MANUAL OF

MEDICAL JURISPRUDENCE

TOXICOLOGY

AND

PUBLIC HEALTH

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OF
MEDICAL JURISPRUDENCE TOXICOLOGY
AND
PUBLIC HEALTH

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PREFACE.

This small manual on Medical Jurisprudence, Toxicology, and Public Health has been written for the use of students who are studying for examination in these subjects. My endeavour has been to include all that the average student may be expected to know; the volume has no pretensions to compete with the many large and excellent text-books on these subjects, which are, however, as a rule, used only for reference by the practitioner and lawyer.

I have to express sincere thanks to my friend, Dr. Thomas Proudfoot, B.Sc., F.R.C.P.E., for his kindness in reading the proofs, and for much valuable assistance; and also to my publisher, who has spared neither time nor expense in endeavouring to make the volume attractive, and as free from errors as possible.

To Messrs. W. B. Saunders Company thanks are due for permission to use figs. 6, 11, 12, and 13, which have been taken from Hofmann's *Atlas of Legal Medicine*; to the Septic Tank Co., London, for drawings of figs. 35 and 36, and to Robert Morham, Esq., for the plan of Colinton Mains Isolation Hospital.

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Surgeons' Hall, Edinburgh,
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MANUAL OF MEDICAL JURISPRUDENCE, TOXICOLOGY, AND PUBLIC HEALTH.

SECTION I.

MEDICAL JURISPRUDENCE.

CHAPTER I.

CRIMINAL PROCEDURE.

The legal procedure in criminal cases differs somewhat in Scotland from the procedure in England and Ireland.

SCOTLAND.

The Public Prosecutors or Crown Counsel consist of the Lord Advocate, the Solicitor General for Scotland, and 4 other advocates-depute who are appointed by the Lord Advocate. These officials conduct the prosecution of the prisoner on behalf of the Crown before the High Courts of Justiciary.

In each county there is a legal official known as the **Procurator Fiscal** who takes the initiative in the prosecution

evident, and which has been brought under his notice either by the police, by the parish officer, medical practitioner, or registrar. One or more Coroners are appointed for each county, and one to every borough with above 10,000 inhabitants. Very often he is a lawyer or medical man; if not, then the official so appointed should have some legal as well as medical knowledge. He is appointed for life, and his duties are defined by the Coroners Act 1887, 50 and 51 Vict. chap. 71.

If the Coroner thinks the case sufficiently grave, he summons a jury of 12 men at least, who are sworn and charged by him, and before whom the case is investigated and evidence led. If there be any person on whom suspicion rests, or who may even be accused, he need not necessarily be present. This inquiry is known as the **Coroner's Inquest**, and is held to determine whether the deceased has died from natural causes or not. Before hearing the evidence both Coroner and jury must "view the body"—a proceeding often greatly resented by the jurymen, especially when the corpse is much decomposed.

Witnesses are cited to appear, and are examined before the Coroner and jury on oath. The evidence of each witness is written down, and forms the *deposition*.

Having heard the case, the jury then bring in a verdict as to whether death has taken place from natural causes or not. If the inquest or recorded verdict charges any person or persons with murder or manslaughter, the Coroner then issues a warrant for their arrest. They are committed to prison, or in cases of manslaughter bail may be taken for their appearance at the Assizes.

In most inquests, a medical man is summoned to attend and to give evidence. The fee paid for this attendance is usually £1 : 1s. The Coroner may request the medical man to make a post-mortem examination of the body to determine the cause of death, and he may even require him to make a chemical analysis of the contents of the stomach and bowels. The sum paid for making an autopsy is £2 : 2s. If the medical man is unable to conduct the chemical analysis, he should intimate this fact at once, so that the contents and tissues may be transmitted to an expert named by the Home Secretary for analysis. Should the medical man disobey the summons of the Coroner to attend the inquest, he renders himself liable to a fine not exceeding £5. If a majority of

the jury are dissatisfied with the medical evidence they may request the Coroner in writing to appoint some other medical man to make a second post-mortem examination.

The medical man should be very careful in giving evidence before a Coroner or magistrate. Even though the surroundings be little in harmony with a judicial inquiry, these are, by the law of England, Courts of Justice. Often the inquest is held in the public room of an inn or public-house, or in a stable or coach-house, and the jury are often uneducated men. If the case goes on to trial, this evidence will be handed to the judge, and to the counsel both for and against the prisoner. Any misstatements or discrepancies in the evidence then given will be carefully inquired into, and a bad impression is always left on the minds of judge and jury when former evidence has to be explained, qualified, or even retracted. If the medical witness has any doubt that the answers given may not exactly convey the meaning intended, he should ask that his evidence be read over to him. He has then the opportunity of correcting any errors before signing it as being true.

Coroners' Inquests are held in cases of sudden or violent death, where the cause of death is not very clear; in cases of assault, where death has taken place immediately or some time afterwards; in cases of homicide; in cases where the medical attendant refuses to give a certificate of death because he is not satisfied as to its cause, or if he is suspicious as to its cause; in cases where the deceased's attendants have been culpably negligent, as, for example, where a newly born infant has been taken a long journey on a winter's day, and has succumbed in consequence of the cold and exposure; or in cases where no return as to the cause of death is made to the registrar after a sudden or brief illness.

Witnesses who have given evidence at the Coroner's Inquest are bound over to appear at the trial before the Superior Court. Dickens gives a good description of a Coroner's Inquest in *The Uncommercial Traveller*.

It is notorious that great discredit is frequently thrown on the findings of the Coroner's Court. This is due to the fact that the verdict is given by a body of men who are often drawn from the illiterate class. Even in spite of medical evidence, and the directions of the Coroner, the jury may return a verdict quite opposed to the evidence. It is the rule for the jury to "view the body" before proceeding with the evidence, but this is a

mere formality in most cases, and to save the expense of £2 : 2s., a medical examination of the body is only too often omitted. Grave miscarriages of justice may arise from these causes. Thus, a verdict after an inquiry lasting two days was returned that an individual had died from disease of the heart. Just before the burial it was found that the body was covered with bruises, and that grave injury had been inflicted on the thigh. The case was proved to have been one of manslaughter, and the guilty person was tried and convicted.

In minor assault cases, the accused may be summarily dealt with in the **Magistrates' Court of Petty Sessions.** A medical man may be cited or subpœnaed to appear in this Court to give evidence, and must attend, the fee allowed being 10s. 6d. for each day. In graver cases the accused is remitted for trial at a Superior Court.

Quarter Sessions.—This is a Court held once every quarter to deal with offences committed in the county or borough. It consists of an assemblage of county gentlemen, who sit as justices of the peace. Many difficult and intricate cases come before such a Court, and often grave miscarriages of justice arise from the fact that the assembly consists of men who are not well versed in legal matters. This Court may award heavy punishments up to penal servitude for life. In Borough Quarter Sessions the sole judge is a barrister, and is known as the "recorder."

From the Magistrates' Court or Coroner's Inquisition the accused may be remitted to the **Criminal Assize Court.** These Assize Courts are held twice, or, in exceptional circumstances, three times a year in the principal towns of the kingdom. There are seven circuits in England, 2 judges being appointed to each to try civil and criminal cases. For London and Middlesex, the Central Criminal Court provides for the continuous administration of criminal justice.

Before being tried by the judge and jury, the cases sent up from the Lower Courts undergo a preliminary investigation by the **Grand Jury.** This consists of not less than 12 nor more than 23 responsible gentlemen who have been summoned by the Sheriff of the county to consider the indictments to be preferred at Assizes, Quarter Sessions, or at the Central Criminal Court.

The Grand Jury hear certain evidence for the prosecution, but counsel are not heard. Having been charged by the judge,

the jury, if satisfied, bring in a "true bill" and the case is then sent on for open trial at the Court of Assize.

If, on the other hand, the jury is not satisfied with the evidence for the prosecution they "ignore" the indictment, and the foreman writes on it "no true bill."

Medical men may be summoned before the Grand Jury and may be requested on oath to make a general statement as to the case.

The final trial takes place before the **Crown Court of Assize,** which is the Highest Court of Justice in criminal matters. The prisoner is here tried before the judge or judges and 12 petty jurymen who take the following oath: "You shall well and truly try, and true deliverance make, between our Sovereign Lord the King and the prisoner at the bar, whom you shall have in charge, and a true verdict give according to the evidence, so help you God." Witnesses who have been served personally with a subpœna must attend, and are examined on oath, but barristers alone conduct the cases.

The jury must be unanimous in bringing in their verdict of "guilty" or "not guilty"; if they are not unanimous, they are sent back to reconsider their verdict. Should they not agree, they are discharged, and the case has to be retried before a new jury.

The punishment is awarded by the judge.

The professional witness is paid £1 : 1s. per day for each case if he reside within 3 miles, and £2 : 2s. if beyond this distance and in addition third class railway fare. (First class is allowed in Scotland.)

By the Act of 1907 criminals have the right of applying to the Court of Criminal Appeal within ten days of conviction.

PROCEDURE IN TRIALS.

The order of proceeding at a trial is as follows: The jury having been sworn and the indictment read, the prisoner is asked if he plead "guilty" or "not guilty." If the latter, the prosecuting Crown Counsel begins the case, and examines the witnesses for the prosecution.

This is known as (1) **The Examination-in-chief,** and is conducted to determine whether the evidence of each witness as given corresponds with the previous deposition or precognition, a copy of which he holds in his hand. The Crown Prosecutor

asks no leading questions, or questions which suggest their own answer.

(2) **The Cross-examination** of each witness follows this, and is conducted by the counsel for the prisoner (who is called the "panel"). It is customary to ask leading questions so as to bring out answers favourable to the prisoner, and has for its object the lessening of the value of the evidence first given against the prisoner. This is the most trying ordeal which the witness has to undergo. All exaggerations are brought down to their proper level. Questions may be put to the witness as to his moral character with the object of injuring his evidence; his accuracy and truthfulness may also be inquired into. The judge, however, often prevents counsel putting vexatious or irrelevant questions. The medical witness may be asked his qualifications, age, experience, number of similar cases he has seen and treated, and so forth. As he cannot enter into argument with the examiner, the latter often appears to have cornered the witness, and he will take care to impress the jury with the small value of the medical evidence.

