturition	5 to 10	c.c.
,, 5	,, 10	,,	,,	,,	10 to 25	,,
,, 10	,, 15	,,	,,	,,	15 to 30	,,
,, 15	,, 30	,,	,,	,,	20 to 30	,,
,, 30	,, 150	,,	,,	,,	25 to 35	,,

It would seem, therefore, that there is a rapid increase in the quantity passed at one micturition during the first ten or fifteen days of life; but that thereafter the increase is more gradual. Martin, Ruge, and Biedermann state the quantity passed at the first micturition as averaging 8 cb. cent.; but no doubt the amount at this time varies within somewhat wide limits, at any rate the degree of distension of the bladder of the new-born infant is very different in different cases.

e. Deposits.—The urine of the healthy new-born infant shows no deposits when fresh; but if it be allowed to stand some little time a slight sediment appears, which is found to consist chiefly of epithelial cells from the bladder or vulva, along with some crystals of uric acid, urate of soda, and oxalate of lime. The latter constituents are, however, so rare as to be quite exceptional, and when they occur they would seem to point to some abnormality in digestion.

The chemical characters of the urine in the infant are important, and call for some consideration.

a. Reaction.—Martin, Ruge, and Biedermann state that the urine in the infant is nearly always slightly acid, and very rarely neutral in reaction; but according to the researches of Parrot and Robin, absolutely normal urine is almost invariably neutral to turmeric paper. The results of the examination of 70 urines by these observers gave 46 as neutral, 17 as very slightly acid, and 7 only as markedly acid in reaction. They attach to the reaction of the urine in infancy great diagnostic importance, and believe that when that fluid is markedly acid there must exist some disturbance in digestion. The urine passed at the first micturition is not infrequently acid; and this may be due to the facts that the emission

of the renal secretion is often delayed in these early days, and that the urine by standing loses its neutral reaction and becomes acid. This belief is strengthened by the observation that acid urine is usually also turbid, whilst clear limpid urine is invariably neutral in early infancy.

b. Uric Acid.—I have always found distinct traces of urid acid in the urine of the infant at the time of birth; but many observers deny that it is present in the renal secretion of the infant save in pathological states. Gautier,* however, states that the urine of infants nursed by the maternal method is very rich in uric acid; and Parrot and Robin have found traces of it in normal infantile urine. The quantity of uric acid excreted in the urine daily varies very considerably at all times of life; but it is probable that the amount evacuated in infancy bears practically the same proportion to the total body-weight as it does in adult life. It has, however, been stated that the quantity of uric acid excreted in the first few days of life is relatively great. It has already been mentioned that in the kidneys of the infant at the time of birth there are found deposits of urates. These are situated in the kidney tubules, usually near the hilus of the organ, and present the appearance of small yellow-coloured cylinders. They can be squeezed out of the tubules in the form of a yellow powder. Virchow and many others have been in the habit of regarding them as physiological in the new-born infant; but Parrot looks upon them as pathological products due to some constitutional weakness which has interfered with the conversion of some of the effete materials of the body into urea, and has left these materials to be discharged in the urine in the form of urates.

Tarnier and Chantreuil † support Parrot in this belief, and connect the appearance of these uric acid infarcts with the pathological state known as athrepsia. Virchow ‡ believes that they are composed of urate of ammonia, whilst Parrot is of opinion that they consist of urate of soda. Their frequent occurrence in new-born infants would seem to weaken the theory that they are pathological products.

c. Urea.—It has been stated by some authors that the urine of the new-born infant contains no trace of urea; but most observers are now of opinion that urea is present, although in small amount,

* *Traité de Chimie appliquée à la physiologie*, tom. ii. Paris, 1874.

† *Traité de l'art des Accouchements*, tom. i. p. 829.

‡ *Gesammelte Abhandlung*, p. 865.

during the first few days of life. In the case of two new-born infants, I was able to demonstrate that there was a trace of urea present. It may be considered as proved that urea is normally present at birth; but as regards its quantity, very different statements have been made. Martin and Ruge have found that the quantity of urea excreted on the first two days of life is exceedingly small, that it increases greatly and suddenly on the third day, and that it then remains nearly stationary until the tenth day; but Parrot and Robin have come to the conclusion that the urea per litre of urine excreted on the first day of life is greater than on the following days, that it decreases gradually during the first four days, that it then more markedly diminishes from the fifth to the ninth day, and that from that time on to the one hundred and fiftieth day there is a slow and gradual increase. The latter authors have also shown that although the amount of urea per litre of urine diminishes during the first nine or ten days of life, yet its total amount increases steadily from the first day onwards. This apparent discrepancy is accounted for by the fact that the amount of urine passed increases relatively more quickly than the amount of urea. It has also been shown that the quantity of urea excreted increases, but not *pari passu* with the body-weight. Thus, a large infant excretes less urea per kilogr. of body-weight than a small infant, although the former excretes more urea per litre of urine. At birth the urine contains 3·03 grammes of urea per litre of urine, or 0·80 per kilogr. of body-weight; but in an infant of from eleven to thirty days old, the urea passed in the twenty-four hours amounts to 0·94 grammes, or 0·23 per kilogr. of body-weight. Parrot and Robin have demonstrated that temperature has an effect upon the excretion of urea, for they found that the urine of a new-born infant contained more urea if the child was placed in a warm atmosphere. The quantity of urea varies with the degree of coloration of the urine; dark urines contain more urea than pale. Neutral urines also contain less urea than acid urines. It may be possible, by noting the reaction and the colour of the urine, to state approximately, without any chemical examination, whether a given urine contains a large or a small quantity of urea. All the circumstances above mentioned, which influence the amount of urea excreted, must be kept in mind when any deductions as to disease are drawn from the estimation of the nitrogenous matter found in the urine; still it is often possible to diagnose errors in diet and

faults in assimilation from the discovery of a markedly abnormal percentage of urea in the urine of an infant, especially if this be accompanied by a morbid variation in the amount of uric acid present.

Schabanowa* has carefully investigated the amount of urea present in the urine in later infancy and in childhood, and has found that the absolute quantity increases steadily with the increase in age until the fourth year, after which time it decreases. She has also been able to demonstrate that the amount of albuminoids in the food has a great influence upon the quantity of urea excreted, although the amount of water produces but a trifling effect upon this constituent of the urine.

d. Chlorides, Phosphates, and Sulphates.—With regard to the chlorides of the urine of infancy different statements have been made; but Parrot and Robin are probably right in asserting that chlorides are always present in the urine of the infant, although sometimes they exist only as a mere trace. It has been found that age produces an effect upon the quantity of chlorides present, although body-weight and temperature do not seem to have any influence upon the amount of these salts per litre of urine. Unlike the urea, the chlorides increase progressively per litre of urine from the time of birth up to the thirtieth day of life. Parrot gives the average quantity of chlorides excreted per litre of urine, and between the ages of three and thirty days, as 0·79 gr., or as 0·22 gr. per kilogr. of body-weight.

Most authors are agreed that phosphates are present, although in small quantities, in the urine at the time of birth. Parrot and Robin have found that the quantity of phosphates varies to a great degree in different infants, and they believe the age of the infant is the chief cause of such variations. Their analyses would seem to show that the infant excretes more phosphoric acid per litre of urine from the sixteenth to the thirtieth day than from the first to the fifteenth day, and that the largest quantity present in healthy urine is 1·95 gr. per litre, or 0·47 gr. per kilogr. of body-weight. The quantity of both the chlorides and phosphates of the urine is markedly affected by the diet of the infant.

Sulphates are present in the urine at birth and during infancy, but in such small quantities as to prevent any accurate analyses being made.

* *Jahrb. f. Kinderhk.*, xiv. 4.

e. Albumen.—Martin and Ruge state that they have found albumen in the normal urine at birth and for several days afterwards, and Dohrn has discovered traces of it in the renal secretion immediately after birth. Parrot and Robin, however, doubt whether it is ever present in the urine of healthy infants; probably this is the correct view, for in only one case did I find albumen in the urine at birth, and that case was one of congenital œdema.

f. Sugar; Allantoin.—It is generally accepted that the normal urine in infancy never contains sugar. Vierordt has found a substance, which he has called allantoin, in the urine during the first few days of life. Allantoin is an oxidation product of uric acid, and after the first week of life it is replaced by urea.

It will have been gathered from much that has been said, that our knowledge of the urine in infancy does not yet rest upon very certain foundations, and it must, therefore, be admitted that it is not at present possible to make great use of the analysis of the urine as a guide in the diagnosis of infantile maladies. Nevertheless certain general statements may be made. The new-born infant excretes less urea, less uric acid, and a smaller quantity of chlorides per kilogr. of body-weight than does the adult individual; but the urine of the infant is excreted in larger amount when compared with the body-weight than that of the adult, and probably it contains also a larger proportion of phosphates. It may be that after the first month of life the infant excretes more urea in proportion to its weight than in the adult, but during the first thirty days of life it would certainly seem that the percentage of urea is less than in later life. The large quantity of urine excreted by the infant is due to the fact that at this time a large quantity of liquid is taken as food, whilst only a small amount passes away by the skin. The small amount of nitrogenous matter excreted in infancy, is probably to be accounted for the active assimilation which accompanies the rapid growth in weight at this time of life. An abnormal increase in the excretion of nitrogenous materials will, therefore, point to imperfect assimilation processes, and these may be produced either by wrong methods of feeding or by such diseased conditions, as athrepsia, diarrhœa, etc. If, in infancy, the proportion of any one of the urinary constituents vary greatly from what has been found to be normal, it may be concluded that some pathological process is at work. The presence of sugar or of albumen points also to a morbid state, and it must be borne in mind

that urinary calculi are not infrequently met with in infancy. In cases of persistent crying, especially if the crying be accompanied by jerking movements of the legs and pelvis, the presence of uric acid calculi ought to be suspected, and an examination of the urine may convert the suspicion into a certainty.

The Cutaneous System in Infancy.

The body of the infant at the time of birth is covered by a whitish greasy layer of sebum mixed with shed epithelial scales and lanugo hairs. This substance has been called the VERNIX CASEOSA. This sebaceous layer has during fœtal life the function of protecting the delicate skin of the infant from the macerating effect of the liquor amnii; but after birth it is no longer needed, and ought to be removed,—indeed, if suffered to remain, it will set up considerable irritation of the skin. It varies considerably in amount in different children and in different regions of the body. Some infants may be covered from head to foot, others may only show the vernix on certain parts of the body. It is usually especially abundant upon the head, and is also present in most cases in the axillæ, in the flexures of the groin, and upon the neck. The vernix caseosa cannot be readily removed by soap and water, but is easily loosened by the use of some lard or oil.

When the sebaceous material has been thoroughly removed, the skin of the new-born baby is found to have a rosy-red COLOUR. This coloration usually persists for three or four days, but in delicate or in premature infants it may remain much longer. It is produced by the slight hindrance to the return of blood to the heart which exists during the first few days of life, and which is the consequence of the great circulatory change which occurs at birth.

The red colour of the skin is, in the great majority of cases, replaced by a yellow tint on the third or fourth day of life. It may almost be said that it is the rule for the infant to be jaundiced for two or three days at this time of life, and to the condition the name of icterus benignus has been given. Many theories have been advanced to explain the occurrence of physiological icterus neonatorum or "spurious jaundice." According to some the jaundice is hepatogenous in origin, according to others hæmatogenous. Those who hold the former view believe that there are conditions in the liver of the infant which lead to the reabsorption of the bile into the

system. Birch-Hirschfeld* states that the cause is an interstitial œdema of the connective tissue of the liver due to venous engorgement, and leading to compression of the bile ducts and obstruction to the outflow of the bile. Silbermann† states that the interlobular bile ducts and biliary capillaries are compressed by the dilated branches of the portal vein and the capillary bloodvessels of the liver, and that the engorgement thus produced is due to the changes in the hepatic circulation which occur soon after birth. Henry‡ believes that the jaundice is produced mechanically by sudden diminution of the portal blood-pressure from the ligaturing of the umbilical cord. Quincke, again, is of opinion that the icterus is due to a delay in the closure of the ductus venosus leading to the direct passage of a large quantity of bile-containing portal blood into the general circulation. Such are some of the more important theories which have been advanced to explain the jaundice of the new-born upon mechanical principles; but some mention must also be made of the theories which regard the icterus as hæmatogenous in origin. The hæmatogenous theory is held by Porak, Schücking,§ Hofmeier,‖ and others; and it is based upon the assumption that the excessive amount of hæmoglobin present in the blood of the new-born infant from destruction of blood corpuscles is decomposed by some fermentative agent, and that the colouring matter thus set free in the circulating fluid produces the jaundice.

There is no doubt truth in both the hepatogenous and hæmatogenous theories; but it must be admitted also that one is scarcely warranted in stating that the condition is in any case purely physiological, for it has been noted that it occurs more frequently in delicate and in premature infants than in healthy new-born children.

It is an interesting fact, not very widely known, that the colour of the skin of negro infants is not black but red at birth. In the case of an infant, the offspring of a pure negro and a Scotch girl, I noted that there was at the time of birth only a slight duskiness over the scrotum and upper arms; and in a second similar case I learnt from a medical friend that the infant had at the time of birth one black mark upon the back, which ultimately spread over the whole body.