(3) **The Re-examination** of each witness may be conducted by the Crown Counsel in order to settle any dubious points which may have arisen during the preceding examinations. No new matter may be introduced, as it would require cross-examination.

(4) The judge or jurymen may also put questions to the witnesses.

The witnesses for the prosecution having been examined, the prisoner's counsel calls his witnesses, who are cross-examined and re-examined. He then makes a speech defending the accused, sums up the evidence, and addresses the jury. This speech is followed by the Crown Prosecutor summing up the evidence against the prisoner. In Scotland, the prisoner's counsel has the last word. Finally, the judge sums up the case and directs the jury clearly as to the question they have to decide.

CHAPTER II.

MEDICAL EVIDENCE.

MEDICAL men may be required to give evidence—

(1) In Police Courts.

(2) In Magistrates' Courts.

(3) At the Coroner's Court.

(4) At Quarter Sessions and Assize Courts or High Court of Justiciary.

(5) In Civil Courts or in County Courts in actions for damages due to negligence or in claims under the Workmen's Compensation or Employers' Liability Acts, or in connection with lunacy cases.

(6) In Scotland also before the Sheriff in connection with the Fatal Accident Inquiries Act 1895, and the Fatal Accident and Sudden Deaths Inquiry Act 1906.

Evidence may be required of medical men as follows :—

(I.) Documentary Evidence. (*a*) Formal Written Reports; (*b*) Written Opinions; (*c*) Certificates.

(II.) Oral or Parole Evidence. (*a*) Ordinary Evidence; (*b*) as an Expert or Skilled Witness.

(III.) Experimental or Real Evidence. (*a*) Identification of the Living; (*b*) Identification of the Dead.

I. DOCUMENTARY EVIDENCE.

(*a*) **Formal Written Reports.**—These are given in answer to a demand made by the Public Prosecutor, and, as a rule, consist of a detailed statement of the facts which one has, as a medical man, observed for himself. For example, it may be a narration of the sequence of symptoms during an illness. In such reports "hearsay" or second-hand evidence is inad-

missible. The reporter must have observed every fact which he has stated.

Very often the report is given on demand of the Coroner. It may be a detailed description of the post-mortem examination, and will be read at the formal inquest. In drawing up such reports, the following points should be observed. It should be made as brief and succinct as is consistent with perfect lucidity. No unnecessary statements should be made, and the facts observed should be noted in their proper sequence, in order that a connected narrative may be presented. Great care should be taken to have all names, dates, numbers, etc., verified. It is better to write figures out in full lest there be any mistake by reason of indistinct caligraphy. There should be a careful and discreet use of all adjectives as such may convey a different impression to counsel and jury than they would to medical men. Thus, in one report where the gall-bladder was described as "enormously distended" a juryman believed that it must at least have been the size of a football. Give measurements of such divergences from the normal, and contrast these with the usual dimensions so that counsel and jury may form an adequate idea of the abnormal conditions. Every technical, medical, or surgical term must be avoided. Such a description as the following which was given would convey but little information either to judge or jury: "A penetrating wound 2 mm. in length was found 2 inches from the left parasternal line in the inframammary region. It passed through the parietal pleura, and involved the pericardium, cardiac muscle, and endocardium of the left ventricle." This should have been the statement: "A small wound was present on the left side of the chest and situated over the heart 2 inches to the left of the breast bone and below the left nipple. This wound passed through the chest wall, and penetrated into the left cavity of the heart." No deductions from personal observations should be reported, but simply observations. If the medical man narrates his own impressions they may be quite wrong. In one case a medical reporter stated that "there were distinct evidences of a severe struggle having taken place, as shown by the fact that the table was overturned and that three chairs were upset, two of the latter had a leg broken and the back of the third had been wrenched off." Further evidence showed, however, that no struggle had taken place, but that a man under the influence of alcohol had smashed up the furniture in the

way described. In another case the reporter deduced that a brutal assault had been committed because a poker was found bent. In reality the poker had been bent in an endeavour to open a box some weeks previously. The report should be free from all such comments. If there are any articles which require description, state how they came into your possession. In conclusion it may be necessary to make deductions from the facts which have been narrated, but these are not always either necessary or desirable.

Having carefully read the report over, it must be signed with name, qualifications, date, and address. A duplicate copy should always be kept before sending the report to the Public Prosecutor. It should be forwarded within two days.

The defence may request a copy of this report, and their demand cannot be refused, but the prosecution alone has access to the precognition or deposition.

When the medical man who has made such a report is placed in the witness-box, he then swears to the truth of the report which he has made.

(*b*) **Written Opinions.** — These are usually confidential opinions given for the guidance of lawyers or counsel in civil cases. Such are of course private and are not read in Court. Often a barrister or advocate requires special information which can only be obtained from a medical or surgical expert, and hence he may ask for such a written opinion. It may also help him in framing questions to put to the witnesses.

Adequate remuneration for such reports must of course be demanded, as they are chiefly used in civil cases.

(*c*) **Certificates.**—The more formal certificates, which may be granted only by medical men whose names are on the Register, are really in effect sworn declarations. The certifier grants them on "soul and conscience," and hence the obligation of granting such should not be undertaken lightly. The nature of the affection should be stated.

Such certificates are given in the medical certification of lunatics; to exempt a man from serving on a jury or as a witness if he is ill, or in such a nervous condition that he could not give his proper attention to the trial. If an accused person be on bail, and unable to attend Court, he must transmit such a certificate.

The medical man granting the certificate may be cited to

appear in Court, and may be questioned as to the condition of the person certificated.

II. ORAL OR PAROLE EVIDENCE.

On being called, the witness enters the witness-box and is sworn to tell the whole truth by kissing the Bible, by uplifting the hand, or by making a solemn affirmation.

(*a*) **Ordinary Evidence** may be required from a medical man. For example, a practitioner may have seen an old man knocked down by a cart. He may be cited to appear as a "common" witness to state in Court the facts of the accident as he observed them and the inferences he has deduced. In such a case he gives evidence as an ordinary individual. When cited as such, the medical man should give no opinion as to the case even if he is asked. The question might be put, "Did you think he was able to walk after the blow?" To answer such implies that the witness has medical or surgical skill, and such a question would go beyond what an ordinary witness would be expected to know, and if giving expert evidence he must be remunerated accordingly.

Ordinary evidence may be (1) *Direct.* This means that the witness states what he himself has observed, as that he saw A murder B with a razor. (2) *Circumstantial.* That is, evidence as to facts more or less remotely connected with the disputed fact, as when the witness states that he found a blood-stained razor in the pocket of A.

(*b*) **Evidence of the Expert or Skilled Witness.**—Sometimes in simple cases the general practitioner may be examined as to his technical knowledge, and he then gives evidence as an expert.

In important cases, however, it is usual to employ specialists in certain branches to give skilled evidence, as the consultant in nervous diseases, the hospital surgeon, the medical superintendent of a lunatic asylum, or the toxicologist. Their evidence is supposed to carry greater weight with the jury. If such an expert have a *subpœna* served upon him, he must attend the trial or else he may be charged with contempt of Court.

Much discredit is often thrown on the evidence of skilled witnesses, as unfortunately both prosecution and defence employ them, and only too frequently the evidence of one is

biassed, or is flatly contradicted by the evidence of another. The jury are, therefore, often left in a state of dubiety, and counsel may recommend them to pay no attention whatever to the evidence of the experts.

In France and Germany certain medical men are officially appointed as experts, and, when ordered by the Courts, they make a detailed investigation into the cases, and either report or give evidence in the Court without bias.

In our own Courts, when trials in which technical matters relating to shipping are debated, it is usual to have a "nautical assessor." He has a seat on the bench, and assists judge and jury in matters which the layman does not understand.

Most of our criminal trials, and many of the civil actions in which medical opinions are required, would be conducted with much greater clearness and satisfaction were such a medical or surgical expert to have a seat on the bench, as is customary in foreign countries.

If a medical witness is questioned as to his *opinion* on facts which as a medical man he has observed, his evidence then becomes "expert" or "skilled evidence." Thus, he may be asked if a certain wound would in his opinion be dangerous to life. The answer he would give would constitute him a skilled witness.

Again, the expert may be asked if he concurs with opinions which are held by other medical or surgical authorities. Here also he is giving answers which only one technically educated could answer, or in other words he gives the evidence of an expert. Thus, a skilled witness may express opinions as to matters with which he is specially acquainted, and such are admitted as evidence.

Usually the expert has been in Court and has listened to the evidence which has been given. He is then put into the witness-box, and is questioned as to his opinion regarding the medical or surgical evidence in their bearing on the case.

In giving medical evidence in civil cases, an arrangement should be made with the solicitors previous to the trial for the payment of a suitable fee. If there is no such written agreement the professional witness will merely receive the recognised payment, which is very small.

When a medical man is approached by either plaintiff or defendant's agents to ask his help as a skilled witness, before consenting he should have all the facts of the case laid before

him. If he can honestly uphold these as correct, then he is at liberty to undertake the duty of a medical expert. If he sees, however, that right is on the other side and that the medical testimony favours it, then his simple duty is to refuse to undertake the case. There ought to be no such individual as a medical advocate or partisan. There ought to be no possibility of evolving double conclusions from medical facts.

Rules to be Observed in Giving Evidence.

When it is likely that the medical man may be subpœnaed to give evidence in a trial, it is his duty to make himself conversant with every point which is likely to come up in the course of the case. Nothing makes so bad an impression on judge and jury as a medical witness forgetting important details, viz. dates, names, sequence of symptoms, etc.

Not only should every detail of the particular case be gone over until he is perfectly familiar with it, but help should be sought from all the standard works. If need be, he should seek advice from recognised authorities either by letters or personal interviews. The examination in the witness-box may be very searching, and endeavours will be made to confuse the witness. It is surely much better to display one's ignorance in private than in the Public Court. Everything that he says will be reported in the newspapers, and his evidence will either redound to his credit or may cover him with shame.[1] A fair, adequate knowledge of his profession is all that the law expects of a medical witness, together with powers of reasonably expressing his knowledge in the witness-box.

It has to be remembered that medical witnesses are questioned by men who are usually better educated than themselves. The counsel engaged in the case will have read up all the usual text-books on Medical Jurisprudence, and especially those parts which deal with the case under trial. These gentlemen in cross-examination will do everything to discredit the evidence given.

The medical evidence given for the defence in the recent Thaw murder trial in New York (February 1907) illustrates well the miserable appearance which a badly educated and unpre-

[1] "Examinations are formidable even to the best prepared, for the greatest fool may ask more than the wisest man can answer."—Colton's *Reflections*, No. 322.

pared medical expert may present. The witness was examined as a specialist in nervous diseases, yet did not know Romberg's test, and stated that the pneumogastric nerve joined the spinal cord in the dorsal region, and was ignorant of the situation of the dorsal region. He could not tell the Argyll-Robertson test, and thought it was named after 2 observers. He had never spoken to the prisoner, yet he affirmed that he was insane.

In answering questions put to them by counsel, medical men are apt to use technical medical or surgical terms, and these, not being understood, have to be explained. Time is thus wasted, and counsel may become impatient and irritable with the witness. A medical man who described certain wounds as "linear abrasions of the cuticle" was rather roughly dealt with when he had to explain these as simple scratches. Neither judge, counsel, nor jury have medical skill, therefore, ordinary language should be employed. "A tumefaction over the malar region" hardly expresses to the layman the presence of a swelled cheek, nor does "a punctured wound in the left inframammary region" convey the knowledge that there was a stab under the left breast.

The witness should be sure that he has fully understood the question put before answering it, and should take care that counsel does not ask him several questions at once before calling for "yes" or "no."

While in the witness-box, his behaviour should be respectful and serious. The occasion is seldom one in which humour may be indulged—the life of a fellow-creature may be at stake, and hence much more weight is attached to the evidence of a medical man who is serious and earnest, than to one who is flippant and jocular.

The answers should be direct, concise, clear, and free from ambiguity. If he does not know, then he should say so distinctly.

It is useless to try and evade questions which may be put. The examining counsel will insist on a straightforward answer, and thus, it is best to answer at once and briefly. The object of cross-examination only too often is to make the witness contradict or entangle himself, and in consequence he may return rude or discourteous answers.

The medical witness should school himself to an equable mind, and no matter how irritating the questions or the manner of putting them may be, he should maintain a dignified

and gentlemanly manner. By doing so his evidence will be much more convincing.

Every question which is put must be answered by the witness. If he thinks that such questions are unnecessary or hurtful, he may appeal to the judge. The latter may prevent such interrogations; if, however, he allows them to be put, the witness must answer them unless they are such as might incriminate himself.

It must, therefore, be a rare occasion when a medical witness refuses to answer any question which the Court allows. Nor can he plead "privilege." The criminal law in Great Britain does not allow of any professional secrecy. Every circumstance relative to the case with which he may become acquainted during an attendance on a patient must be revealed if the Court allows such interrogation. Refusal to answer questions may render him liable to be committed for contempt of Court. In some cases a private or written answer handed to the judge will be sufficient. Information which has been derived from others must not be given as answers. It is inadmissible, being hearsay evidence.

Certain facts may be stated, and the medical witness may be asked his opinion regarding these.

Such answers and opinions must be given with perfect honesty. Doubtless they may injure some one, but with that the witness has no concern. His duty is to tell the truth without considering the consequences. He has been sworn to tell the truth in the interests of justice. For the same reason his evidence ought to show no bias in either direction.

As the trial may not have come on for long after the crime, it is quite permissible for the medical witness to *refresh his memory* by referring to his notes. These, however, must have been made at or shortly after the criminal proceeding, and must be in witness's own handwriting. A late transcript of notes will not be allowed to be used, as in the interval the witness might have read much about the case and might have had his mind influenced by such; this might consequently influence him in making a recent draft of his notes. He will be asked when the notes were made, and under what circumstances they were taken.

The examining counsel may demand as answer "yes" or "no." Many questions, however, do not admit of such a categorical answer. Instead of indulging in any argument with

the examiner (for in such he will almost invariably come off worst), the witness ought to appeal to the judge to allow him to make an explanatory statement or a qualification of his affirmation or denial. The object of all evidence is to give information to the jury, and hence he is only doing his duty in giving as clear and concise a statement as possible.

The medical witness should not quote from any recognised medical or surgical works, as he is for the time being the medical authority.

Counsel may, however, read a passage or passages from some well-known text-books, and the medical witness may be asked if he agrees or disagrees with the statements there made. If he has any reason to think that the authors are not being fairly quoted, then he may ask to see the works, and satisfy himself that the writers are being correctly represented.

Such quotations are usually made from the works of deceased medical men. The work of a living author should not be referred to, as he could be cited as a witness to give evidence.

In the English Courts it is usual for the witnesses to be present in Court, and they may hear the evidence of one another.

In Scotland the witnesses are "enclosed" or detained in a room. As their names are called out, each in turn is conducted to the court-room where the evidence is to be given. Having been examined, the witnesses may then take their places in the court-room and may listen to the evidence of the succeeding witnesses.

As regards "skilled witnesses," it is advisable that they should hear the whole case argued. When, however, an expert witness is being examined the rest should be excluded from the Court so that they may not hear the evidence of each other.

Execution or Capital Punishment.

This is the extreme penalty awarded in criminal law, and in this country is now only pronounced on the prisoner in cases of murder. The tendency from century to century has been to mitigate the degree of punishment, and what were capital offences a hundred years ago, are now often classed as minor offences, and punished only by fine or imprisonment. The

method of inflicting the death penalty has also by successive stages become less barbarous.

The Draconian laws of Athens (621 B.C.) were said to have been written in blood and were extraordinarily severe, the most paltry theft or even laziness itself being punished with death. Condemned criminals were often stoned to death, burned alive, or thrown from a rock. Crucifixion was a usual method of execution amongst the Romans, Greeks, Assyrians, Persians, and Egyptians. The condemned were often made to fight with wild beasts in the arenas of Rome and Greece, and Nero employed many diabolical methods of executing criminals, as wrapping them up in tarry clothing and setting them on fire, or driving a stake through their bodies from below upwards. The laws of Rome directed that the parricide should be sewn up in a sack with a viper, ape, dog, and cock, and thrown into the sea.

In England previous to the fourteenth century the laws were dreadfully harsh; the gallows, block, or pillory were in constant use. Capital punishment was so frequently carried out that it rather tended to increase the savage and bloodthirsty passions of the people, hence wholesale murders were often committed, and for the pettiest reasons—a loaf of bread or some meal. In 1285 a man was torn to pieces with horses for the crime of debasing the king's coinage, and in 1293 3 men, one of them a jeweller, had their right hands chopped off in the streets of London for a like offence. As a rule the execution was carried out immediately after the sentence had been pronounced.

On the 30th April 1591 a man was convicted in Edinburgh for the murder of his father, and on the succeeding day he was broken on the wheel. In 1601 a murderer was sentenced to have his right hand struck off, then to be hung on a gibbet till he was dead, and his body hung in iron chains on the Borough Muir near Edinburgh. In 1667 the executioner mangled a man so shockingly in carrying out a similar sentence that he was turned out of office.

Beheading was also frequently the mode of execution at this time both in Scotland and in England.

In 1615 a Jesuit priest was hanged for speaking against the State. Witchcraft was invariably punished by strangling and burning. In 1678 ten women were executed in Edinburgh for "having had carnal copulation with the Devil."

For stealing some vegetables 2 men were hanged on the Borough Muir near Edinburgh in 1623. About this time in Scotland adultery and incest were punished by the execution of both parties.

The murderer of the Lord President of the Court of Session in 1689 was, after having been tortured to extort confession, carried on a hurdle to the Market Cross of Edinburgh, where his right hand was cut off; he was then hanged, the pistol with which he had committed the deed being hung round his neck. His body was hung in chains between Edinburgh and Leith.

In 1726 a woman was hanged in Edinburgh for forgery.

It is only necessary to add that sawing the criminal asunder, pressing to death (*peine forte et dure*), breaking on the wheel, pouring melted lead on him, tearing to pieces with red-hot pincers, starving to death, drowning, etc., have all been methods of dealing out the death penalty in different countries at different times.

In the sixteenth century the criminal was impaled by a stake being driven into his heart while he lay in his grave partly covered by earth.

Poisoners were punished by being boiled alive in the reign of Henry VIII. (1491-1547), and "it seems that 3 or 4 persons were so boiled" (Sir James Stephen). A criminal who attempted to poison the Bishop of Rochester, and who succeeded in poisoning some of his household, was actually boiled to death in 1532.

Drowning was the usual method of executing women during the Middle Ages in Great Britain. In 1611 a man was drowned at Edinburgh for stealing a lamb, and in 1623 eleven gipsy women were drowned in the North Loch below Edinburgh Castle. The last occasion in Scotland was in 1685, when the Wigtown martyrs were executed by drowning.

The "strong and sore torture" (*peine forte et dure*) was until the middle of the eighteenth century the regular and lawful mode of punishing persons who refused to plead when arraigned for felony ("standing mute"). A woman was so punished in 1442 for treasonably speaking of Henry VI.; in 1586 a woman was executed by these means at York for refusing to abjure the Catholic faith; in 1605 a man was pressed for murdering his children and stabbing his wife; in 1657 another murderer was so punished. In 1720 a man pressed for a considerable time at last confessed and was

released, and the following year a man bore a weight of 250 lbs. for seven minutes. As late as 1741 a prisoner was pressed to death at Cambridge, as he had not confessed by the torture of tying his thumbs tightly with whipcord. A statute of 1772 abolished this punishment, and enacted that any one standing mute should be considered guilty and punished according to his crime. A statute of 1828 enacted that any one "standing mute" should be considered as pleading "not guilty."