* Virchow's *Arch.*, Bd. 87, H. 3.
† *Arch. f. Kinderheilk.*, viii. H. 6.
‡ *Arch. of Med.*, Oct. 1883.
§ *Berl. Klin. Wochenschr.*, No. 39, 1879.
‖ *Zeitschr. f. Geburt. u. Gyn.*, viii. H. 2.

Shortly after birth there takes place a more or less extensive DESQUAMATION OF THE CUTICLE of the infant's skin. This epidermic exfoliation, according to Parrot, commences usually on the second or third day of life, and may continue till the thirtieth, fortieth, or even sixtieth day. The fine hairs also are usually shed at this time. In its characters it resembles the desquamation that follows measles. It is not to be confounded with the disease known as dermatitis exfoliativa.

The SUDORIPAROUS GLANDS are not well developed at birth, neither is the secretion of sweat active in the first weeks of life; but the SEBACEOUS GLANDS secrete freely in the infant. Transpiration from the skin is not great in early infancy.

From the consideration of the characteristics of the cutaneous system in infancy, it will be gathered that the hypodermic method of administering drugs is not suitable on account of the delicate nature of the skin, and that for the same cause the introduction of drugs into the system by inunction or by bathing is remarkably successful in early life.

Allusion has already been made to the secretion of a milky fluid from the breasts of a new-born infant (*vide* Chap. IV. p. 64).

The Temperature in Infancy.

Many of the physiological peculiarities of the infant have now been considered; and, since the regulation of the heat of the child's body is dependent upon the performance of the circulatory, respiratory, hæmopoietic, and other functions, it will be convenient here to study the normal temperature of the infant and its variations in disease.

METHODS OF DETERMINING THE TEMPERATURE IN INFANCY.—The temperature of the body of an infant is an important fact to elicit, and this may be done in either of two ways. The *first* method, which may be called the "rough and ready," consists in the placing of the observer's hand on some part of the body of the infant, *e.g.*, the head, chest, or abdomen. If the skin be markedly hot, one may obtain important information from the use of this method, especially if one supplement it by counting the pulse; but, on the other hand, the skin may be only slightly hotter than usual, the difference being not easily appreciated by the hand, and, therefore, it is desirable that a more certain method of estimating the temperature be used. The *second* and the more reliable

method is found in the use of the clinical thermometer. It must not, at the same time, be forgotten that even this means is occasionally attended by fallacies. Sometimes the practised touch of an old physician is a better gauge of temperature than the newest and most approved thermometer in the hands of an unskilful medical tyro. As a general rule, however, the clinical thermometer, when properly used and when the necessary precautions are taken to avoid fallacies, is the means which will most satisfactorily indicate the variations in body-heat which are so common in infancy. Thermometric observations may be made in the axilla of the infant, or in his mouth or rectum. If it be decided to take the temperature in the axilla, this region of the body ought to be carefully dried, the index of the thermometer should be shaken down, and then the instrument ought to be introduced into the arm-pit, and the hand placed at the side so as to close the space. The axilla is a small space in the infant, especially if wasted and thin from disease; and therefore, unless the space be carefully closed, the thermometer will indicate only the temperature of the surrounding air. It is best for the physician himself to hold the child's arm to the side, so as to make sure that the instrument is kept in its place. After the mercury has attained a stationary level the index may be read off, and this will usually be at the end of from ten to fifteen minutes. From what has been said it will be evident that the axilla is not an altogether suitable place for thermometric observations, and it is found that in practice more reliable results are obtained from the introduction of the thermometer into a closed cavity such as the mouth or the rectum. In the case of the mouth the instrument need only be held *in situ* for some five minutes (the rapidly registering thermometers do not even require so long a time), and the temperature may thus be easily ascertained. The result thus obtained will be from ·5° to 1° F. above that found in the axilla. The thermometer should be placed below the tongue, and care must of course be taken that it does not get broken. The rectum is in infants a very convenient place for obtaining the temperature, for it is not subject to changes from the surrounding air, and unless the instrument be pushed into a mass of fæces, an unlikely occurrence however, the readings will be very accurate. The rectum in the infant, as has been stated, is large and comparatively straight, and is, therefore, more suitable for thermometric observations than is this part of the bowel in the adult. The bulb of the thermometer

should be well greased with vaseline, then gently introduced for a distance of about two inches into the rectum, and finally the instrument should be held in position by the observer to prevent its being broken by any sudden movement of the little patient. During the taking of the rectal temperature the child should lie on its left side or on its back upon the mother's or nurse's knee. After the thermometer has been some three minutes in the rectum the level of the mercury may be read off: the instrument must then be carefully withdrawn, and cleansed and disinfected before it is used in another case. It has been recommended that the temperature of the vagina be ascertained in a female infant; but this locality has no advantage over the rectum.

Normal Temperature in Infancy.—Many observations* have been made upon the temperature of the infant at the moment of birth, and the results thus obtained enable us to state that the normal heat of the body at this time is about 37·25° C. (99° F. approx.). As this is a higher temperature than that normally present in the adult, it has been concluded that it must be also higher than that of the infant's mother. Some observations would seem to support this view: thus Wurster† found that in a breech presentation the rectal temperature of the infant was higher than the vaginal temperature of the mother; and Schäfer‡ demonstrated that the thermometer placed in the rectum of the infant immediately after birth, and before the tying of the cord, gave a higher reading than when placed in the mother's vagina.

Barensprung and Schröder have shown, however, that the maternal temperature in the pregnant uterus is higher than that in the unimpregnated organ, and Parrot has estimated the uterine temperature during labour at from 38° to 38·5° C. Whilst, therefore, the body-heat of the infant at birth is greater than the vaginal temperature of the mother, it is at the same time less than that of the maternal uterine cavity.

* Fehling, "Ueber Temperaturen bei Neugeborenen," *Arch. f. Gyn.*, 1874, vi. 385.—Lépine, "Sur la température des nouveau-nés," *Compt. Rend. Soc. de biol.*, 1869.—René, "Exposé de quelques recherches sur la température axillaire et sur la température rectale chez les enfants," *Rev. Méd. de l'est*, 1877, vii. 146.—Sommer, "Ueber die Körpertemperatur des Neugebornen," *Deutsche Med. Wochenschr.*, Berlin, 1880, vi. 569.—Squire, "Infantile Temperatures in Health and Disease," *Lond. Obst. Soc. Trans.*, x. pp. 274–298.

† *Beiträge zur Tocothermometrie mit besonderer Berücksichtigung des Neugebornen.* Zurich, 1870.

‡ *De calore et pondere recens natorum*, 1863.

During the first half hour of life the temperature of the infant falls very distinctly; but if the child be healthy and not premature, the temperature thereafter rises again to 37·2° C., or even to 37·8° C. The normal temperature during the first week of life is stated by Roger* to be 37·8° C. (100° F.); but this is too high an estimate according to Eröss. In feeble and in premature infants the loss of heat after birth is much more marked than in healthy full-time children; and in the former, also, the temperature does not rise so high in the first week of life as it does in the case of the vigorous infants. In some weakly premature infants the temperature after birth may fall as low as 33° C.; but in ordinary cases the average minimum post-partum temperature is 35·84° C. (Eröss). In the great heat-loss which occurs in weakly infants is found an explanation of the success which has attended the use of the "couveuse" or "incubator." The weakly or premature infant is placed in the incubator, which is a wooden box heated by means of hot-water bottles; he is here surrounded by cotton wool, and his body temperature is in this way maintained, and his chances of life greatly increased. During the first few months of life it is very difficult to say what is the normal temperature of the infant, for there is at this time great thermic mobility. This irregularity is no doubt due in great measure to the incomplete development of the heat regulating mechanism of the body. Great variations in the body temperature are usually found during teething. Demme states, however, that after the first year of life the thermic oscillations are less decided, the body-heat is no longer so much affected by external influences, but now begins to be regulated in the same way as in adult life. The physiological daily thermic variations which are seen so well in the adult are also present in the infant as early, according to some observers, as the sixth day of life; but these oscillations in temperature are often obscured by the effects of disturbing external conditions, and by the instability of the internal heat-regulating mechanism. Nevertheless, in healthy infants it can often be observed that the temperature rises slowly during the day, attains its maximum about 6 P.M., and then slowly sinks to its minimum, which is reached about 2 A.M.†

* "De la température chez les enfants," *Arch. Gén. de Méd.* Paris, 1844–1845.

† A very complete summary of the many contributions which have been recently made to the subject of the temperature in infancy is found in Raudnitz's Memoir (*Arch. di Patol. Inf.*, July 1888).

The Significance of Temperature Variations in Infancy.—The temperature, like the pulse and respiration, is very unstable in early infancy; and this fact must be borne in mind when the thermometer is used as a guide to diagnosis and prognosis. It has been already noted that there is a great tendency for the temperature to fall much below the normal immediately after birth, and this tendency exists throughout early infancy; it, therefore, often happens that some febrile diseases, such as pneumonia, may at this time of life run their course with a normal or even subnormal temperature. The rise is masked by the pre-existing subnormal temperature. On the other hand the body-heat in infancy may rise very high without there being the same degree of danger as in adult. Thus, a *sudden* rise to 106° or 107° F. in an infant does not necessarily entail a fatal termination. Further, very trifling causes may send the temperature up to a considerable and disproportionate extent; and very often a dose of castor oil, the alteration of a splint or the change of a dressing, may quickly bring the thermometric readings down again to the normal. Sudden changes of temperature are not to be dreaded in infants, it is the gradual steady ascent of the mercury which forewarns of danger. "Short notice, soon past; long foretold, long last," is a rule which applies in pediatrics as in meteorology. In all cases the thermometric readings must be considered along with and not apart from the other signs and symptoms of disease. Still it may be stated generally that temperatures below 97° F. or 36° C. are very low, that those above 99° F. or 38° C. are sub-febrile or moderately febrile, and that those above 104° F. or 40° C. are markedly febrile or hyperpyretic. The above figures may be safely applied to the diagnosis of febrile maladies in infancy, if, at the same time, it is remembered that the temperature is then variable and unstable.

CHAPTER XII.

THE PHYSIOLOGY AND HYGIENE OF INFANCY.

GROWTH—THE WEIGHING OF INFANTS—HYGIENE OF THE NURSERY—VENTILATION—WARMING—LIGHTING—PERSONAL HYGIENE—EXERCISE—SLEEP—BATHING—DRESS—CARE OF THE EYES—VACCINATION.

The consideration of the functions of circulation, blood formation, respiration, urination, cutaneous secretion, and heat regulation, leads naturally to the study of the hygienic laws relating to the dress, exercise, and care of the skin in infancy, and to those which should regulate the ventilation and heating of the nursery, in which the child spends so much of his time. But before discussing these and cognate subjects, we must pay some attention to a matter very closely related to the physiology of infancy, to wit, the normal growth in length and increase in weight of the infant.

Growth, both in length and weight, has always afforded the medical man and the mother most valuable indications as to the state of the general health and development of the infant. It is true that the appearance of the body as gathered from the inspection of the face, trunk, and limbs, and the general tone of the muscular tissues, as tested by pinching up a fold of skin in the neighbourhood of the thigh, yield very important data from which conclusions may be drawn as to the state of nutrition; but in the careful measurement and weighing of the child are found more certain and useful means of diagnosis in early life. Whilst hints as to the state of development may also be obtained from the progress of dentition and from the date of the commencement of walking, the frequent weighing of the infant at regular intervals will serve as a more delicate index of the general state of nutrition and of bodily health.

Estimation of the Weight of Infants.—Many instruments have been invented for the accurate weighing of infants; but probably none is more easy of application, or more reliable in its action than the baby-weigher of Sutils (Pèse-Bébés du Docteur Sutils). This instrument, the component parts of which are seen

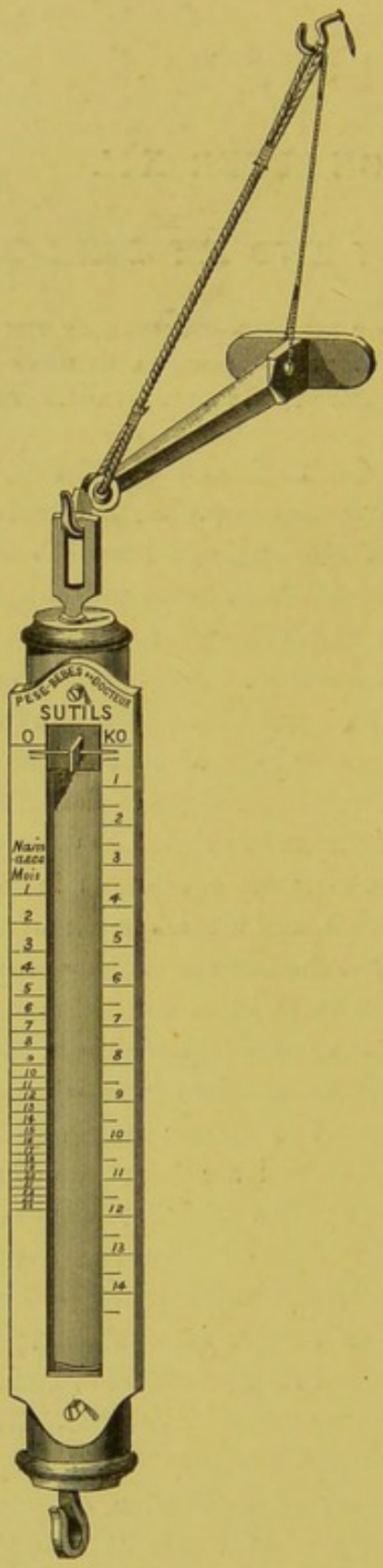


Fig. 14.—Sutils' Infant-weigher.