On the Continent, tearing to pieces by horses, quartering alive, disembowelling, drowning in a sack, flogging to death, and so on were made use of during the Middle Ages.

In England for many centuries hanging has been the usual method of execution, and was the ordinary punishment for felonies. Those guilty of treason were, however, in the case of men, hung, drawn at the tail of a horse, and quartered; while women found guilty of treason were burned. So late as 1783 a woman was burned to death for petty treason (murdering her husband); it was customary, however, for the culprit to be first strangled by drawing a noose tightly round her neck while she was tied to the stake, and then the faggots were set on fire and the body consumed.

Witchcraft was punished by burning to death, and so late as 1722 a woman was executed in this manner at Dornoch in Sutherlandshire.

Until the year 1832, the criminal was executed on the second day after his condemnation, and his body either given for dissection or hung in chains near the place of the murder. Since that date, however, the body of the executed must be buried within the prison in which he was confined.

Up to 1868 executions were always carried out in public in Great Britain. In London a permanent triple gallows stood at Tyburn until 1783, when on 3rd December 10 persons were executed. The uproar and confusion incident to the processions from Newgate to Tyburn caused the authorities to change the place of execution to the front of Newgate prison, where criminals were hung publicly until 1868. In Edinburgh the place of execution was the Grassmarket, but after 1784 this was changed to the front of the Tolbooth prison (a building to the west of St. Giles Cathedral, and now demolished), where many a disgraceful scene was witnessed.

Previous to 1783 the prisoner was hung by drawing away a cart on which he had been standing, after his neck had been

placed in the loop. In other cases he was made to mount a ladder, and his head having been placed through the noose his body was swung off. From 1783 to 1874 the culprit stood upon a platform, part of which fell from under his feet upon a bolt being withdrawn, and he was left suspended.

Since 1874 the method of execution in Great Britain has been by "the long drop." A certain length of rope is allowed to each prisoner, proportionate to his weight. When the platform falls, the condemned person falls with it the length of the slackness of the rope. The momentum thus obtained and suddenly checked suffices to dislocate or fracture the cervical vertebræ, and thus causes death by injury to the cervical portion of the cord.

Since 1868 the Act provides that all executions must take place within the prison, privately, in presence of the Sheriff, jailer, chaplain, and surgeon of the prison. It is also provided that the execution take place on the first Monday after the intervention of three Sundays from the day on which sentence was passed, and at 8 A.M. In the royal burghs of Scotland one of the magistrates must be present.

In France, execution is performed by decapitation by the guillotine; in Spain, garrotting; in Austria, strangling; in Germany, beheading either by the axe or guillotine; in the State of New York, electrocution or hanging.

Until about the year 1823 there were more than two hundred offences for which capital punishment might be inflicted; thus, the cutting down of a tree, the robbing of a rabbit warren, stealing from a shop goods of the value of 5s., etc., might bring death to the prisoner. In the year mentioned about one hundred felonies punishable by public execution were removed from the statute book.

At present capital punishment may be inflicted for four crimes only, viz. murder, treason, piracy with violence, and setting fire to His Majesty's dockyards or arsenals.

III. EXPERIMENTAL OR REAL EVIDENCE.

(*a*) **Identification of the Living.**—Identity has to be proved both in the Civil Courts in cases where the plaintiff (prosecutor) lays claim to property, or in questions of succession, and in the Criminal Courts in cases of assault, rape, kidnapping of children, etc.

An enormous number of people disappear from their friends every year. In one case where a female dead body had been found, the chief of police received within a few days more than three hundred letters of inquiry from parents whose daughters had gone amissing.

The identification of persons is usually settled by the police. Various questions, however, may be referred to the medical man for his expert opinion, as the time wounds take to heal, the disappearance of scars or of tattoo markings, etc.

Some individuals have the ability to change their features to such an extent that they appear perfectly different individuals. Charles Peace, a noted criminal who was executed in 1879, was able to change his facial appearance that he not only deceived the detectives with whom he spoke, and who were looking out for him, but even his wife and son failed to recognise him.

In the Criminal Courts, when an individual is arrested on a charge of assault, rape, or such like, if there be a doubt as to his identity, should he consent to be examined, he must be informed that any evidence which such an inspection may furnish regarding his guilt will be used against him.

In endeavouring to determine the identity of a person much importance is as a rule placed by judge and jury on the **Family Resemblance**. This may be shown in the features, mould of body, character of voice, certain gestures, or deformities (*e.g.* polydactylism). The decision of the House of Lords in the *Douglas Peerage Claim* in 1769 was chiefly based on the resemblance which the claimant bore to his reputed father, and which claim was upheld by the Court. A servant gave birth to a child with six fingers on the right hand, and sued her master for aliment, declaring that he was the father. The Court upheld her contention mainly because the master had six fingers on each hand.

It has to be remembered that though this family likeness may be strong during early years, lapse of time and residence in foreign lands may greatly modify the former resemblance. The voice and accent may also undergo a complete change.

At best, family resemblance is uncertain. Frequently the various members of one family bear no resemblance to each other, while, on the other hand, there may be a very striking likeness between them.

Cases of mistaken identity are very common. The police

records abundantly show that wrongous apprehensions take place, and many innocent persons have been sentenced to long terms of imprisonment, and have even been executed in mistake for the real culprits. The recent cases of Beck, Lewis, and Edalji are familiar to most readers. The Beck case may be summarised as follows: In 1877 a man, John Smith, was sentenced to five years' imprisonment for theft. He asserted his innocence, and stated that he was a Jew and had been circumcised. In 1896 Beck was charged with similar offences, and was identified by 10 women as well as by his handwriting as Smith. Beck asserted that he was not John Smith, as he (Beck) had been in Peru from 1875 to 1882, and could not have been the offender. Beck was, however, sentenced to seven years' penal servitude. Two years later the authorities discovered that Smith had been circumcised, while Beck was not. The latter was liberated in 1901, and was rearrested for similar frauds in 1904. While waiting sentence the real John Smith was apprehended for defrauding women, and thus the mistake in identity was revealed. Beck received a free pardon and £5000 as compensation.

In a recent case (February 1907) a hotel porter positively identified a man as one who had stolen certain articles. In reality it was a brother of the accused who was the thief. Where the evidence of identification rests with a single witness it should be accepted with great caution, as such recognition is one of the least reliable facts.

In cases of assault, when suspicion may have rested on one or more persons, it is usual to place them amongst several other individuals, and then to ask the prosecutor to pick out the assailant. This he or she may not be able to do, or a false identification is made, and the person so selected may easily be able to prove his innocence.

Individuals have laid claim to property or estates, and in many cases long-continued lawsuits have resulted on account of the difficulty of proving the identity of the claimant.

Tichborne Case.—Arthur Orton, a butcher's son, claimed to be Sir Roger C. Tichborne and thus heir to the estates of Tichborne in Hampshire. Sir Roger was supposed to have been drowned at sea many years before, and although there were striking and obvious points of dissimilarity between Arthur Orton and the real Sir Roger, the impostor was accepted by 17 servants, the family lawyer, and even by Sir Roger

Tichborne's mother as her son. The real heir was, when he left England, thin and bony; but after a residence of twelve years in Australia, it was alleged he had become a remarkably stout man. The claimant was taller, and had marked differences in feature and markings on his body as well as in mental characters from the real Sir Roger. The latter could speak French perfectly, while Orton did not know one word of it, and could not recall his alleged mother's Christian name, nor his birthplace or early companions. After a trial lasting one hundred and three days his case broke down, and on the one hundred and eighty-eighth day of his new trial for perjury Orton was sentenced to fourteen years' imprisonment with hard labour. His trial cost over £55,000.

Another illustrative case of imposition may be narrated. Martin Guerre went to the wars, and being absent eight years was supposed to have died. During his campaigns he made the friendship of a fellow-soldier named de Tilh. The latter came to know all the family history of Guerre, the names of his wife and children, and other intimate facts. Tiring of the army and longing for domestic happiness, de Tilh bought his discharge and went to Guerre's village, where he personated Martin Guerre. As both men closely resembled each other, de Tilh was received by Madame Guerre as her husband, and lived with her for three years, and begat children by her. No doubts were cast on his identity either by his supposed wife or by 7 relatives of Guerre's. De Tilh became, however, dissolute, and Madame Guerre's fears being aroused, he was tried as an impostor. The inquiry remained doubtful, however, but the unexpected return of the real Martin Guerre caused the rearrest of the impostor, and his punishment soon followed.

Duration and Amount of Light Necessary for Identification.—Numerous cases are recorded where a bright flash of lightning, and even the flash produced by the explosion of gunpowder in a pistol, have been sufficient to allow of identification. The "flash in the pan" which accompanied the discharge of the old flint-lock pistol afforded usually quite sufficient illumination to allow of the recognition of the assailant. The darker the night, the more easy is identification by such momentary flashes. Quite recently a workhouse superintendent was killed by revolver shots. In his dying deposition he said that he recognised his murderer by his voice, and by the light of the flashes from the revolver.

In determining the identity of an individual, any distinguishing features which he presents have to be carefully inquired into. Thus, for example, the presence of more or less definite scars, moles, mother's marks, etc., on certain parts of the body have to be noted. If it were definitely known that a claimant possessed these in his youth, and if on examination they were found to be present, this correspondence would form strong presumptive evidence as to the validity of the claim.

Occasionally for purposes of fraud, scars and such-like markings have been artificially produced. The fictitious character of these can generally be easily proved.

Remarkable cases have occurred of the coexistence of similar marks or scars in 2 different individuals, marks identical in character and position being present on their bodies. Thus, in the case of Martin Guerre and de Tihl, both men possessed similar scars on the face, each had a blood-shot eye, and each had four warts similarly placed on one hand.

In 1794 an innocent man was executed for murder. The proofs of his guilt lay in the close resemblance which he bore to the real murderer, and especially in the presence of a scar on the forehead and another on the hand, and these were identical in the 2 men.

Characters of Cicatrices.—If the wound has been inflicted by a sharp instrument, and if the edges have been accurately apposed, the wound may heal by (1) *first intention.* In the case of small wounds such cicatrices are almost imperceptible.

(2) As a rule, however, owing to the contraction of the elastic fibres in the skin, the edges of the wound are drawn apart, causing it to gape. The wound becomes filled up with granulation tissue; this slowly undergoes organisation, and the epithelium from the surrounding skin grows over it, so leading to the formation of the cicatrix. In the process of healing a more or less fusiform scar is left. *A scar is invariably present if the true skin has been injured.*

(3) If the wound has suppurated for some time the cicatrix which results is still more marked. If the wound has been so deep as to cut the muscles transversely, the tissues gape widely, and the resulting scar will be wide or oval in shape.

Scar tissue consists of connective tissue which unites the two sides of the wound. As a result, neither hair follicles nor

sweat glands are present in the cicatrix. In the process of healing the embryonic connective tissue which is first formed is vascular. A recent scar is, therefore, red or pink in colour. As the connective tissue fibres become more numerous and contract, the capillaries which traverse the wound become to a great extent obliterated. The scars of old wounds are, consequently, much less vascular than the adjacent skin, and appear as white and glistening streaks. A cicatrix of some age is, therefore, harder and whiter than the skin which surrounds it; it is devoid of hairs, and also dry owing to the absence of sweat glands.

Scars can be rendered more distinctly visible by rubbing the skin briskly; this causes the surrounding skin to become red and hyperæmic, whilst the scar remains more or less white. In dark-skinned people the whiteness of scars is very noticeable. Contused or lacerated wounds on the legs of adults often lead to the production of brownish-coloured scars.

Characteristic Scars.—The appearance which certain scars present is distinctive of their cause. Thus, the operation of "*wet cupping*" usually leaves six or more short parallel scars situated on the lower part of the back of the chest, or on the loins. *Venesection* scars are situated over the bend of the elbow, on the dorsum of the foot, or in the temporal region, and run along the course of the veins and not transversely to them. The pitted scars of *vaccination* are easily recognised, as are also the scars which result from *small-pox*.

Setons or issues were formerly used in surgery as counter-irritants. A *seton* consists of a skein of silk or a piece of bone passed through a fold of skin, and moved in the wound each day so as to keep up a discharge. In the treatment of otorrhœa, blepharitis, or glandular swellings in the neck, the seton was placed at the nape of the neck, on the upper arm, or on the shoulder. The scars which result from such treatment appear as two depressed circular or oval cicatrices separated from each other by an interval of from $\frac{1}{2}$ to 1 inch of skin. An *issue* was a wound kept open by the insertion of a small hard substance, such as a pea. A single depressed cicatrix may represent such an antecedent procedure.

Scars which have resulted from the breaking down of a **Syphilitic Gumma** are usually recognised by the great loss

of substance which has occurred. Such scars are very depressed.

Scrofula or Tuberculosis of the Glands leads to the formation of scars which show great irregularity and furrowing. The edges are very hard and uneven, and bridges of cicatricial tissue stand up from the scar. Such cicatrices are extensive, and are often situated at the sides of the neck.

Lupus gives rise to thin bluish-white cicatricial areas.

Gunshot Wounds result in disc-like scars, which are depressed at the centre, and usually adherent to the underlying tissues. They may be tattooed from particles of carbon which have been carried in.

Scars Produced by Flogging are occasionally seen on the backs of old soldiers, sailors, or convicts; they appear as fine white lines which run diagonally across the back; at intervals along each line small depressed circular scars may be made out; these correspond to the metallic bead, knot, or wire which was twisted round each thong so as to make the castigation more severe. These lines may form a cross pattern over the back, indicating that the punishment had been inflicted from either side.

Disappearance of Scars; Modification of their Appearance.—Scars of any size when once produced cannot be removed. They may be modified in shape or size, but the scar tissue is permanent. Their original shape and extent may be changed. Irregularly shaped or depressed scars may be excised and changed into linear scars. Thus, convicts who have been branded with a number have burned away the normal skin between and around the figures so as to get rid of their identification marks. Strong mineral acids or actual cautery may be employed for such purpose.

The question of the disappearance of scars was debated fully in reference to the Tichborne case. Sir Roger Tichborne had a scar on one eyelid; he had been bled; an issue had been made in his left arm; his temporal vein had been opened. The impostor had none of the scars which such operations should have left. It was argued that the scars had disappeared during his residence in Australia.

The wounds which result from leech-bites, cupping, or other slight superficial cuts or punctures may heal without leaving any scar visible to the naked eye. Friction applied

to the skin and the employment of a magnifying-glass will generally reveal them however.

Growth of Scars.—They increase in size only if the part of the body on which they are situated increases in size. Thus, a scar which extended across the whole palm of the hand in the child will do the same in adult age.

Age of Scars.—No definite opinion can be given in reference to the age of a cicatrix. It remains red and tender for from two to four weeks after the infliction of the wound. As the cicatricial tissue undergoes contraction the scar gradually becomes paler, until after the lapse of three or four months it becomes white and glistening, and no further changes occur.

A man accused of murder had a cut on his thumb. He alleged that this had been received three weeks previously. A medical examination showed, however, that the wound could only have existed for two or three days. This corresponded to the time of the fatal assault, and mainly on this fact he was convicted.

Birth Marks or Mother's Marks (Nævi).—These are permanent marks, as they consist of a plexiform enlargement of the cutaneous vessels. They can be removed by electrolysis, but at each point where the needle has been introduced a small depressed cicatrix remains.

Very small or very superficial nævi may undergo a certain amount of contraction, and so may become much less noticeable as years advance.

A young child was sold as a slave, and twenty years subsequently was identified by her friends mainly because she possessed two small moles on the inner sides of her thighs. On the strength of this evidence she was liberated.

Tattoo Markings (from the Tahitian word *ta* = a mark).—Various designs are often found tattooed on the bodies of soldiers, sailors, criminals, and very often on women with whom they associate. The marking may consist of initials, or hearts pierced with darts. Elaborate designs may be in the form of females more or less clad, and only too frequently the subject is obscene. In the East tattooing has been developed into a fine art, and the Burmese and Japanese are especially skilful in their designs. Lombroso states that dangerous lunatics are so often and abundantly tattooed that the presence of these markings might prove of value in distinguishing between dangerous and harmless lunatics and criminals.

Tattooed marks have frequently proved of the greatest service in identification. Military deserters were tattooed with a large D as lately as 1879. The devices are usually situated on the arms or front of the body, though in the case of soldiers and sailors the whole body may be covered with an elaborate coloured design. The operation consists in painting the design on the skin, and laying on a heavy coat of the colours which are desired. A bundle of four or five needles tied together and fixed into a cork is then used to prick the skin deeply over the picture. The force employed must be sufficient to cause the needles to penetrate into the true skin, and to convey there particles of the pigment. As a rule a slight bleeding takes place. The operation is not unattended with danger; septic inflammation both of the tissues and of the glands may be set up, or erysipelas may follow. One operator inoculated above 20 persons with syphilis through the practice of keeping the needles in his mouth while he himself was suffering from the disease.

Permanence of the Markings.—This depends (1) on the colouring agent which has been employed, and (2) on the depth of its insertion. Carbon particles give an almost indelible blue-black tattoo. The following substances containing carbon are employed as black pigments—soot, Indian ink, gunpowder, coal dust.

The more brilliant colours are less permanent, as vermilion (sulphide of mercury), Prussian blue, indigo, cobalt, common ink (tannate of iron or anilin dye). Some of these may indeed fade away entirely, leaving only the blue-black outline.

In about one case in ten the evidences of tattooing disappear more or less completely. An examination of the nearest lymphatic glands, however, demonstrates the presence of the colouring matter, which has been carried there through the lymphatics. These glands are almost always pigmented when extensive designs are tattooed.

Lately a son identified the body of his father, whom he had not seen for eighteen years, from the presence of certain tattoo marks on one arm.

Removal of Tattoo Marks.—If the pigment has been deposited immediately under the cuticle, it is possible that the tattooing may be removed. A severe abrasion of the skin over this area may remove it entirely. It might be done artificially by raising the cuticle by means of a blister, and then scrap-

ing off the pigment, or acting upon it with dilute acids or alkalies.

If the pigment has been carried into the corium, then it cannot be removed subsequently without at the same time destroying the skin, and so leaving a scar in place of the tattoo mark. Where this has been attempted by caustics or cautery a magnifying-glass will reveal many particles of pigment which have not been removed. Sir Roger Tichborne was tattooed along the whole length of his left forearm. Arthur Orton, however, had no such markings, but above his left wrist there was a large scar. The defence alleged that his initials A. O. had been tattooed in this spot, but that they had been obliterated by burning away the skin, and so producing a scar.

Hair.—The colour of the hair, its length, and distribution over the face forms an important means in establishing identity. Even in comparatively early life the hair may lose its colour. It is by no means uncommon to meet with persons aged twenty to twenty-five years whose hair is grey or even white. Such individuals, as a rule, are of a gouty or rheumatic constitution. The hair, on an average, grows in length $\frac{1}{2}$ an inch per month.

Change in the Colour of the Hair.—It is a comparatively easy procedure to change the colour of the hair. Criminals often try to elude the police by shaving their beards, and dyeing their hair.

To Lighten the colour of the hair, it must first be well washed with soap, soda, and water, or with a weak solution of ammonia, to get the hair free from natural or artificial grease. In many cases this is sufficient to lighten the hair very considerably, especially if it has been very dirty. The employment of a solution of peroxide of hydrogen is very usual at the present time. The individual continues to rub this solution into the hair until it has attained that degree of lightness ("golden tint") which is desired. The hair is then washed thoroughly with plain water.