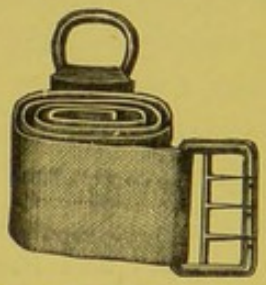


Fig. 15.—Band for suspending Infant from Weigher.

in Figs. 14 and 15, I have used both in dispensary and private practice for more than six months, and have found in it a most useful index of infantile health. It is of comparatively small size, can be very easily fitted up in any room, permits of the rapid performance of the operation of weighing, its action is little interfered with by the struggles of the infant, its use is very rarely objected to by the mother, and what is of great importance in private practice, the instrument is portable. When fitted into its case, the weigher with all its accessories is not much larger than a policeman's baton, which in outward appearance it closely resembles. On one side of the scale of the instrument are figures representing the age in months, and on the other side is inscribed the normal weight of the infant (in kilogrammes) at each month; so that in this way it can be seen at once whether there is any deviation from the normal standard of health or not.

The instrument having been suspended from a nail or cupboard handle, the infant is divested of his clothes, the band is fastened round his body below the armpits, the ring in the band made fast to the hook attached to the lower end of the weigher, and the position of the index in the scale is ascertained. If the exact weight of the infant's clothing be known it will not be necessary to undress the child, and in this way time is saved, and the infant not exposed to the chilling effects of the air. This instrument may be safely used for all infants of less than three or four years of age.

The weight of the infant ought to be ascertained as far as possible at regular intervals of time, and under similar circumstances. The weighings may be carried out daily, or weekly, or monthly. When it is simply desired to ascertain whether or not a healthy infant is gaining weight regularly a weighing once a month may be sufficient; but when it is wished to form a diagnosis or prognosis in the case of an infant who is ill, daily, or at any rate weekly, observations must be made.

The regular weighing of infants at such times as those of dentition or weaning has a great value, as regards both the diagnosis and the prognosis of any pathological states. It may, for example, be sufficient to weigh the baby in order to form an opinion for or against the use of a certain kind of artificial food; or, again, the weight of the infant may afford an indication of some deep-seated constitutional malady which is powerfully influencing the develop-

ment of the infant. Sutils* has specially emphasized the value of the infant-weigher as a check upon the treatment of children who may be sent out to nurse in crèches and similar institutions. The use of weighing instruments has been of great value in enabling physiologists to determine the normal rate of increase in infancy and childhood; and it may be well to detail some of the results which have been thus obtained.

Increase in Weight in Infancy.—At the moment of birth a full-time healthy infant has an average weight of about 3000 grammes (about 7½ lbs.)—3200 grammes if a male, 2900 grammes if a female. Many circumstances operate in determining the weight of the infant at the time of birth. Thus it has been shown by Hecker, Spiegelberg, and others, that first infants usually weigh less than later children. Hecker says that a first child weighs 140 grammes (5 oz.) less than the later children. Dungan has stated this same fact in another way, for he has shown that the weight of the infant augments with the age of the mother, the first-born having an average weight of 7·17 lbs., and succeeding infants an average of 7·27 lbs. It has also been affirmed that the weight of the infant increases not only with the age of the mother and the number of labours, but also that certain years, "the age of predilection," are favourable for the size of the child. Thus Wernick has found that the years of the age of predilection were 24, 29, 31, and 35 for the second, third, fourth, and fifth labours. Sex, as has been already mentioned, also has an influence upon the weight of the infant, female children as a rule weighing less than male. Possibly race may have some effect upon the infant's weight. It will, therefore, be evident that no hard and fast rule can be laid down to guide us to the normal weight at birth; but it may be stated generally that 7½ lbs. may for all practical purposes be taken as the average weight of the infant at the moment of birth.

All are agreed that there is a natural loss in weight during the first two or three days of life; but various estimates of its amount have been given. Bouchaud† places the loss during the first two days at 100 grammes; Gregory‡ estimates it at 203 grammes; and Steiner at 222 grammes, or about 6 per cent. of the total body-weight. This loss in weight is no doubt due to several

* *Guide pratique des Pesages.* Paris, 1889.

† *Thèse de Paris*, 1864.

‡ "Ueber die Gewichtsverhältnisse Neugeborener," *Arch. f. Gyn.*, 1871, ii. 48, 65.

causes, among which may be mentioned the evacuation of the meconium and of the urine, the activity of the skin, the diminution in the amount of subcutaneous fat, and the change from the intra-uterine to the extra-uterine mode of nutrition. Pathological causes, such as umbilical hæmorrhage, may lead to a still greater loss in weight soon after birth. The diminution in weight goes on for two or three days, the loss on the first day being always greater than that on succeeding days. Male infants, it would appear, lose less than females. It may be stated generally that there is no marked increase till the umbilical cord has separated on the fourth or fifth day of life.

The infant regains its original birth-weight on the fourth or fifth day, and thereafter it continues steadily to gain weight unless any pathological condition supervene. Male infants commence to gain weight more quickly than female, and the children of multiparous than those of primiparous women (Kezmarszki*). Delayed ligaturing of the umbilical cord also, it is said, causes a rapid increase in infant weight (Ribemont).

Many observations as to the daily rate of increase in weight during the first months of life have been made by such writers as Bouchaud, Fleischmann,† Albrecht, and Biedert; and the average of the results thus obtained has been put in tabular form by Tarnier and Chantreuil (*Accouchements*, i. p. 835). Hähner‡ also has investigated the daily increase in weight during the first year of life, and, for the sake of comparison, I have placed his table alongside of that prepared by Tarnier and Chantreuil, as follows:—

Daily Increase in Weight in First Twelve Months.

Month.	Hähner's results.	Tarnier and Chantreuil's average results.
1st,	24·5 grammes.	30·6 grammes.
2nd,	36·5 ,,	31·0 ,,
3rd,	20·3 ,,	27·4 ,,
4th,	15·6 ,,	22·4 ,,
5th,	22·3 ,,	18·0 ,,
6th,	10·8 ,,	14·8 ,,
7th,	22·5 ,,	12·8 ,,
8th,	14·0 ,,	11·4 ,,
9th,	9·0 ,,	11·0 ,,
10th,	10·3 ,,	8·4 ,,
11th,	16·3 ,,	7·4 ,,
12th,	10·0 ,,	5·6 ,,

* *Arch. f. Gyn.*, v., 1873.

† *Ueber Körperwagungen der Neugebornen und Säuglinge*, 1877.

‡ *Jahrb. f. Kind.*, xv., H. 1.

Hähner begins with an original body-weight of 3100 grammes, and the other authors with one of 3250, and this fact may account for some of the discrepancies between the results in the early months. It will be evident from this table that no hard and fast rule of daily rate of increase in weight can be laid down; but it will also be seen that there is a steady diminution in the daily gain in weight as the infant grows older, and that the period of most rapid increase is during the second month of life. Auvard* has divided the first year into four periods of three months, and has found that in the first trimester the daily gain is 25 grammes, during the second trimester 20 grammes, during the third 15 grammes, and during the fourth period of three months only 10 grammes.

It will be sufficient for practical purposes to remember that the body-weight of a healthy infant ought to be doubled by the end of the fifth month, and trebled by the end of the first year of life. Thus, if the infant at birth weigh 7½ pounds, it ought at the fifth month to weigh 15 pounds, and at the twelfth month 22½ pounds. There is during the second year of life a further increase in weight of about 5 pounds; but thereafter there is a diminished annual rate of increase, the yearly gain during the next six years being only about 4 pounds.

Many circumstances may interfere with the normal gain in weight. Dentition and weaning retard the increase in weight, so does the occurrence of pregnancy or the return of the menstrual flow in the mother; and if infants are artificially fed they gain weight much more slowly than if suckled by the mother or wet-nurse, and the effect of the early feeding persists after weaning. Pathological conditions also have a marked influence upon the infant's weight, the occurrence of a gastric or intestinal attack, the presence of fever, or of syphilis, or of some pulmonary affection, rapidly causes the child to become less heavy than is normal.

Growth in Height in Infancy.—The increase in height, like that in weight, is more rapid in early than in later infancy. The infant at the time of birth measures in length some 19½ or 20 inches (49 to 50 ctms.). The male child is usually 1 or 2 centimetres longer than the female. Quetelet† many years ago investigated the rate of increase in length in infancy, and found that in the first month of life there is rapid growth, there being an increase of 4

* *Le Nouveau-né*, 1890, p. 18.

† *Ann. d'hyg.* x., 1833.

ctms.; in the second, a growth of 3 ctms.; in the third, one of 2 ctms.; and in the following months an increment of from 1 to 1·5 ctms. There was a total increase in height in the first year of nearly 20 ctms. (about 8 inches); in the second year, a growth of 9 ctms.; in the third year, one of about 7 ctms.; and in the fourth and fifth years, an annual increase of about 6 ctms. (about $2\frac{1}{2}$ inches). Liharzik* has given figures, which, although they do not exactly correspond with those of Quetelet, Bouchaud, and others, have the advantage of being more easily remembered. This writer has enunciated an ingenious law of growth in length, which is founded upon the fact that in certain intervals of time, in arithmetical series, there is an increase of $7\frac{1}{2}$ centimetres in each period. After the twenty-first month of life he has found that the rate of increase is less, being only 5 centimetres in each interval. Liharzik's law may be best understood by a reference to the following table:—

Length of infant at birth,								50	ctms.
,,	,,	at end of	1st	month,				57·5	,,
,,	,,	,,	3rd	,,				65·0	,,
,,	,,	,,	6th	,,				72·5	,,
,,	,,	,,	10th	,,				80·0	,,
,,	,,	,,	15th	,,				87·5	,,
,,	,,	,,	21st	,,				95·0	,,
,,	,,	,,	28th	,,				100·0	,,
,,	child	,,	36th	,,				105·0	,,
,,	,,	,,	45th	,,				110·0	,,
,,	,,	,,	55th	,,				115·0	,,
*		*		*		*		*	
Length of man at end of 276th month,								180·0	,,

Although to some degree artificial, this law affords a very ready means of estimating approximately the healthy rate of increase in height at any given age in infancy, childhood, or youth.

All parts of the body do not increase in equal proportion. At birth the head and upper limbs are relatively larger than the lower parts of the body; but as the child advances in age the legs rapidly grow longer, and the centre of the body falls from the umbilicus to the pubes. The head grows more slowly than the body and limbs. Reference has already been made to the increase in the cranial and thoracic circumferences in infancy (*v.* page 31).

It must constantly be borne in mind that great individual differences exist in the rate of growth of children. Physiological causes

* *Law of Increase of Human Body.* Vienna, 1858.

of these differences are found in the effects of race, of climate, and of heredity; and pathological causes are discovered in the retarding influence of syphilis, rickets, and gastro-intestinal and wasting diseases. The healthy growth of infants is dependent in a very conspicuous manner upon the maintenance of the laws of hygiene during this period of life; and it is, therefore, convenient at this point to consider the ventilation, warming, and lighting of the nursery, and the bathing, dress, and exercise of the child.

Hygiene of the Nursery.—It is slowly coming to be recognised that the nursery is, or ought to be, the most important room in the house, for in it are being reared those young and delicate little ones who are so sensitive to noxious effluvia, insufficient fresh air, and all the other sanitary failings which are so common in modern houses. It must constantly be remembered that infants are at the mercy of their surroundings, they cannot move away from insanitary conditions, and probably no room in the house is more continuously occupied by its inmates than is the nursery. It is perhaps utopian at present to hope that the best room in the dwelling should be given up to the use of the baby; but I know of isolated cases in which it has been done; and if medical men would but educate public opinion in this matter, it would not be long before the practice became universal, in at any rate the upper and middle classes of society. It is not necessarily meant that the dining-room or drawing-room be turned into a nursery, for these rooms are seldom the most healthy in the house, they are often quite otherwise; but it is intended that the children's room be the best as regards ventilation, lighting, drainage, and warming. If it can at all be carried out, there ought also to be both a day and a night nursery, and these two rooms ought to be separated by a partition, not simply by a curtain. The room which has been occupied by the children all day is not suitable for sleeping in, and children ought to begin the day in a fresh, purified room, and not in one that has been in use all night, and has not yet lost the odours consequent upon the performance of the toilette. Both the day and night nurseries should be large rooms in the upper flat, with sufficient window space, and with a south-east or north-west exposure.

Ventilation of the Nursery.—Thorough ventilation of the nursery is necessary if its inmates are to grow well and remain healthy. This is true of the day nursery in which the children are constantly moving about; but it is doubly true of the night

nursery in which for many hours they lie in the same part of the room unconscious of their surroundings. Pure fresh air is absolutely essential for the maintenance of health; and yet how often is the nursery kept almost hermetically sealed—doors, windows, and even chimneys being closed continually. Enough has been said when speaking of the physiology of respiration to disprove that old notion that infants require less fresh air than older people; but it may here be repeated that the breathing of children is relatively quicker than in adult life, and the excretion of waste material from the lungs relatively greater in infancy. There is, therefore, no reason at all why infants should not be allowed as much cubic space in their dwelling-rooms as adults. Eight hundred cubic feet of space will be as a rule sufficient for one child; but as the nurse usually occupies the same room, this allowance must be doubled if the infant's health is to be preserved. For each additional child in the nursery eight hundred cubic feet of space must be added. This rule applies specially to the night nursery; a smaller allowance may be made for the day nursery, if the practice be enforced of opening wide the windows when the child is not inhabiting the room. A nursery in which dwell two children and a nurse ought to be about 16 feet square and 8 or 9 feet high. Any of the methods usually employed in ventilating apartments may be applied to the nursery, always provided that the method be thorough. The natural means of ventilation by windows, door, and fireplace, supplemented by the use of Tobin's tubes, will be amply sufficient for any ordinary nursery. With regard to night nurseries, never let the dangerous practice of placing the infant's cot in a bed-closet or alcove be indulged in; the free currents of air which prevail in the centre of the room never reach such recesses, and infants who sleep in such places never receive the necessary amount of fresh air. The child's bed may be placed near the centre of the room some little way from the wall; it ought not to be placed directly under the window nor in a draught.