A solution of chlorine in water is sometimes employed to bleach the hair. The shades may vary from chestnut to that light yellow colour which by many is much admired in the ladies of the ballet. This agent, however, has the disadvantage of rendering the hair very brittle, and the smell of chlorine is very difficult to get rid of. Dilute solutions of nitric or hydrochloric acids are also used to procure a light golden

yellow colour. If the hair be thoroughly freed from the acid no harm results.

Darkening of the Hair.—This object may be obtained by applying various dyes after the hair has been well washed. Thus, the hyposulphate of bismuth dissolved in ammonia water causes a more or less marked darkening according to the amount used. Pyrogallic acid gives a brownish tint to the hair. More frequently, however, two solutions are employed, one containing a salt of the metal to be deposited, and the other the precipitating agent, usually sulphuretted hydrogen. A common hair dye consists of a solution of acetate of lead; this is well rubbed into the hair, and a second solution containing sulphuretted hydrogen, or sulphide of potassium, or yolk of an egg is then applied. The hair immediately becomes dark from the precipitation on each hair of the black sulphide of lead. Solutions of silver or bismuth are also employed as hair dyes as their sulphides are very dark. If the first application has not made the hair sufficiently dark, the process is repeated until the individual is satisfied. The silver sulphide produces a very permanent dye.

A paste of chalk, litharge, and lime in water was formerly employed. The hair was moistened with this for some time; it was then washed with dilute acetic acid or vinegar, and finally with yolk of an egg, in order to precipitate the lead from the acetate of lead which had been formed.

Unless great care is exercised, unequal dyeing of the hair may result, some patches being much lighter or darker than others, and a rather ridiculous appearance is presented.

Detection of Dyed Hair.—The metallic dyes may be recognised by the following procedure. A little of the hair is steeped or boiled in dilute hydrochloric or nitric acid to dissolve out the metal, and appropriate tests are then applied to this solution. The individual may also be kept under observation for a few days, when an inspection of the head will reveal the new hair, growing in its natural colour.

Cases of poisoning have often arisen from the too free employment of hair dyes containing lead.

In certain workmen the hair becomes dyed owing to the fumes given off in the trade processes. Thus, the hair of ebony turners, dyers, or copper smelters may be green, while that of cobalt miners or workers in indigo factories may be blue.

Foot or Boot Prints.—It may be a naked footmark which has been imprinted on a floor in blood, or which has left its impression on soft or muddy ground. The question may arise, Is this footprint the same as that which the accused would make? The impression in sand is usually smaller than the foot or boot which has produced it, whilst the impression in earth, clay, or mud is larger.

The footprint differs according to whether the person has run, walked, or stood. It is smaller when a person is running than when he is walking, and this again is smaller than when he is standing. Two burglars were lately identified in Glasgow because of the impress their boots had left in the sawdust of the shop they had entered.

A public-house in Liverpool was broken into a few months ago. The floor of an attic bedroom was thickly coated with dust; imprints of bare feet were seen on this floor with the peculiarity that the left foot showed no toe-marks; this led to the apprehension and conviction of the prisoner, who had no toes on his left foot.

In a recent trial for murder the prisoner was apprehended mainly because of a peculiarity in the footprints. Pieces of flooring were produced in Court bearing stockinged footprints in blood. The peculiarity of the prints was that the foot of the imprinted sock was very short, causing 2 inches of the leg of the sock to come under the heel.

The evidence which convicted 2 men on a charge of setting fire to a hay-rick consisted in tracking their footmarks in the snow, and in the fact that the eyebrows and eyelashes of one prisoner were singed. Hay-seeds were also found on the clothes of one of the accused, who stated that they were clover and bents from a pig-sty owned by his brother. On examination the pigs were found to have been bedded in straw and leaves, but not in hay.

If the accused be willing to furnish evidence, he is made to wet his feet with a mixture of whiting and water, and then he walks, runs, and stands on a length of brown paper. These imprints may then be compared with those he is alleged to have made.

If it be a *bootprint*, it has to be compared with the boots the accused wore at the time of the alleged crime. If there are any peculiarities, such as the distribution of hobnails, boot protectors, etc., common to the impression and to the boot

worn by the accused, these would furnish strong presumptive proof of his identity (*circumstantial evidence*).

Preservation of These Impressions.—It is often necessary to preserve such impressions made on a floor or in soil, sand, or snow. If on a wooden floor, those pieces of the planks which retain the impression are cut out and can be kept for comparison; if in clay or sand, then casts may be made of the foot or bootprints. Solid powdered paraffin may be sprinkled into them and melted by means of a hot iron or shovelful of coals. This process is repeated until the cast is sufficiently thick to be removed. Melted paraffin just on the point of solidification may be poured in, and a cast obtained.

Powdered stucco or cement may be sprinkled in, and caused to set by placing a very wet cloth over the impression.

In snow, impressions of bootprints have been taken by making a strong solution of gelatine in boiling water, and allowing it to cool down to the point when it is just about to solidify. It is then poured into the impression, and a cast is at once formed.

Deformities such as spinal curvature, club-foot, hare-lip, cleft-palate, or injuries which have led to deformity, as badly united fractures, fracture of the nasal bones, and such like, form excellent means of identification.

Stature as a means of establishing identity is not of great value. After the age of eighteen years it is seldom that more than 2 inches are added to the height. A young adult may, however, be made to appear taller if he hold himself erect, as happens when he joins the army. In old age, or after an exhausting illness, the individual may lose height on account of stooping. In the former case it is irremediable because of the shrinkage of the intervertebral discs, and the bevelling away of the anterior parts of the bodies of the vertebræ.

Evidence of the Exercise of Particular Trades.—Many occupations leave traces on the operatives in respect to changes in the form of the body or malformations which they induce.

Soldiers.—Men who have served in the army are easily recognised by their erect bearing, and by their habit of standing at attention when addressed.

Shoemakers, owing to bending over the last, develop a concavity of the body of the sternum and a marked depression at the lower end of that bone, along with lordosis of the spine. The pulp of the right thumb is flattened from the continual

pressure of the awl; the nail of the left thumb is frayed in the process of waxing the threads; there is callus round the middle finger, and numerous cuts on the second phalanx of the index fingers from drawing the thread tightly.

Tailors who work with their legs bent under them, develop well-marked bursæ over the external malleoli.

Saddlers exhibit a flattening of the pulp of the left index finger with numerous needle pricks on the skin.

Cabdrivers present numerous callosities on the second and third fingers of either hand, caused by the friction of the reins.

Masons and especially hewers, develop large callosities at the base of the thumb and index finger of the right hand where the mallet rests. Callosities are also formed on the palmar surfaces of the roots of the fingers.

Tanners have broad flattened fingers, and the skin of the whole hand is usually stained a deep brown colour from the tan.

Dressmakers exhibit a very jagged and pigmented condition of the skin of the left index finger from pricks of the needle.

Clerks who are engaged much in writing, develop callosities on the radial side of the right middle finger owing to the pressure of the pen. Where the tip of the little finger presses on the paper another callosity is, as a rule, also formed.

Memory and Recollection of places and people by the claimant are often of importance in establishing his claim, as well as his retention of his native language or dialect.

Resemblance to Former Portraits or Photographs.—This may or may not be an aid in proving identity. Many people completely change in their facial and bodily appearance from youth to adult age. Any marked peculiarities which the claimant had in his youth may be recognised in the portrait, and may, if they still exist, help in his identification: thus, the eyebrows meeting over the nose, any distinctive feature in the nose or mouth, similarity in the colour of the eyes, etc. In a photograph light blue or grey eyes appear as light eyes, whilst dark brown or dark blue eyes appear as dark eyes. The shape of the ears is important to note, as they differ in every individual. The lobe may be large or small, and adherent or free from the cheek. The concha may be very large, and may stand out widely from the head, or it may be small and closely apposed.

Handwriting.—The evidence of this as a proof of identity has in many cases led to long-continued legal debates. A

clever forger is well able to counterfeit handwriting, and as the evidence of so-called handwriting experts is usually conflicting, and very often fallacious, this test has little value in establishing identity.

The man Beck (already alluded to, p. 23) was wrongly identified in 1896, and sentenced to seven years' imprisonment largely on the evidence of an expert who declared that the writing on bank cheques was his. In reality the cheques had been filled in by an old criminal named Smith.

Much importance was attached to the alleged identity in handwriting in convicting Captain Dreyfus of treason against the Government of France, and in his being sentenced to imprisonment for life.

Finger-prints have been in recent years added to our means of identification, and have extended its scope almost indefinitely. A finger-print is an impression of the fine lines which exist at the tips of the fingers and thumbs. These ridges are due to the presence of enlarged papillæ of the true skin arranged in curving lines on the palmar surface of the finger-tips.

Fig. 1.—Plain and rolled impressions of thumb of right hand.

The arrangement of these lines is special to and characteristic of each person, and never changes. No two individuals have them arranged in the same way. Advantage of this fact has been taken by Mr. Francis Galton, and by a scheme which he has devised prisoners are registered, and can be identified. In prisons the thumb-mark is considered of almost more value than the photograph. In India official documents and deeds are often signed by the thumb-mark as being impossible of forgery.

The thumb-mark is taken by making the person rub the front of his thumb over a copying-ink pad, or over a thin layer of lamp black, and then impressing his thumb on to a glazed card. This gives a "direct impression." If the thumb be rolled over from one side to the other, a more extensive impression is registered, or a "rolled impression."

Invisible finger-prints on articles of furniture, glass, etc., may be made much more evident by sprinkling over them finely powdered lamp black or chalk, according to whether the surface on which the prints are, is light or dark. If the loose particles be blown away the greasy ridges retain the powder, and the impression is rendered evident.

The patterns given by the skin ridges are arranged for the most part in (*a*) arches, (*b*) loops, (*c*) whorls, and (*d*) composites or combinations of the former. By an analysis of these types thumb-marks are classified into nine groups.