Heating of the Nursery.—Nothing has yet been invented for warming the nursery that excels the ordinary open fireplace; but to prevent accidents there ought to be a fire-guard. Hot-water pipes are not needed, although not necessarily injurious; but the open fire has the advantage of acting both as a means of heating and of ventilation. Gas, coke, or coal stoves are an abomination in the nursery; they are positively dangerous. The temperature of both day and night nurseries ought to be about 65° F. If the room have

a south-east or north-west exposure, the rays of the sun in summer will be a sufficient source of heat. The windows should, however, be provided with blinds to lessen the power of the direct rays of light in the early morning, when the children are still asleep. An over-heated nursery is as bad as or worse than a cold one.

Lighting of the Nursery.—Infants, like plants, cannot grow well and healthily unless they have sunlight. A fall in temperature has been noted in infants experimentally kept in a dark room, and along with such a fall there must necessarily be increased liability to catch cold. The windows of the room ought to be large; they should, as has already been noted, be provided with blinds, and they should be protected on the inside by iron bars. Gas is now so generally used as an artificial light that it may be hopeless to protest against its employment in the nursery; but I have little doubt that oil lamps and candles are less noxious means of lighting. A word of warning with regard to lucifer matches may not be out of place here; these necessary articles ought to be put carefully out of the reach of infants, for many cases of poisoning have occurred from children's sucking them.

The Furnishing of the Nursery.—Many articles of furniture in the nursery are unnecessary. In the night nursery there need be only a bed for the nurse, a cot or crib for the infant, a washstand, and a few chairs. The crib should have high sides, a hair not a feather mattress, and no curtains. The walls of both the day and night nurseries should be covered with a plain paper, or what is still better, they may be simply painted. They can thus be easily cleansed, or can be disinfected in cases of fever. A carpet upon the floor is unnecessary, and may be even objectionable; the boards may be best stained or varnished, for they can then be easily washed at frequent intervals. The furniture of the day nursery, like that of the sleeping apartment, ought to be simple, inexpensive, and small in amount. Only necessary articles should be found in a nursery. Fixed-in basins communicating with the drains ought on no account to be permitted in children's rooms. Everything ought to be kept spotlessly clean, and the utensils in use in the night nursery ought to be emptied as soon as is practicable. The nursery, furthermore, ought to have a bright and cheerful look, for young children are much influenced by their surroundings. Pretty, tasteful pictures ought to be placed upon the walls, for there is no reason why the child's æsthetic sense should not be trained from the very

first year of life. It is not difficult nowadays to obtain very cheaply most artistic drawings and paintings for the walls. It is very necessary from a health point of view that the infant should be happy in his surroundings, and this can only be carried out if the nursery be bright, pretty, and cheerful. Toys in the nursery ought not to be forgotten, and the playthings should be simple and free from all danger. Accidents from choking upon toys, or from licking off the brilliant paints with which they are covered, are unfortunately too common. In conclusion, it may be said that the nursery ought never to communicate directly with the W.C. or bathroom.

Such are some of the hygienic precautions that ought to be taken to render the nursery not only a healthy but also a happy room for the children to live in. Further details will no doubt occur to the physician who has to treat infants; but some mention has been made of the more important matters.

Personal Hygiene in Infancy.—In considering the personal hygiene of infants, it must constantly be kept in view that at this time of life the individual is unable himself to regulate his bodily functions, and to attend to the laws of health as regards exercise, bathing, dress, and the like. The baby, like the paralytic man, is unable to feed, dress, or bathe himself, and both alike are at the mercy of their attendants. Perhaps the most helpless being in the world is the new-born infant.

> "Then the poor babe, too, like a seaman wrecked,
> Thrown from the waves, lies naked o'er the ground,
> Weakly and void of every vital aid."

But though his helpless state has been appreciated by the poet, it is to be feared that the popular mind has not grasped the idea that, since the baby is unable to look after his own bodily hygiene, it falls upon his attendants, lay and medical, both to learn the rules of health in early life and to apply them to the infants under their care. Correct views as to the dress, the exercise, the bathing, and the sleep of infants are much needed; and it has already been seen with how many errors the subject of infant feeding is surrounded. The diet of infancy has been fully considered in a previous chapter; the questions relating to exercise, dress, etc., fall to be discussed here.

Exercise in Infancy.—Exercise is a necessity at all ages; but it goes without saying that the kind of exercise suitable for adult

life is impossible for the baby. In infancy not only are the bones less firm and more yielding than in later life, but the muscles also, although active enough, are not well fitted to stand any great or long-continued strain. Chemical analysis has shown that the muscular tissue of the infant contains proportionately more water, more extractive matters, more fats, more salts, and less myosin than does that of the child or man. Waste products, especially sarco-lactic acid, are rapidly produced in the muscles of the infant, and it may be that it is on this account that the young child tires so quickly. A knowledge of these physiological facts is necessary for the proper understanding of exercise in early life. It is most cruel to swathe a baby in tight bandages; he ought to be allowed perfect freedom of movement several times a day, and his clothes ought never greatly to impede or hamper his natural activity. One has only to watch a young infant in his bath in order to be made aware of the enjoyment which perfect freedom from restraining bands and clothes gives to the baby.

The best exercise a young infant can get is that afforded by allowing him to lie on his back and kick out his legs, and turn about at will. It is a mistake to encourage him to sit up at too early an age. His backbone is far from strong, and his muscles are yet weak. He will sit up naturally enough, and in good time, if left to his own devices. He will probably begin to creep at the age of nine months, and when he is a year old will be able to stand alone, and he will walk a month or two later. In regard to this matter there are great individual differences, and one baby cannot be advantageously compared with another. It is often no matter for congratulation when a child walks at an unusually early age. The great principle, however, is that whether the baby lie, or creep, or walk, he must have exercise. When it is possible, the exercise ought to be in the open air and in the sunshine. In damp or rainy weather, and when the wind is either in the east or north, the house is the best place for young children; under all other conditions, children ought to spend part of the day in the open air. When they are in the open air, they ought always, except when so young as to require to be carried in the nurse's arms, to walk or run. Perambulators are dangerous alike to the infants in them and to the pedestrians in the streets; but they are more dangerous to the former than to the latter. It is very difficult to keep a child warm in a perambulator; and when he falls asleep

in it, as he often does, with his head hanging over the side, he is particularly liable to take cold. It ought, by the way, to be accepted as an axiom, that when a baby catches a cold, some one is to blame, and the *some one* is never the baby himself. He is helpless, he cannot move into danger, neither can he move out of it. Some one, mother or nurse, is to blame in the matter.

No infant ought to be tossed up in the air. This form of exercise may frighten him into quietness; but not one baby in a hundred enjoys being thrown up in the air and caught again in the arms of his attendant. Moreover, on some occasion the nurse or the father will fail to catch the child, and permanent injury to the spine may be the result of the fall. Neither ought a young child to be dragged by the arm when out walking; if the little one lags behind, it is a sure sign that he is tired, and he ought, therefore, to be carried. There is a most dangerous practice which Chavasse has with perfect justice called "daring death." This consists in the lifting of a child by pressing the hands against the ears. It has been too often demonstrated that the occipito-atloid joint may thus be dislocated, the medulla ruptured, and immediate death caused.

There is one other point concerning the exercise of a young child which it is well not to forget. The exercise ought not to be purposeless, the child ought not simply to be taken out "for a walk;" but he should be encouraged to trundle a hoop or drag a toy cart. In this, or in some other way, the daily outdoor walk may be made an enjoyment instead of a penance.

Sleep in Infancy.—Reference has already been made to the bed and bedroom of an infant; but it is now necessary to say something with regard to sleep itself. From the very first the infant ought to be accustomed to sleeping in a cot or bassinet by himself. The habit of allowing young children to sleep with their nurse or their parents is an objectionable one, and has resulted in many deaths from accidental suffocation. In one case, which occurred in my own practice, an infant of about nine months was suffocated simply by being allowed to lie with his face buried in his father's shoulder. The father slept heavily, and on waking found his infant dead!

For some time after birth infants spend their time in alternately eating and sleeping. It is very important to remember that children require more sleep than grown-up people. The practice of allowing children to "sit up" at nights is a pernicious one. A baby sleeps

for eighteen out of the twenty-four hours; and for children of two and three years of age, thirteen hours and eleven hours respectively are necessary. The presence of a precocious little one in the drawing-room in the evening may give the mother feelings of pride, and excite from her admirers wondering comments, but the spectacle is a sad one when looked at from the health point of view. "Tired nature's sweet restorer" is most necessary in the early stages of life's journey. A child's entertaining behaviour in the drawing-room is but a small thing to put into the balance against the temporary or permanent loss of health occasioned by the want of sleep.

It is an important accomplishment when the mother is able from the very first to train her children into regular habits in sleeping. Except when a baby is suffering from illness, he ought to be able to sleep continuously from 11 P.M. to 5 or 6 A.M.; and in the case of children over one year in age, they ought to sleep from 7 P.M. to 6 or 7 A.M. without any interruption.

There is an error which a mother commonly commits once, but never again, and that is the awakening from sleep of her baby, in order to show some friend the beautiful colour of his eyes. The experiment results in a complete demonstration of the power of his lungs, and is not usually repeated.

To frighten little children into quietness at bedtime is a most grievous error; and yet this pernicious practice is far from uncommon. Its results are far-reaching, for whilst it is certainly a present source of acute mental suffering to the children who are its victims, it may also be the cause of various nervous diseases, such as "night terrors" and convulsions in the immediate future. To frighten children to sleep by telling them ghost stories or by threatening them with a visit from the policeman, is a procedure which may be flattering to the ghosts, but it is a cruelty to the child and an insult to the police.

The Bathing of Infants.—Very soon after birth the infant ought to be bathed. After the umbilical cord has been tied and divided, the nurse ought to receive the infant in her arms and to carry him to the front of the fire, where the bath has been prepared. The vernix caseosa ought to be carefully removed from his body in the way which has already been described, and the infant ought then to be placed in a bath of hot water at a temperature of about 105° F. The head should be first wetted, and then the rest of the

body may be plunged in the water. A bland soap, such as old Castile or Pears', should be used; and after the infant has been thoroughly cleansed, he ought to be wrapped in warm flannel and carefully dried lying upon the nurse's lap in front of the fire.

There is an ancient but erroneous procedure known as the hardening of children. The practice of plunging newly-born children into cold water, nay, even into water mixed with ice, in order that their bodies might be made more robust and less sensitive to cold, is a very old one, and it is to be feared that this practice is still far too commonly met with. The result of this hardening process is the death of all the weakly infants. We can easily understand how it is that infants that have been hardened are strong and robust: they were originally so; those who were weak went to the wall. It is easy to understand this when it is remembered how much of the body-heat is lost soon after birth. Barensprung found that an infant lost 0·83° C. after his first bath. It is nevertheless most necessary that in early life children should be regularly bathed, but the temperature of the water used must be neither too high nor too low. A temperature of about 98° F. is a very safe one for the bath; and in order to ensure that the water is neither too hot nor too cold, it is well for the mother or nurse to use a bath-thermometer. Nurses are, as a rule, averse to the use of a thermometer, and even when one is provided for them, omit to employ it. They prefer the rough and ready method of ascertaining the heat of the water so graphically described in the following reported conversation which I read recently in a comic paper:—

"*Anxious Mother.*—I wish, Susan, that when you give baby a bath you would use the thermometer, so as to ascertain whether the water is at the proper temperature.

"*Susan.*—Oh, don't you worrit about that, ma'am, I don't need no 'mometers. If the little 'un turns red, the water's too hot! if it turns blue, it's too cold; and that's all there is about it."

It is not possible to expect that mothers in the poorer classes should use thermometers; all that can be reasonably asked of them is to see that their children are bathed in some way or other. There can be no doubt that dirt stands next in importance to cold and bad food as a causal factor in the production of infantile maladies and disease. To "look beautiful through the dirt" may be a possibility, but to be healthy under the dirt is not practicable.

With regard to the many toilet powders which are recommended for use in the nursery, it may be said generally that when the infant's skin is kept clean and dry there is but little need for such dusting powders. If employed at all, the preparations should be simple and their composition should be known.

Dress in Infancy.—When it is remembered that children's skin is very delicate, and that they are very liable to feel the effects of any sudden changes in temperature, it will be seen at once how important it is that little ones be properly clad. It is not my place to insist upon certain kinds of clothing, but I do feel it my duty to protest against that old pernicious practice of allowing children to go about with bare necks, arms, and legs. There are very few months in the year when a child can safely dispense with woollen underclothing; and all the garments ought to fit loosely and be frequently changed. There is a little error which is often thoughtlessly committed, and that is to permit children to romp about in the house with their "going out" clothes on. Out-door clothes ought only to be assumed when the child is ready to start out, otherwise the child runs a great risk of catching cold.

The medical man is sometimes asked what is the proper time for "short-coating" a baby. No fixed number of months can be laid down as a rule for the time of change from long garments to short. The more active the infant is the sooner he will have to be shortened. But really a more important question is whether a baby should ever wear long clothes at all. It would seem to me that short clothes tied at the bottom are as warm and as useful as long clothes, even from the very first days of life. I have never yet found a mother who could satisfactorily explain the use of long clothes; but I suppose fashion and appearance have much to do with it. Some savage races compress the head of the baby, Chinese mothers squeeze the feet of the female infants, and British babies wear long clothes for the first three or four months of life: the last-named practice is certainly not injurious to the health of the child, but it is as useless as are the other customs just mentioned.

The Hygiene of the Sense Organs in Infancy.—Particular care must be taken of such delicate organs as the eye and ear in young infants. Ophthalmia neonatorum has destroyed or injured the eyesight of thousands of individuals; and it is always well in hospital and dispensary, if not also in private practice, to drop into the eyes, immediately after birth, one drop of a one or two per

cent. solution of nitrate of silver. This procedure, first recommended by Credé in 1880, has no doubt been the means of preventing many attacks of conjunctivitis in infancy, and of almost entirely banishing ophthalmia from maternity hospitals. During the whole period of infancy also great care ought to be taken of the eyes and ears; they ought to be kept scrupulously clean, and nurses ought to be particularly careful not to allow the child to force foreign bodies into either the auditory canals or the nasal passages.

The Vaccination of Infants.—There is one rule of infant hygiene which is enforced by law, and that is vaccination. There is probably no one medical practice which has been more effectual in preventing disease than has vaccination, and yet there are still some individuals who, by shutting their eyes to the good effects and opening them wide to the almost infinitesimally small number of cases in which evil results could be traced to vaccination, have persuaded themselves, and would persuade others, that the operation is dangerous, brutal, immoral, and to be protested against and resisted. Perhaps the most extraordinary objection ever made to vaccination was that lodged recently by a Plumstead father, who said that "it was well known that bulls go mad every seven years, and that the cows make them mad; that these same cows are used for vaccinating children; and that the children go mad." We feel tempted to ask whether it is safe any longer to drink the milk of cows?

Infants ought to be vaccinated within three, or at any rate within six months after birth. There seems, indeed, to be no reason why they should not be vaccinated immediately after birth, for Wolff (*Arch. Virch.*, 1889) has shown that infants only one day old are completely receptive and support the operation well. Early vaccination of infants is especially useful during an epidemic of small-pox.

Either human virus from another infant or bovine lymph from the calf may be used; but the latter is probably slightly less regular and less reliable in its action than the former. The lymph may be kept ready for use in sealed glass tubes or dry upon ivory points, and the operation should be performed upon the left upper arm of the infant. The cuticle should be scratched with a lancet, and the lymph applied without any hæmorrhage taking place. If the infant's surroundings are insanitary it may be necessary to treat the vaccinia pustules antiseptically, but usually neither antiseptic pads nor protective shields are required.

CHAPTER XIII.

THE PHYSIOLOGY AND HYGIENE OF INFANCY —Continued.

THE PHYSIOLOGY OF THE NERVOUS SYSTEM—MOTOR PHENOMENA—SENSORY PHENOMENA—IMITATIVE MOVEMENTS AND THE WILL—SENTIMENTS AND INTELLECTUAL TENDENCIES—INTELLECTUAL PROCESSES IN INFANCY—MORAL AND MENTAL HYGIENE—DIAGNOSIS OF NERVOUS DISORDERS IN INFANCY.

The Physiology of the Nervous System.

The investigation of nervous phenomena in infancy is full of interest; for to all, save those whom we may justly term unnatural and inhuman, it must ever be a most engrossing and attractive study to mark the first faint glimmer of dawning intelligence in the infant mind; to note with joy and pleasure each lovely developing trait of character; to observe, alas! that sometimes even in the baby there are tendencies which require to be checked or corrected; and to study all the early indications of a hidden, unknown future of mental activity.

From the moral philosopher, busied with such problems as the evolution of the idea of personality, the study of the dawn of the intellect in early life well deserves much greater consideration than it has yet received. Mental processes are confessedly difficult to understand, and the deepest thinkers of this, as of other ages, have been oftentimes baffled by the intricacy and complexity of the problems which psychology has presented for solution; but had philosophers studied more attentively the development of the mind in the young, greater progress had assuredly been made with the elucidation of intellectual processes in the adult. The working of the brain in the infant, complex enough no doubt, is at any rate simpler and less thickly surrounded by qualifying conditions than it is in the fully grown man or woman. The moral philosopher might with profit follow Darwin's example in the study of the mind of his little boy.

Again, it is surely of the utmost importance that they whose business it is to educate the young should have as thorough a knowledge as possible of what may be termed the raw material which is put in their hand to fashion into individual minds well adapted for the requirements of modern life. The educationalist cannot lightly pass over this subject.

The dawn of intelligence in the young may be looked at from another point of view, for, says James Sully, "the first years of a child's life are of peculiar antiquarian interest; his first years correspond to the earliest known stages of human history; the naïve conceptions of Nature, the fanciful animistic ideas of things, rude emotions of terror, are traits of early progenitors." To a great extent the evolution of the mind in a child is an epitome of the infinitely more gradual development of mind in the human race. It yet remains to be seen how far it is possible to reconstruct for ourselves the mental manifestations of primeval man from the close observation of intellectual processes in the young; but the endeavour cannot fail to be intensely interesting to the historian and archæologist, and the task is rendered lighter by the fact that there are at present existing races of savages available for observation and comparison whose habits, it is conceded by all, must closely resemble those of primitive man.

To the naturalist also the subject is an interesting one, for in childhood are found many instances of phenomena which when they occur in animals are termed instinctive; to the poet the dawn of the intellect in childhood has had an interest and a charm which have led to the production of countless poems of wondrous beauty; and to the Christian the study of the inmost thoughts of those little ones whom the Master loved to bless must always be a duty and a pleasure not to be lightly surrendered for less profitable and less humanizing purposes. In the "Chronicles of Glenbuckie" we read of a clergyman, whose life has been brightened by the advent of twins, and he says: "For my part I never hitherto cared much for infant bairns, and I often wondered how grown up people, especially men, could take unfeigned pleasure in them, but that feeling has undergone a mysterious change. The great and all-wise Creator seems to have unsealed a dormant well-spring in my heart—it must, I suppose, have been there before—for I can now not only tolerate, but in point of fact I never tire of gazing at them. They

have such marvellously queer ways, and make such queer faces; while they beat the air with their helpless cluster of clenched fingers that you would think they were fighting for dear life with dangerous but invisible foes. There seems also to be a most sympathetic and tender connexion between them, for when one begins to cry the other purses its lips with sweet sensitiveness, and immediately there is a chorus, or, as one might say with stricter accuracy, a duet of a most plaintive and touching character. Truly the study of children is an elevating and refining thing."

It is, however, chiefly from the standpoint of the medical man that the phenomena of nervous action in the infant must be here studied. The comprehension of infant minds is one of the characteristic traits of the well-trained family physician, and no one who desires to succeed in the treatment of the maladies of infancy can afford to leave unstudied the peculiarities of nervous and mental processes in the young. An example of the inconvenience caused by the absence of such a knowledge has already been given (*vide* page 16), for if the medical man there referred to had been aware of the circumstance that fear is a powerful factor in the development of the intellect in infancy, and that this emotion is always present during the examination of a young child, he would not have had to deplore the failure in diagnosis which occurred.

Investigation of Nervous Phenomena in Infancy.—Strangely enough the investigation of normal and pathological nervous phenomena in infancy has been left by the medical man and scientist very much in the hands of the laity. Most text-books on Diseases of Children say little or nothing about the development of the nervous functions, and especially of those relating to psychology; whilst they contain at most a passing reference to the methods of diagnosing motor or sensory disturbances, and the more obscure mental derangements or psychoses in infancy. It is, therefore, necessary in this branch of the subject to gather materials from sources other than the strictly scientific.

In the first place, the information collected by the mother or the nurse of the child is of the utmost importance, for with them lies the privilege of watching closely under the most varying circumstances, and for prolonged periods, all the manifestations of mental activity which may be visible in the early years of life. The mother may lack the scientific method, but she is nevertheless a close observer, and it is seldom that a novel phenomenon in the daily life

of her child appears without being duly noted by her. She has, it is true, an unconscious bias towards the exaltation of her own child's mental accomplishments, and possibly the element of exaggeration is sometimes present in her statements, still the information which she is able to give us, especially if the material take the form of the so-called "mother's records," is of the greatest value in enabling us to lay the foundations of a system of infant psychology. Next in importance to the information obtained from the mother or nurse may be placed the observations of the family medical man, which, although founded upon a much smaller number of facts, have the value of being conducted in a more critical manner. There has not, however, been a complete absence of the scientific investigator from this field of research, for observers, of whom may be named Sully, Preyer, Perez, Tiedeman, Taine, and Froebel, have specially devoted themselves to the study of the subject with most gratifying results. Such are the three great sources of information bearing upon the development in the infant of the complex functions of the brain and spinal cord. I have in the writing of this chapter drawn largely from the admirable works of Preyer* and Perez;† I have also had the privilege of reading several most interesting "mothers' records;" and I have from time to time been able to check many of the statements contained both in the works of the above-named authors and in the "records" by personal observations upon the children under my charge in private or dispensary practice.

Activity of the Nervous System in Infancy.—The nervous system is not quiescent in intra-uterine life, for one of the most certain signs of pregnancy is found in the recognition of fœtal movements by the mother about the mid-term of gestation. At birth, also, the infant, if born alive, shows evident signs of activity in his nervous system, for no sooner is he expelled from the maternal passages than he begins to breathe, to extend and to flex his arms and legs, and to cry lustily. If these movements are absent the infant is significantly described as "still-born." With regard, however, to the time when the infant can be said first to have a will, and to think and reason, nothing absolutely definite can be stated. It has been generally conceded that the period of the dawn of the intellect corresponds more or less closely with the first

* *Die Seele des Kindes.*

† *Les trois premières années de l'enfant.* Paris, 1888.

three or four years of life. It is impossible to define exactly the period of sunrise in the physical world: there are indications of the dawn before the sun's disc appears above the horizon, and even after the light is illuminating the mountain tops there is still twilight in the valleys; so it is with the dawn of mental activity,—the time cannot be fixed within limits, but the phenomena can be noted. Allowance must always be made for great individual differences,—some children are precocious, others are dull and backward, but in all practically the same phenomena are witnessed.

The Phenomena of Nervous Action.—The helpless state of the new-born infant is proverbial, and has formed the theme of many a touching verse; it is only after several weeks that the baby can hold up his head, and even the most sanguine mother does not claim that her child is able to recognise her before the second or third month of life; yet during this period of life there are many phenomena, most interesting and curious in themselves, which show that the brain is not quiescent, although as yet probably no pure act of will is possible. These phenomena must now be studied somewhat in detail.

Motor Phenomena in the Infant.

The *movements* that the young infant makes are the first phenomena to attract attention; and as many of those movements are, when they occur in the adult, associated with certain definite mental states, it may be supposed that in the infant also they have a similar relation. It is probable, however, that many of the movements made by young infants have no ideas behind them at all. Such, for example, are the so-called *automatic or impulsive movements* which everyone who has seen a baby in his bath or lying upon his nurse's knee must have noticed. They consist in little jerking movements of the arms and legs, and commence to show themselves as soon as the often unnecessarily tight clothing is removed and free scope given to the limbs. There are, also, peculiar little twitching movements of the muscles of the face which often occur when the baby is lying quite still. It has been said that these little grimaces, when they occur in the first baby, are attributed to angels' whispers, but when they appear in later arrivals are promptly checked by a dose of peppermint water. Whether we accept the theory of the angelic or of the stomachic origin of these

movements, it is probably true that their presence betokens a condition of exuberant vitality in the nervous system of the little one; and this condition persists throughout childhood, for the restlessness of babies and young children is well known—better known, perhaps, than appreciated. Other examples of these very interesting impulsive movements are found in the crowing sounds that infants make when they are being dandled or during feeding, and in the irregular movements of the eyeballs seen immediately after awakening from sleep during the first weeks of life. These latter squinting movements often give rise to unnecessary anxiety on the part of mothers, who fear that they betoken brain disease, or that they will remain as a permanent disfigurement. They are usually very transient phenomena. Preyer noted that the nose became mobile in the seventh month, and that at this time also the infant struck about him vigorously. He also observed in his little boy a very curious phenomenon, which he placed in this class of automatic movements, and although he did not notice it till the eighteenth month of life, it may yet conveniently be mentioned here. It was observed that when the child carried a spoon to his mouth he at the same time gracefully extended his little finger, and this movement he repeated under similar conditions until the end of the third year of life. Preyer believed it to be performed entirely unconsciously, and states that there was no possibility of its having been learnt by imitation. I have recently met with a case in which a baby boy of not more than seven months performed this elegant movement of the little finger in a very perfect way. The automatic movements of infancy diminish in number as the child grows older. They must be regarded as inco-ordinate and involuntary in their nature, although it must be conceded that it is not always possible absolutely to eliminate all sensory stimuli, and so to prove that they are truly automatic and due to spontaneously exploding nerve discharges in the motor centres of the spinal cord or brain. The hypothesis that they are produced by the activity of a lower motor centre transmitted through motor nerve to a muscle is probably quite correct.