Prisoners are now identified by their thumb-marks, and the culprits in burglaries or assaults are often arrested through leaving their thumb-marks on furniture, etc. These impressions are "developed" by dusting on powders, and then photographing them, and so can be compared with the Identification Register of prisoners. Burglars are now so well aware of the risk of such tell-tale evidence that they frequently take precautions so as not to leave any finger-marks, as by wearing gloves, or by carefully wiping away their finger-marks from window panes or furniture.

In the case of the brothers Stratton, who were tried for murder in 1904, the circumstantial evidence largely lay in the impression of thumb-marks on a cash-box found in the room where a murder had been committed.

A thief who stole money from a packet in transit was detected by the impress of his thumb on the sealing-wax with which he had refastened the packet.

A thief who broke into a London house helped himself to a glass of wine before leaving, but, unfortunately for himself, he imprinted on the glass two finger-prints; these led to his arrest and conviction. The same fate lately befell a burglar who left the impress of his thumb on a window pane.

Bertillon System of Registering Criminals.—This method is universally employed in France, and has been found of the greatest value in establishing the identity of criminals. In a single year 562 persons who gave false names and addresses

were identified by this system. It is applicable only to adults. Briefly, the method is as follows: four measurements are taken—

(1) Greatest length of the head. These are subdivided into three principal classes,—long, medium, and short,—and again each of these classes is further divided into three according to the breadth of the head.

(2) Greatest breadth of the head.

(3) Length of left middle finger.

(4) Length of left foot.

(5) Length of left forearm.

Each of these groups is divided into three classes—small, medium, and large. Descriptions of the nose, ears, and colour of the eyes are also recorded, as well as the presence of any marks or scars on the body. Profile and front view photographs of the face are also preserved. The disadvantages are that costly instruments are required, and the measurers must be specially trained.

The Identification of Prisoners in England is carried out by employing photography, measurements (stature and various parts of the body), and registration of finger-prints. The latter two (anthropometry and finger-prints) were devised by Dr. Garson. Any special marks on the body are also noted.

In America a systematic registration is made of all distinguishing marks on prisoners, as scars, tattoo marks, birth-marks, etc. A card is made use of for each prisoner, and bears an outline of the anterior and posterior body surfaces. On these the position of the body-marks are indicated. A reasonable correspondence in age, stature, colour of hair, and marks is found sufficient in establishing identity.

(*b*) **Identification of the Dead.**—In ordinary circumstances the identity of the deceased is proved by friends, and by the police. Those who have been most intimately related are generally able to recognise certain characters in the dead body which were present in their relative. Errors in identification do, however, frequently occur, and are more liable to be committed when a dead unclothed body requires to be identified, because death causes marked changes in feature and complexion. In September 1906 a woman identified a body as that of her husband, and buried it as such. Six months later the real husband turned up, and though acknowledged by his father,

his former wife would not believe that she had been mistaken.

Even well-marked malformations may not allow of certain identification. Thus Ogston relates the case of the finding of the dead body of an old man. The left ear, and the index finger of the left hand, were awanting, and the stumps were well cicatrised. The body was claimed by 2 young women as that of their father who had similar deformities. On their return from the funeral a boatman told them that he had just ferried their father across the river.

The merest trifles may lead to the identification of a dead body. In one case a belladonna plaster bearing the letters G-14, and affixed to the back of a woman found drowned, led to her identification.

The trunk of a female was found in Boston Harbour in 1905, and later the arms and hands of the same body. On the left hand there was a peculiar ring which led to identification of the body, and the arrest of the murderers.

In the case of a man accidentally killed, the tailor's name on the metal buttons of his trousers enabled his relatives to establish his identity.

On the leg bones of a decomposed body two garters were found, one red and one white. A woman who made them swore that she had given them to a certain man, and thus proved his identity. Certain hammer-shaped fractures on the skull of the deceased, led to the arrest of a man who had been seen carrying such a tool, and with whom he had been quarrelling. The accused was found guilty and convicted.

If the body be in a fair state of preservation, identification is made by looking for distinguishing features (marks, scars, tattooing) as in the case of the living. A post-mortem examination may also reveal evidences of former diseases as phthisis, pleurisy, etc. from which it may be known that the alleged deceased person had suffered.

The colour and length of the hair may be important guides, but both hair and nails continue to grow for some time after death.

Identification by Experts.—Identification may, however, only be possible by experts. Thus, skill is required in proving the identity of bodies exhumed after a long period of burial; when pieces of the body are found; when the skeleton, or merely a few bones or pieces of bone have been discovered.

If part of the body be alone found, then it may present characters which may lead to identification. Thus, the presence of Pott's disease of the vertebræ might lead to identification in the case of the trunk only being found. If the limbs be found, they may show evidences of former fractures or of disease of the joints. The remains of Dr. Livingstone, the African explorer, were identified from the presence of a false joint in one arm.

In order to prevent identification, and to get rid of the body more easily, a murderer may cut it into pieces, and may mutilate the face. As each part of such a body is found it should be carefully described and photographed, so that it may be proved that they all belonged to the same body. In the case of a woman murdered in 1837 and dismembered, the various parts of her body were found scattered through different localities in London. All were, however, proved to be parts of the same body, because of the correspondence in the incisions of the skin, and of the half-sawn and half-broken ends of the bones. The same circumstances determined the identity of the limbs and trunk in the case of the female remains found in Boston Harbour in 1905.

In deciding such a question, it has to be remembered that the trunk may be in a more or less advanced stage of putrefaction, whilst the extremities belonging to it may be comparatively fresh.

The skeleton alone may afford indications as to the crime as well as to identification. The skeleton of a man found buried in a garden was identified from the presence of the bones of a sixth finger on the right hand, and a sixth toe on the left foot, deformities which were known to have existed in a man who had disappeared nine months previously. The owner of the garden and a woman were arrested, tried, and condemned for the murder.

The remains of Charles I. were identified in 1814, when his coffin was opened, because of the presence of the small pointed beard which was still adherent to the dark skin of the chin, and also by the cleanly cut fourth cervical vertebra which the axe had severed.

Peculiarities in respect to the curvature of the left tibia and fibula, together with a marked contraction in the left side of the pelvis in a skeleton, led to its identification as belonging to a deformed, rickety person who had suddenly disappeared.

A female skeleton was dug up eleven years after the death of the alleged woman. Round the bones of the neck several coils of a cord were found, clearly pointing to death by strangulation, and a ring on one of her finger bones led to her identification.

The case of Eugene Aram has become classic through the romance of Lord Lytton. Aram was born in 1704 and became a schoolmaster. An intimate friend of his suddenly disappeared in 1745 after a swindle played on the townsfolk. Some of the missing property was found concealed in Aram's garden. He was arrested, but acquitted. Continuing his studies he became proficient in many languages—Latin, Greek, Hebrew, Arabic, Chaldee, and others. Fourteen years later he was denounced by a confederate who confessed where the murdered man had been buried. The bones were exhumed and identified. One of the temporal bones was fractured and indented. Aram was arrested, tried, and sentenced to death. The sentence was carried out within three days, on 5th August 1759. Aram conducted his own defence with great ability, arguing that the train of circumstantial evidence was faulty, that it was impossible to identify a skeleton after so long a period, and that the fractures might easily have been produced on the dry bones.

In another case a man was arrested on a charge of having murdered his brother who had disappeared some years previously. A medical examination of the skeleton dug up from under a floor, revealed the fact that it was that of an old woman.

A fireman disappeared from the boiler he was attending. Blood and charred remains of clothing having been found, it was presumed that he had been murdered. An examination of the ashes of the furnace revealed the presence of numerous small pieces of burnt human bones.

Identity may be proved by an examination of the skull, jaws, or even from the teeth alone.

Identification from the Teeth.—The peculiarity of dentition, the presence of stopping in certain teeth, or the peculiarity of such, the operation of crowning, bridging, or the presence of vulcanite, gold, or platinum plates bearing teeth may all lead to identification, the dentist who performed these operations having records as to whom they belonged. The lower jaw with its teeth resists decomposition longest, and thus affords good grounds for identification.

The body of the Prince Imperial of France who was killed in the Zulu War of 1879 was identified mainly by the particular gold stopping of a molar tooth.

In the Charity Bazaar fire which took place in Paris in 1897, the fact that a certain lady of title had met her death there, was proved by the dentist identifying a platinum plate with teeth, which he had supplied to the deceased. The plate exactly fitted the cast he had taken of her jaw.

The body of an old lady was buried by her murderer, and lay thus concealed for four years. It was identified mainly by the presence of certain stopped teeth still present in the jaws.

The finding of the crown of a child's tooth in the room where the murder was alleged to have been committed, and the absence of the corresponding crown in the child's dead body, was sufficient to bring the capital charge home to a murderess.

A remarkable case occurred in London in 1831. An old Irish woman named Caroline Walsh was murdered by a woman with whom she had gone to lodge on 19th August. Next day another old Irish woman, named Caroline Welsh, was found lying in a neighbouring street, and soon after being admitted to the hospital she died. The murderess affirmed that the latter was her lodger. A medical examination of the exhumed remains of Caroline Welsh showed that she had lost her incisor teeth a considerable time before her death, while it was a remarkable fact that Caroline Walsh, the murdered woman, though aged eighty-four, had exceptionally good incisors. Mainly on the last fact the prisoner was convicted.

Great care, however, ought to be taken in basing identity on such evidences, and Draper records a case as an example of an error which may be committed. In 1898 the remains of a young woman's body were found. A man identified the head as that of his daughter who had run away from home some days previously. He based his recognition mainly on the particular stopping of certain teeth. The father was on his way home with the remains when he received a telegram stating that his real daughter had returned safely, but married.

Evidences of Identity after Destruction of the Body.—Even though the body has been cut up, and the parts boiled, burned, allowed to putrefy, or acted on by caustic alkalies or strong acids, identification may yet be possible.