Another class of movements, the *reflex*, may now be considered. These differ from the automatic in the very important detail that they are dependent upon external agency for their production. A reflex movement is one which results from the irritation or stimulation of one or other of the sense organs—the eye, the ear, or the

skin. The peripheral end of a sensory nerve is stimulated, the stimulus is transmitted along it to one of the lower sensory centres, thence to a lower motor centre, and thence through a motor nerve to the muscle or set of muscles which is to be thrown into action. In this way, for example, the closure of the eyelids which occurs when a body such as the finger is brought into contact with the eyeball or eyelashes is caused. It has been found that the time occupied in the transmission of the stimulus and in the production of the reflex movement is greater in the new-born infant than in older children; and there is some difficulty in reconciling this fact with the statement that has often been made, that the sensory nerves are more excitable in new-born children than later in life. Soltmann's recent observations* would seem to throw some light upon this question. He has been led to believe, from experiments upon new-born animals (dogs), that the irritability of the sensory nerves in young infants is not greater than in adults. He has found that the excitability of sensory nerves is much less in new-born dogs, that it gradually increases up to the tenth or twelfth week, when it exceeds that found in the adult, and that thereafter it diminishes again. He is able to explain this phenomenon partially, for he has found that in the vagus and sciatic nerves of the new-born dog there are more nerve fibres without axis-cylinders than in these nerves in the adult. With regard to infants, he makes the very interesting inference, that the convulsions which occur with special frequency at the dentition period may be due to a state of increased excitability occurring about the eighth or ninth month in the human subject, and corresponding to that found about the twelfth week in dogs.

Many reflex movements are found in infancy; in fact, it is certain that the greater number of the movements of the young child are reflex in their character. Preyer noted that sneezing and coughing occurred as soon after birth as breathing—that in fact the first respiratory movement was often a sneeze. During the first week of life he observed yawning, choking, hiccoughing, wheezing, and the spreading out of the toes when the sole of the foot was tickled. On the ninth day clasping was noted, and on the tenth protrusion of the lips. It was not till near the end of the first month that snoring appeared. Preyer observed vomiting in the fifth week, and laughing due to tickling in the eighth. Sighing did not appear till the seventh month, and expectoration not till a yet later date.

* *Jahrb. für Kinderhk.*, xiv., H. 4.

Many reflexes are exceedingly complex movements, calling into action many muscles. Thus in the act of sneezing there is not only the violent expiratory effort carried out by the muscles of respiration, but also movements of the limbs and screwing up movements of the eyes. Other reflexes are more simple, such as those produced by tickling the palms of the hands or the soles of the feet. Tendon reflexes such as are found also in adult life are often present in infants. It is true that the patella reflex, ankle-clonus, and the osseous reflexes are not so constantly met with in infants as are the reflex movements starting from stimulation of the skin or mucous membrane; but when present they are perhaps more distinct in infancy than in later life. Preyer believes that the tendon reflexes are not so easily inherited as those of the skin and mucous membranes, being less useful to the individual. The pain reflexes—the movements, for example, produced by the prick of a pin—are less easily excited in very young infants than in older children.

None of these movements have intelligent will behind them, for they are found in anencephalic infants, and can be produced in a frog without a head. In fact, it is on this account that the baby with his numerous reflex movements has been—somewhat rudely, perhaps—compared to a decapitated amphibian. The reflexes, also, can all be performed during sleep; and we must conclude that in the baby these movements, like the automatic, give us no information regarding conscious mental action. Crying, even, is at first simply a reflex, due to stimulation of the skin by the cold air, by clumsy hands, or by some other irritant, and in the young infant this act, so full of pathetic meaning in later life, is unaccompanied by the signs of passion or fear shown by the heaving of the chest or the holding of the breath. There is a quaint conceit, according to which the infant in his first wailing cry laments his heritage of original sin; but whilst it is true that the baby at an early age, alas! begins to show tendencies that do not set for righteousness, it is equally true that the first cry is founded upon a physical and not upon a mental condition. The conclusion must be drawn, that neither the automatic nor the reflex movements of the young infant give any information regarding his conscious intelligence; strangely enough, it is rather in the absence of certain of these movements, their inhibition, that the first evidences of will are to be found. Preyer first noted the inhibition of reflexes (*e.g.*, the control of the sphincter vesicæ) at the tenth month of life; but the tendon reflexes

never can be inhibited at any time in life. Before, however, the signs of willed actions can be studied, a few words are necessary in explanation of what are termed the *instinctive movements* of infancy. These movements, which are not very numerous, owe their name to their resemblance to certain complicated acts which occur in animals, and which are in them the evidences of instinct.

The most familiar examples of *instinctive* movements in the case of the lower animals are all grouped around the function of nutrition, and so also in the infant the most definitely instinctive movement (sucking) has to do with the reception of food. The fact that a young chicken can almost immediately after its exit from the shell pick up quite accurately grains of corn of very small size, is a familiar and convincing instance of instinct. It is not an act of imitation, for chickens that have been blindfolded, and that have never had an opportunity of seeing the parent hen perform this movement, can carry it out perfectly correctly. Instinctive actions are closely allied to reflexes, but there are differences. Instinct, according to Romanes, whose definition I adopt, "is a term comprising all those faculties of mind which are concerned in conscious and adaptive action, antecedent to individual experience, without necessary knowledge of the relation between means employed and ends attained, but similarly performed under similar and frequently recurring circumstances by all the individuals of the same species."* Sucking is one of the earliest instinctive movements seen in the infant. It brings into play a large number of muscles. The infant seizes the nipple with the tongue, lips, and gums, and by a peculiar lingual movement causes a vacuum in the buccal cavity. The sucking pads prevent the passage inwards of the cheeks between the gums, and the milk is drawn into the mouth. Then follows another movement, that of swallowing, which is also present not only after birth but no doubt also during fœtal life. Now, the infant has never been taught to carry out the complicated movement of sucking, and yet from the very first the act is carried out perfectly. It has been performed also without any antecedent individual experience, and it thus differs from a rational movement, which is the result of previous experiment. Instinctive movements, further, are not infallible—they show a want of adaptability to novel circumstances. Thus, in the case of sucking, it is well known that a baby will suck away complacently at your little finger, or at his

* *Animal Intelligence*, International Scientific Series, p. 17.

bath sponge if he be allowed to do so. The instinctive movements which the infant is capable of performing are very few in number when compared with the acts of instinct seen in the young of the lower animals, and in the case of a baby there is less need for these protective acts, the mother being able to watch over, guard, and feed her offspring for a prolonged period of time. It is a reasonable hypothesis to believe that instinctive movements are inherited legacies from ancestral experiences, and although they are most interesting, yet it cannot be held that they give any indication of intelligence or reason. The consideration of the production of instinctive movements, however, leads us to believe that both a higher motor and sensory centre must be involved.

Other most interesting instinctive movements are those of licking, biting, chewing, and teeth-grinding. Preyer's child at the tenth month of life always bit and no longer sucked the finger put into his mouth; but biting no doubt occurs some time before this age is reached. Chewing is a movement which becomes specially evident at the time of teething, but it also may be found prior to this period. Grinding the teeth appears almost simultaneously with the eruption of the first milk incisors. Licking appears early, for it can be noticed in some cases as soon after birth as sucking. The instinctive movements of grasping, holding up the head, sitting, standing, and walking, appear later in infancy; these are not purely instinctive, but partly rational and voluntary, for they involve the principle of imitation. During the first three or four months of life, however, the seizing movements, the clasping movement by means of apposition of the thumb, for example, are involuntary, and are either reflex or purely instinctive in character. Intentional grasping and voluntary holding up of the head appear first about the end of the fourth month of life; and as time goes on these movements are perfected, for they are at first irregular and incomplete. Before speaking of movements which involve the will of the child to a greater or less extent, it is necessary to describe the condition of the sense organs, those "gateways of knowledge," in the young infant.

The Sense Organs in the Infant.

It is through the senses that perceptions are formed, and the formation of perceptions leads on to the production of imitative movements. At the time of birth the sense organs of sight, hear-

ing, taste, smell, and touch are structurally perfect, and do not differ from the same organs in the full-grown man, but the extent to which these organs are functionally active varies very considerably.

The Sense of Taste.—The sense of taste is probably the first from which distinct perceptions (or rather "recepts") are derived, for an infant is able very soon after birth to distinguish between sweet and bitter things, and probably the first really pleasurable sensation the baby has is derived from the sweet taste of the milk. Preyer found that during the nursing period the infant had a preference for sweet tastes, and that this preference showed itself early; for on the second day of life his boy accepted food which he refused on the fourth. During the sixth month of life it was noticed that the infant refused the breast milk after having been fed with sweetened cow's milk. From the seventh month onwards new tastes caused looks of surprise, of enjoyment, or of disgust, to pass over the countenance. Whilst the quality of tastes is early appreciated, the perception of intensities is a later acquirement. It is very noteworthy that both the first movements and the first sensations are connected with the all-important function of nutrition.

The Sense of Smell.—This sense is not present at the time of birth, probably on account of the fact that the liquor amnii has long been in contact with the nasal mucosa; and even although it is probable that the infant can distinguish between agreeable and disagreeable odours a few hours after birth, still the senses of smell and taste are very apt to be confused. It is well known that infants more often carry sweetly smelling things, *e.g.*, a rose, to the mouth than to the nose. Preyer noted in his boy this inability to separate smell and taste at the eighteenth month of life; and even in later life it is not uncommon for these senses to be difficult of clear definition. We sometimes speak of an odour as having the smell of the taste of some fruit, and the tobacco smoker has a difficulty in saying whether he smells or tastes the weed. At any rate, the infant is not possessed of that acute sense of smell which is the heritage of the young of many of the lower animals, although in isolated cases there may be an approach to keenness of smell in the baby. Thus not long ago a lady told me that she felt sure that her little baby girl distinguished persons more by the sense of smell than by any other means. Smell, like taste, may be present on the

first day of life, but the discrimination of degree as well as of quality comes much later.

The Sense of Touch.—The sense of touch, it may safely be concluded, is present from birth onwards, for many of the reflex movements of early infancy are excited by stimulation of the skin; but this sensibility to contact and to temperature is less marked at this time of life than in later infancy. When the delicate nature of the skin of the infant and the complete development of its nerve-end organs are taken into account, it may seem strange that the child does not feel more acutely changes in temperature, and resent more actively any but the most gentle handling. But the explanation of these phenomena is to be found not so much in the nature of the skin as in the comparatively incomplete development of the brain. Such parts of the infant's body as the lips, tongue, and nose, are sensitive to touch, to cold, and to warmth even in the first month of life, but these regions are not so markedly sensitive as in later infancy. Preyer noted sensitiveness of the external auditory canal in the seventh month.

The Sense of Hearing.—It is difficult to say definitely when a baby begins to *hear sounds*. It has always been supposed that he is deaf for the first three or four days of life on account of the presence of mucus in the middle ear, and of the oblique position of the membrana tympani; but it is impossible to deny that he may be able to hear at an earlier date than this, although direct proof is wanting. It is only possible to judge of the effect of auditory impressions by the movements which the child makes, *e.g.* starting, winking the eyes, or screaming, when loud sounds strike the ear; and, as can be imagined, it is often difficult to say whether the sound bears a causal relation to the movement or not. The sense of hearing, which is of such educational importance in later childhood, is, strangely enough, of comparatively little value in the earliest days of life. "Every mother," says Preyer, "loses many thousands of words that she speaks, whispers, or sings to her child, without the child's hearing a single one of them, and she says many thousand words to him before he understands one. But if she did not do it, the child would learn to speak much later and with much more difficulty." This author states also that his infant boy started with fright at the sound of a loud voice at the end of the first month of life, that the sensitiveness increased in the second month, that in the fourth month he turned his head towards noises, such as the

ticking of a watch, and that in the seventh month he directed his gaze towards some one singing and showed joy at the sound of military music. No doubt, however, children differ much in the readiness with which they learn to appreciate sounds and musical notes.

The Sense of Sight.—With regard to the *sense of sight*, it is almost certain that in the first days of life the child is only able vaguely to distinguish light from darkness. Preyer states that his child showed a sensitiveness to light on the first day of life. During the first week of life it has been noted that infants seem to be attracted by bright lights, as those of candles or gas, and the liking for bright and shining things increases with age. Winking the eyes seems to be connected with other sensations than those of sight; fear, surprise, pain, loud sounds, etc., all produce this reflex movement in early life. Fixation of the eyes is not present immediately after birth, but is first seen, according to Darwin, on the ninth day of life; at that time, however, and for five or six weeks afterwards, the attention is only caught, and transiently caught, by bright lights and colours. Co-ordinate movement of the eyeballs, also, is gradually acquired during the first two months of life, when squinting movements cease. It is a noteworthy fact that the colour sense is very late in being developed; yellow and red can be distinguished comparatively early, but such colours as green and blue are not, as a rule, differentiated till the second or third year of life is passed.

Such are, at any rate, the results brought out by Preyer's most elaborate tests, although it must, I think, be admitted that all such experiments at this early time of life may contain fallacies.

If it be true that the primitive races of mankind had no colour sense, and that it has only been acquired since the time of Homer, then it is interesting to note that in the baby is found an indirect proof of this supposition. It is only natural to expect that if the perception of colour is late in appearing in the race, it will also be late in appearing in the individual. It is also of interest in this relation to note that the commonest sense aberration found even in adults is what is known as colour blindness or Daltonism. The whole subject of the colour sense is one which demands greater investigation than has yet been expended upon it.

The accommodation of the eyes for near and far vision is, as might be expected, imperfect at and soon after birth. Preyer found signs of hypermetropia on the twelfth day of life, he noted apparent

accommodation first in the ninth week, and perfect accommodation in the seventh month. As late as the twenty-third month he noted that his child did not appreciate distances perfectly. The sixth month was found to be the earliest date at which the child seemed to interpret objects seen, for at this time he laughed when nodded to by his father. In the seventh month he stared hard at strange faces.

Imitative and Deliberate Movements and the Will.

Such are the conditions of the sense organs, and of the motor apparatus in the young infant; and it now remains for us to study the first signs of intellect, the first manifestation of a rational grouping together of sense perceptions, the first evidence that conceptions are being formed from these perceptions, and the first visible proofs of reason seen in willed and imitative movements. The method in which the first idea is formed in the mind is still an unsolved problem; but it is possible to conceive that the perception of rapidly recurring and slightly varying sense impressions has at any rate something to do with the origin of an idea. Our memory does not go back further than the third year of life as a rule, and no one is able to recall the time when first the glimmer of an idea began to lighten up the darkness of that confused and chaotic medley of perceptions, with their accompanying reflex, automatic, and instinctive movements. Observations upon self, therefore, are impossible, and it is necessary to draw our conclusions from the phenomena which occur in young infants; and when it is borne in mind that many of these phenomena take place independently of mental action, it will be seen that the subject is surrounded by difficulties of a stupendous kind. If it were possible to say exactly at what age the first imitative movement is performed, we should be enabled to give a date for the first manifestation of will. An imitative movement presupposes that the child has perceived many such movements in others, that he has learnt to appreciate similar movements of his own body by the sensations they cause, and that he has formed an image in his mind of what the movement is to be. This is a complicated process, therefore, and is a great advance upon the reflex-movement mechanism. The higher mental centres are now brought into activity. The appearance of these movements marks an important epoch in an infant's life, for it shows that now the child is exercising his will.

The first imitative movements are those of laughing and smiling, of crying with tears (for at first crying is a pure reflex, and is not accompanied by the flow of tears), of the making of gestures with the hands, of pointing with the finger, and of nodding the head. Many other examples might be given, but these are sufficient in order that an idea may be obtained of the kind of movement. With regard to the date of the first appearance of such deliberate, voluntary movements, it has to be remembered that individual children vary very much in this respect, and that, probably, the third month may be taken as roughly indicating the commencement of the epoch of the will. The holding up of the head is considered by Preyer to be the first voluntary movement, and this act, as is well known, occurs at or soon after the third month of life.

But the question may be asked, Has the baby no thoughts prior to the third month? All that can be said in answer to this is that, if the infant has many thoughts or ideas before the third month of life, it is most likely that they are associated with the satisfaction of hunger, with the feeling of the need of sleep, and with the painful impressions of loud sounds, brilliant lights, and rough handling. But after the third month the range of mental vision is vastly widened. To put it into everyday language,—"The baby begins to notice things," he begins to fix his gaze upon people, upon animals, upon brightly coloured and attractive articles, upon parts of his own person, as his arms and legs, and upon the hundred and one other things to be found in the nursery. He begins to try experiments in natural philosophy, he learns to measure distances with his eye, he appreciates the difference between hard things and soft, and he plunges into the mysteries of equilibrium and the law of gravity. He begins, also, to distinguish between auditory impressions; he likes to hear his mother singing gently over his cradle; he objects to being shouted at or spoken to loudly or crossly. Taste and smell are senses through which he begins to become more fully acquainted with the possibilities of the artificial preparation of viands with appetizing tastes and odours. It would be impossible to enumerate one-half of the baby's acquirements in the first year of life; and as the year is ending, a still greater advance is rendered possible by the acquisition of the powers of language and of locomotion.

Moral and Mental Hygiene in Infancy.

From what has been said of the motor, sensory, and mental phenomena in infancy, some idea will have already been gained concerning the hygienic rules of moral and mental training at this time of life; but for a more thorough knowledge of this subject it is necessary also to consider the very large question of the influence of feelings, sentiments, and intellectual tendencies in the developing of the infant mind. The nervous phenomena have been studied; but the way in which the phenomena are influenced and moulded by such feelings as fear, anger, and love, and by such tendencies as credulity, curiosity, and imitation, still calls for some notice. It requires very little consideration, and a very small amount of observation, to make it evident that the development of the intellectual powers is greatly influenced by the feelings and tendencies above mentioned, and it is also not difficult to observe that the most potent feelings and tendencies in early life do not altogether correspond with those whose influence is greatest in later life. Thus in infancy, fear, astonishment, credulity, and curiosity are important factors in the unfolding of the mental powers and in the acquisition of knowledge, whilst in later life other tendencies, such as ambition, love, suspicion, and the like, are the more prominent in the shaping of the intellectual life. It should be noted that the feelings and tendencies of early life are closely allied to, and in some cases exactly correspond to those seen in savage tribes now, and to those which were undoubtedly present in the early races of mankind in former times. Children prefer to hear about the somewhat rough and tumble boisterous times of the Judges in Israel, and they are delighted with the old ballads of stirring times on sea and land which have been handed down from the days when the world was young.

A few words may be now said with regard to some of those factors which educate or lead out the intelligence in young children.

Fear in Infancy.—Fear is a very potent means of teaching a child, and it is usually through fear that children learn to inhibit or stop certain actions or movements. How difficult it is for us to make a child sit still! he is constantly moving about; when his legs and arms are quiet his tongue is busily engaged asking questions, and when he is for a minute silent his hands are pretty

sure to be engaged either in lawful, or, alas! more often in unlawful pursuits. How few there are who can control a child's restlessness save by threats! I do not mean to infer that the restlessness should be put a stop to, for it is a healthful sign of the overflowing vitality of child life, I only wish to point out that few persons can control it save by making the child afraid. The baby is full of fears—a strange face causes him to start back or to burst into tears; but more than all other causes of fear are those which act through the ear. Sudden or loud noises, or simply uncommon sounds, are quite sufficient to terrify young children. The auditory more than the visual impressions convey the sense of terror to the infant mind. It is customary to jump a baby up and down in the air when he is troublesome, quiet often ensues, but I cannot help thinking that it is the stillness of fear, not of satisfaction and enjoyment. Fear is a powerful and useful means of training a child when it is exercised by an experienced hand, but it is a most dangerous weapon when wielded by an ignorant person.

It is necessary, however, that fear should be used, but used with caution, as a means of training infants. Obedience is the first lesson a child ought to learn, and although theoretically the best way of teaching obedience may be by reasoning in love with the child, that is a means which it is difficult to employ, for he does not possess the power of reasoning at the early age when it is necessary for his training to begin. A child must be made to fear the consequences of disobedience. The dread of bringing a sad look to their mother's face may be sufficient to deter some children from doing wrong: other children will require stronger measures and sterner means.

Anger in Infancy.—Anger is another emotion which is very prominent in early life, and in this character, as in that of fear, the child resembles the less civilized races of mankind. Anger to a certain extent is permissible: a baby has no other way of showing his need of food, his want of sleep, or his dislike to the existing state of affairs. Surely it is only natural that a baby should be cross when it is remembered how foolishly he is often treated.

The following quotation, taken from an American paper, is not perhaps scientific in form; but it contains so much that is true of infant life, that I cannot refrain from quoting it here:—

"Tommy Cute, aged one, having suffered as long as he can stand it, writes to us, in order that his grievances being known to the public, they may immediately be cured.

"I object, he says, in the first place, to being forced to adopt Farmer Jones's brindle cow for a foster mother.

"I object also to the existence of a like relationship between myself and the condensed milk factory or the corn-starch mill.

"I object to personating a churn. I prefer to take my butter after the churning process is completed.

"I object to being obliged to go about with my neck and arms bare. When it is hot the flies and mosquitoes bother me, and when the air is chilly I feel as though I were freezing to death.

"I object to having strangers make faces at me. They give me an awful start sometimes when they think they are amusing me.

"I object to being the only child in the family. It's awfully lonesome not to have any brothers or sisters. I wish I had been born when it was fashionable to have large families.

"I object to being taught baby talk. What good does it do me? After I have become proficient in it I have to go to work and unlearn it, and learn grown folks' language. Why don't they teach me that in the first place?

"I object to having folks bore me with their silly stories which I have heard so many times that they are veritable chestnuts.

"I object to having people try to humbug me all the time. They tell me what I should do and what I should not do. I notice they are not given to taking their own medicine. What dunces they are not to know I learn more from what I see than from what they tell me!

"There's a lot of other things to which I object, but this will do for a starter."—*Boston Transcript.*

Whilst anger is a safeguard to the baby in many instances, protecting him from wrongs varying in magnitude from the persistent pricking of a pin to the annoyance of a sunbeam resting on his face when he wishes to sleep, it has also its dangers. Frequent and violent attacks of rage interfere with both the moral and the physical development of the child, and may even cause convulsions and other nervous diseases. In the case of badly trained children, anger is no longer a physiological factor in life and development, it is a symptom of a pathological condition. I know some families in which the baby is the master of the whole situation, an autocratic ruler in his little kingdom, a despot whose power is feared by father, mother, grandparents, and nurse alike, and for whom a dose of wholesome neglect three times a day would be the best homage his subjects could yield to him.

Love and Jealousy in Infancy.—Love, affection, or sympathy is another sentiment which is present in early life, and which has some influence in shaping intellectual development. The affection shown by young children is rather a general sympathy with all things than a special love for human beings. At the risk of

offending mothers, it must be said that infants apparently have as much affection for and sympathy with inanimate objects, as toys and dolls, and with animals, as they have love for their brothers, sisters, and other relations. In fact, another sentiment, jealousy, is a very powerful one in adjusting the relationship between very young children—yes, and between children also who are not very young. Last year's baby is invariably jealous of this year's arrival, and so in turn will this year's baby be jealous of next year's. Jealousy, further, is a fertile cause of anger in young children, and everyone must be able to call to mind many instances of scenes in the nursery which had their origin in the struggle for the possession of a favourite toy, picture-book, or animal pet. It is in such directions that we must carefully watch the development of the infant mind, endeavouring as far as in us lies to supplant the passion of jealousy by the nobler sentiment of love and self-sacrifice. The sacrifice of self is the highest development of human life and thought, and there seems to me to be little cause for wonder that children possess this sentiment so little when grown-up people are also so sadly lacking in this respect. "Train up a child in the way you should have gone yourself," says Mr Spurgeon, and there can be little doubt that if self-sacrificing love were a more frequent adornment of the home circle amongst the elders, it would also make its way into and take a firm hold of the group of little ones in the nursery.

Wonder and Curiosity in Infancy.—Wonder or astonishment, and curiosity, are powerful educative tendencies in infant life. In the earliest days the baby carries everything to his mouth; he is probably curious to find out whether it tastes pleasantly or not. Later on, children handle everything within their reach, from the simple wooden toys of the nursery to the expensive chronometer of the father. "Helen's babies" were anxious to find out how the wheels of the watch go round, and that is the keynote of the greater part of intellectual progress in young children. Preyer's son at the tenth month of life performed the following experiment,—he rapped with his spoon upon a plate, then struck his finger against the plate, was evidently full of wonder at the difference in sound, performed the experiment over again, reversed the procedure, and was evidently engaged in an attempt to master the idea of cause and effect. Many less astonishing experiences could, no doubt, be furnished by every mother, and very little reflection is necessary in order to compre-

hend of what value the sentiment of wonder is in the education of the little ones. A lady writer says very truly and beautifully, "The element of wonder, of which Carlyle says so much, is not sufficiently recognised in the education of the very young. We live in the true wonder world. No land of the imagination can equal it. The lives of children might be filled with delight by sympathy and companionship in this miracle play in which we are the daily actors. But, no; we put on glasses that blur the whole into commonplace; and when the little ones, fresh from God, see and hear, and come to us fresh with the story, we smile or frown, and call 'litter' that which God has raised from the dead and clothed with marvellous and unfathomable beauty. Through their spontaneous wonder and nature love, children may be led by easy paths into the marvellous realm of cause."

Credulity in Infants.—One of the most characteristic features of mental activity in the young is the credulity or trustfulness shown in the acquisition of information. Young children believe all that is told them; they accept without a word of doubt those fairy tales and legends which almost form part of the nursery curriculum of study, and, what is more important still, they grasp no meaning other than the literal in what they hear. A glance through the volumes of *Punch* and the other comic journals reveals the striking fact, that a very large proportion of the jokes are founded upon awkward remarks made by children in consequence of their literal acceptance of statements made to them by parents or friends. Thus Tommy says to Mr Brown, "Are you not a good swimmer, Mr Brown?" "Oh, yes, I can swim," says Mr Brown; "why do you ask?" "Oh, pa said you couldn't long hold your head above water," was the reply. It would not be difficult to give many examples of such unfortunate remarks as the above; but a protest ought to be lodged against the laying of any censure upon the child for making such statements. The child is not to blame for reading the plain meaning and not the double meaning of any remark that is made, it is rather the custom of using expressions with double meanings that should be censured. Great caution should always be employed in answering children's questions. It is often most trying and difficult to satisfy children when they ask for information, but the best rule undoubtedly is to answer each query once for all, fully and rationally, and in simple language; and thereafter, should the query be repeated, simply to recall to the child's memory the fact that the

question has already been asked and answered. We cannot be too careful to guard this trustfulness of the child's disposition; only too soon does he show signs of departing from the truth, and of screening himself from blame or punishment by mendacity. Engagements with children ought to be rigidly kept, and the utmost truthfulness ought to be preserved in all dealings with them. As has already been said, children are born imitators, and too often they seem to learn more easily our bad qualities than our good ones.

There is one other feature which is specially characteristic of the mental life of the young, and that is perversity; but whilst children often display this disposition most provokingly, it must not be inferred that there is, of necessity, an evil principle underlying the perversity. Children always find it more easy to obey a positive than a negative command, they will more readily do something than refrain from doing any act at the desire of others. The training of infants ought to be conducted on such lines as recognise this peculiarity in their character. If it be desired that a child sit quietly, he will more readily do so if he be asked to occupy himself in some way or other, than if he be simply commanded to sit still and do nothing. The recognition of this principle will much reduce the amount of perversity seen in the lives of little children.

Intellectual Processes in Infancy.

Such are some of the many influences which are naturally brought to bear upon the intellectual life of the young; and, thus influenced, the intellect expands until the complicated processes of attention, memory, association, comparison, imagination, reason, generalization, and judgment, are found in their fully developed state in adult life. It is easy to see how the character may be affected by the predominance of any one tendency over the others, and the most healthy mental life is that in which there is a due admixture of all the influences. Development to be natural must not be one sided, but many sided. In some cases the imagination may be found powerful, in others the reason, in others the power of generalization, and it may be said of all these cases that they are the result of an unequal drawing out or educating of the mental faculties. As might be expected, many mental processes are but imperfectly performed in early life; for example, in the case of generalization, young chil-

dren are very hasty in drawing conclusions from insufficient data and from superficial resemblances. One little girl was very fond of the song called "Mary had a little lamb," and often sang it; but conceive her mother's amazement, when one day she declared that she had heard two new lamb songs,—one was, "There is a happy *lamb*, far, far away," and the other was, "There is a *lamb* that is fairer than day." There are also signs of hasty generalization in the remark of the little boy, which was to this effect—"I saw a man making a horse, he was just finishing, he was nailing on the last foot."

A little natural philosopher of five years of age gave one day the following evidence of his somewhat primitive reasoning powers:—"Mamma," he said to his mother who was giving him a bath, "be sure and wipe me dry, so I won't rust." The faculty of association is a powerful one in children. A little boy brought up in a very earnest family was taught to ask God to bless his papa and mamma, and all those friends who were so fond of him; but one day his nurse was telling him about the cow that gives us milk, and butter, and cheese, and the little one put his hands together and uttered his first spontaneous prayer, "God bless cow."

The association of ideas is seen in many acts in the everyday life of little children. Putting on coats and hats suggests to them going out of doors, the ringing of the dinner bell is soon recognised as an indication of meal times, and the changing expressions on the mother's face are associated by the children with their own good or bad behaviour.

Another most interesting phenomenon is that termed by Froebel "the physical finding of self." To the question, When does a child become conscious of his own personality? no clear answer can be given. Most probably self-consciousness has a gradual dawn, the child recognising first his hands and arms, then his legs and body, and this chiefly through the muscular sense; but, perhaps, occasionally the awakening of the idea of self is sudden, as when a little child catches a glance of himself in a mirror, and recognises that he is looking at himself and at no other. Self-consciousness and retentive memory both originate, in all probability, during the third year of life—exceptionally they may arise during the second year. In connexion with this question it is interesting to note that children for a long time speak of themselves in the third person and not in the first. Binet (*Rev. Philosophique*, Dec. 1890) has pointed out

also that the ideas of young children upon all objects are utilitarian, for they look upon a knife, for example, only as a thing to cut with.

Moral and Mental Training.

Many of the rules for the moral and mental training of infants have been incidentally mentioned in the discussion of the factors which mould the disposition and the intelligence in early life; but it may be well here to gather together some of the most important of these laws.

If properly reared mentally and morally, children are the brightest and most lovable of creatures; but if brought up on erroneous principles, they become veritable despots and autocrats in the family circle. Spoiled children form a sad spectacle, and are a source of distress not only to their parents but to all with whom they come in contact. It ought to be recognised that it is as wrong to spoil a child morally and mentally as it is to let a baby catch cold, or to permit an infant to eat food unsuitable for or dangerous to bodily health. In the hands of the parents of this generation and of their medical advisers lies, to a very large extent, the power of shaping that unknown future of happiness or misery which is the heritage of every little child born into this world.

The great maxim in the mental and moral training of children is that they learn far more from what they see than from what they hear. One must practise what one preaches if one would influence successfully a child. One of the deepest thinkers and wisest men* says, when speaking of the education of a child:—"At six months old it can answer smile with smile, and impatience with impatience. It can observe, enjoy, and suffer acutely, and in a measure intelligently. Do you suppose it makes no difference to it that the order of the house is perfect and quiet, the faces of its father and mother full of peace, their soft voices familiar to its ear, and even those of strangers loving; or that it is tossed from arm to arm, among hard, or reckless, or vain-minded persons, in the gloom of a vicious household, or the confusion of a gay one? The moral disposition is, I doubt not, greatly determined in those first speechless years."

The mental and moral food supplied to children is often as inappropriate and even as dangerous as the eatables with which unthinking parents fill their stomachs. Someone has said the

* Ruskin.

education of a child begins twenty years before its birth, in the education of its father and mother; and it is too true that the ignorance of parents often most unhappily mars the early training of their offspring. One great and fundamental fact with regard to children and their education is this: children are not simply men and women in miniature, not simply little men and women, they are also undeveloped men and women, and their training to be natural must take place along developmental lines. For example, the sentiments which influence mental and moral development in the young differ from those which are potent in later life. Fear, anger, jealousy, curiosity, wonder, and trustfulness are all most important factors in the evolution of child intelligence. In older people, other sentiments, as ambition, love, and the like, come into play in the shaping of mental activity. The curiosity of children is proverbial. They wish to get at the root of every matter; they are continually asking questions; and they are not satisfied with superficial or partial answers. It is a great mistake to refuse to answer children's questions. When a question is asked, answer it fully and once for all; if the question be repeated at any future time, then allow the child himself to recall the answer. In this way children are prevented from falling into the bad habit of asking simply for asking's sake. Children exhibit curiosity in other ways than by asking questions; they are constantly making experiments in natural philosophy; in the early days they are training themselves in the measurement of heights and distances, and in the mysteries of the laws of gravity and of equilibrium. The experiments may result in bruised heads and knees, but the child learns more by these experiences than by any other methods. It is a dangerous thing to check a child's curiosity; it is a wise thing to direct it into useful channels. Complicated toys are mistakes, the endeavour to understand them tires the infant brain. On the other hand, simple toys, especially those which illustrate some of Nature's great laws, are educative factors almost without their equal in early life.

Children are naturally extremely trusting; they believe all that is told them, and it is dangerous in the extreme to cheat or mislead them. Not only do wrong statements take a deep hold of infants' minds, but, what is much worse, the natural trustfulness of the child is gone. This trustfulness extends into all their mental processes; it is a fact of everyday occurrence that children understand

statements literally, that they grasp only the evident meaning. Children know nothing about double meanings.

The punishment of infants for faults committed is a necessary element in their training; but it is essential that the parents make themselves absolutely certain that the children have done wrong before they administer chastisement, otherwise they place a premium upon lying. An unmerited punishment rankles deeply in the infant mind.

In the education of young children it is a mistake to commence learning by rote at too early a period. The education in the nursery is many-sided—the child learns by means of sight, hearing, touch, and taste, and through these sense avenues he gathers together an enormous amount of information in the first years of life. The education in the school is one-sided—there is too much learning by rote, too much exercise of the memory; it would be better if the scholastic training were more truly a continuation of the nursery education. There is a grave risk that the information gained in the school is of a superficial character and is not properly understood by the child. It would be much better, for example, if geography were taught by means of numerous models of rivers, lakes, and mountains, than simply by the learning of long lists of names of places, and seas, and hills from the text-books. It ought never to be forgotten that mental processes, memory amongst others, are but imperfectly developed in children, and that to force them is to injure the healthy evolution of the brain. It is necessary to bend, but never to break, the twig that is to grow into a stately, upright tree.

"'Tis education makes the human mind;
Just as the twig is bent, the tree's inclined."

Diagnosis of Nervous Disorders in Infancy.

The diagnosis of nervous maladies in the infant is surrounded by difficulties, some of which are absent in the case of the adult. For example, many of the means employed in the diagnosis of diseases of the nervous system in the adult require the intelligent co-operation of the patient; such methods are inapplicable in the infant, who cannot reason, or who, through fear, gives no answer to the questions of the medical man. The dynamometer and the æsthesiometer are, therefore, in the infant of little or no use in the detection of motor and sensory disturbances. Further, the estima-

tion of the existence and degree of pain is always a most difficult matter to determine during the first years of life. At the same time, in the presence of disease of the nervous system in infancy, the medical man ought to employ all the diagnostic methods at his disposal for the elucidation of the signs and symptoms of the malady. The use of the electrical current, for example, has of late years thrown a flood of light upon the nature of many of the paralytic affections of infancy; and it is now known that paralysis in early life is not always spinal in origin, but that there are also many cases in which it is truly cerebral (the so-called birth palsies).

Amongst the means of diagnosis at command, the medical man must not omit the examination of the head and spinal column. The anatomical peculiarities of the cranium render possible a more thorough clinical investigation of this part of the body in infancy than in later life, and this fact may be by the physician turned to good account. Reference has been made to this subject in an earlier part of this work (pages 43–48 and 60–61), and the subject does not require to be further treated here.

Motor derangements are common in infancy, for besides the well-known "infantile paralysis" (poliomyelitis anterior acuta), there are also the "cerebral palsies," due in most instances to injury of the head during labour. It is difficult to estimate the degree of paralysis present in infancy, for, from pain or some other cause, young children not infrequently allow a limb to hang apparently helpless, although there may be neither paresis nor paralysis. In investigating such cases electricity is of the greatest value. The "reaction of degeneration" present in infantile paralysis is a most important diagnostic and prognostic aid; and in other diseases there are also changes in the normal electrical reactions which must not be overlooked by the physician. Instead of paralytic phenomena, however, there may be present an increased degree of muscular contraction, and this may show itself in the appearance of clonic or tetanic contractions, fibrillary twitchings and tremors, or of contracture. The frequency of convulsions in early life has been already noted, and during the last few years much has been done in the investigation of the pathogenesis of spastic paraplegia and of bilateral spastic hemiplegia in the infant. In all such diseases the medical man ought thoroughly to test the reflexes—both the tendon and the organic reflexes—using the same means as those employed in the adult. The condition of the patellar tendon reflex or knee-jerk may, for example, be ascer-

tained by tapping the tendon just below the patella with the finger or with the ear-piece of a stethoscope. The co-ordination of the muscular movements ought also to be inquired into; but, as may be expected from a study of the physiology of the motor phenomena of infancy, it is very difficult to draw from the condition of co-ordination much information as to nervous disease in early life. It is also almost impossible to test satisfactorily the muscular sense in infants.

As has been already stated, the most unsatisfactory part of the examination of the nervous system in the infant is that which relates to the SENSORY PHENOMENA. Infants cannot express in words such sensations as numbness, tingling, formication, and the like; and the estimation of the presence of pain or of hyperæsthesia is surrounded by many difficulties. Neuralgia is probably hardly ever met with in early infancy, and whilst the existence of headache may be put beyond question by the behaviour of the young child, no doubt many such sensory disturbances pass undetected. As has been said, it is almost impossible to learn anything of the tactile sensibility by the æsthesiometer; and the testing of the sensibility to temperature by means of hot and cold test-tubes is surrounded by so many possible fallacies as to render this diagnostic method of little or no importance in infancy.

The condition of the sense-organs, such as the eye and ear, is often a very important guide in early life; but here again many difficulties beset the physician, for it is a matter of some trouble to determine, even approximately, the acuteness of vision or of hearing in early infancy. Nevertheless the ophthalmoscope and the aural speculum may be put to good use by the pediatrist in the detection of disease. Speech irregularities also may throw light upon some obscure nervous phenomena at this time of life.

Trophic changes and vaso-motor phenomena may be noted in infancy as in adult life, and they may yield to the medical attendant information of very considerable importance in the formation of a diagnosis.

One of the most difficult problems which pathology presents to the physician for solution is that relating to disorders of the intellectual faculties in early life. It seems more than probable that all the forms of insanity which occur in the adult may be found also in the infant; but idiocy and imbecility are the varieties of mental disorder most commonly investigated in the young child. Pavor

nocturnus or "night terrors" is a form of mental aberration which is almost peculiar to the infant, and which few physicians do not meet with at some time or other, if their practice lie much amongst children. In the present state of our knowledge, it is most difficult to draw the line between pathological and purely physiological mental and intellectual processes in early life. No doubt also many of the cases of so-called "moral depravity" in young children are simply the result of bad training and ill-advised punishments.

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