A woman, Harriet Lane, was murdered in 1874, and buried

on the premises. A year later the murderer dug up the body, and having cut it into pieces tried to get rid of it. On examination some parts were highly putrescent, others mummified, and others changed into adipocere. Some articles of clothing, the smallness of the bones, a scar on the right leg, and other points, led to her identification.

Even after the body has been burned a careful examination of the fragments may allow of identification. Care must first be taken to prove that they are really the remains of human bones, and not the bones of lower animals. Mistakes have often occurred in thinking that the bones of oxen or sheep were human bones; if they are not human bones, it is unnecessary to determine from what animal they have been derived.

The case of Dr. Parkman is perhaps the most illustrative in this connection. On 23rd November 1849, the doctor was seen to enter the Medical School in Boston in order to receive money due to him by Professor Webster. He was never seen alive again. A week after his disappearance the police made a search through the school. They found a naked human pelvis with its soft parts, a right thigh, and a left leg in a privy. Amongst the ashes of a furnace, fragments of bone, broken pieces of artificial teeth, and pieces of gold settings for teeth were found. In an old tea chest mixed with tan and debris, an entire trunk having a penetrating wound in the left side was discovered along with a left thigh. The head, arms, forearms, and both feet were not found. All the parts found accurately fitted each other. They were evidently not parts which had been dissected. When the fragments were placed together and measured the exact height was deduced. The age of the deceased was calculated to be about sixty. Part of the right half of the lower jaw was found in the ashes, and showed that the alveoli had undergone absorption. An artificial plate also found fitted into this gap, and Dr. Parkman's dentist identified the plate, and showed that it exactly fitted the cast of his patient's mouth. Professor Webster was tried and convicted.

But few cases have occurred where the murderer has attempted to get rid of the body by means of the strong mineral acids, or by strong alkaline solutions. The Luetgert case of 1897 is, however, an example. The wife of a sausage manufacturer in Chicago disappeared after having been seen

to enter the sausage factory with her husband. The police were apprised of Mrs. Luetgert's absence, and a search through the factory was made. A wooden tank contained a quantity of reddish-brown strong alkaline fluid with several fragments of bone, together with a gold ring bearing the initials L. L. and a plain gold guard ring, both known to have been worn by the deceased. Part of an artificial tooth also belonging to his wife was found on the floor. The husband was tried for the murder on the theory that after having killed his wife he had dissolved the body in a boiling solution of caustic soda, and had burned the bones which had escaped solution. The victim had false teeth on an aluminium plate, but this metal becomes dissolved in an alkaline solution. The husband was convicted.

Determination of Sex from the Bones.—If the bones have belonged to individuals below the age of puberty it is very difficult or almost impossible to determine the sex.

Female Skeleton.—In the case of the adult *female*, the bones are usually smaller, lighter, and finer altogether than those of the male; they are smoother, and have less prominent ridges and processes for the attachment of muscles. The joints are also of less size than in the male. The skull is smaller, as are also the frontal sinuses and zygomatic arches. The facial bones are more delicate and smaller, and this is especially noticeable in the case of the jaws and teeth. The neck of the femur is placed more nearly at a right angle to the shaft, and the latter is curved forward at its upper part. The *bony pelvis*, however, affords the best marked characters. Taken as a whole it is larger and more expanded than the male pelvis. The superior inlet is elliptical in shape in the female, while in the male it resembles in shape the heart as conventionally represented in a playing card. The pelvis is shallower in its vertical diameter and the basin is wider. The true pelvis is roomy, and maintains its diameter almost completely from inlet to outlet, whilst in the male it narrows greatly from above downwards, or is funnel-shaped. The acetabula are more widely separated and the foramina are larger, the pubic arch is wider, and the coccyx remains movable; the sacrum is broader and less curved, and the angle which it makes with the spinal column is less marked in the female than in the male.

Age as Determined from the Bones.—If the bones are fresh

and the ends covered with cartilage, the colour of the latter will afford information. Up to the age of sixteen years the cartilage has a reddish-pink appearance; after this age, however, it becomes whiter and less vascular.

In old age all the bones become lighter in weight, less dense, and more brittle. Much more accurate information can, however, be obtained by an examination of the centres of ossification for the various parts of each bone. These unite with the parent bone at very definite ages as a rule, and thus the degree of union of the epiphyses with the diaphyses affords a fairly accurate criterion as to the age of the individual.

Cranial Bones.—It is found that the individual bones unite to form the complete skull within a few years of birth. The sutures delimiting the bones persist, however, until advanced life. The interfrontal suture is the first of these to disappear, the separation between the two halves of the frontal bone being indistinguishable after the twenty-fifth year. The sutures disappear first on the inner table of the skull. If all the sutures of the skull are indistinct, indicating fusion of the bones, the individual must have reached the age of fifty to sixty years. In old age the bones of the skull become thinner from the absorption of the diploë, the dura mater becomes adherent to the inner table, and the bones become brittle and fracture readily.

Inferior Maxilla or Jawbone.—The size and shape of this bone are important in determining age. The relation which the ramus bears to the body of the jawbone as to its angle, changes with advancing years. In *infancy* the jawbone is very small, and the ramus and body form but a small angle. In *adult age* the angle made by the ramus and body is almost a right angle. The bone is massive and large, and the mental foramen is situated midway between the upper and the lower borders of the bone. In *old age*, when the teeth have fallen out, the alveolar processes undergo absorption, and only the basal part of the body is left. The angle again becomes obtuse owing to the edentulous character of the jaws, and the necessity for their approximation in order that the food may be masticated. The mental foramen as a consequence becomes situated close to the upper border.

Teeth.—The presence of the teeth, and the nature of these teeth, afford excellent evidence as to age up to the fourteenth

year. During childhood age can be determined in a much more trustworthy manner by an examination of the teeth, than by the skeleton.

Milk or Temporary Teeth.—At the sixth month of intra-uterine life the alveolar cavities are formed, and at birth the germs of all the permanent teeth are present. As a rule, eruption of the milk teeth does not commence until the sixth or seventh month of life. There are exceptions, however, and the infant may be born with two or more teeth. On the other hand the period of eruption may be greatly delayed. In rickety children the central incisors may not appear until the end of the first year.

It is seldom that the temporary teeth erupt in a perfectly regular manner. They are twenty in number. The following table gives the average periods when they appear:—

PERIOD OF ERUPTION OF THE TEMPORARY TEETH.

Lower central incisors	*6th* to 7th months
Upper central incisors	*7th* to 8th ,,
Upper lateral incisors	*7th* to 9th ,,
Lower lateral incisors	10th to *12th* months
First temporary molars	12th to *14th* ,,
Canines	*17th* to 18th months
Second temporary molars	*18th* to 24th ,,

Permanent Teeth.—The number of these and their kind are used as a test of the child's age by the factory inspector. Thus, in a child of the alleged age of nine years there ought to be at least twelve permanent teeth. The first molar is often called "the six-year old tooth" as it appears at the sixth year of life. There are thirty-two permanent teeth.

PERMANENT TEETH.

	Time of Appearance.	Number of Permanent Teeth at corresponding Age.
First molars	6th year	4
Middle incisors	7th to *8th* year	8
Lateral incisors	8th to *9th* ,,	12
First bicuspids	*9th* to 10th year	16
Second bicuspids	11th to *15th* year	20
Canines	12th to ,, ,,	24
Second molars	*12th* to 14th year	28
Third molars (wisdom)	18th to *25th* year	32

Vertebræ.—The arch unites with the body of each vertebra

at the third year. At the twenty-fifth year the spinous and transverse processes fuse with the rest of the bone to form the complete vertebra. The vertebræ forming the sacrum begin to fuse together from below upwards at the eighteenth year, and the process is complete at the twenty-fifth year. The coccyx in males does not unite until a much later age, whilst in females it may remain freely movable throughout life. In old age the whole spinal column bends forward. This is due to the absorption of the intervertebral discs, and to the bevelling off of the front edges of the vertebral bodies.

Ribs.—The cartilages become ossified as age advances. At the twentieth year the cartilage of the first rib has undergone this change. The cartilages of the succeeding ribs gradually and progressively become ossified until, at the middle of life, all the cartilages have become osseous. In the case of women this process of ossification is delayed owing to the fact that their ribs are more freely used in respiration.

Sternum.—Until the age of fifteen years the five segments of which this bone is composed remain separate. After this period the lower segments commence to unite. It is not until the twenty-fifth or thirtieth year that the upper segments fuse together. Only after the age of forty is the manubrium united to the body of the sternum.

Larynx.—The cartilages of the larynx become calcified or ossified in advanced life, and hence are more easily fractured through violence inflicted on the aged.

Upper Extremity. Humerus.—At the age of five years the nucleus of the head unites with that of the greater and lesser tuberosities of this bone to form the head. At the age of twenty the upper epiphysis unites with the shaft of the bone. The external condyle unites with the lower end at the sixteenth to seventeenth year; whilst the internal is not united until the seventeenth to eighteenth year.

Radius and Ulna.—The upper epiphysis of each fuses with the shaft at the sixteenth to seventeenth year, and at the twentieth year the lower epiphysis unites with the diaphysis.

Lower Extremity.—The Y-shaped cartilage of the acetabulum disappears at the eighteenth year when the three bones, ilium, ischium, and pubis, fuse together.

Femur.—The head of this bone unites with the shaft at the age of eighteen or nineteen years, whilst the lower epiphysis remains ununited until at earliest the twenty-first year. It

may not, however, fuse until the twenty-fifth year, and until the epiphysial cartilage becomes ossified growth in stature may take place. In old age the angle which the neck of the femur forms with the shaft becomes less obtuse, and the bone also becomes much more brittle. As a result, fractures of the neck of the femur readily occur in old age.

Tibia.—At the age of nineteen or twenty years the lower epiphysis unites with the shaft, and at the age of twenty-one or twenty-two years the upper one undergoes fusion.

Age of Union Between Epiphysis and Diaphysis, or of Bone to Bone.

7th to 8th year	Union of rami of ischium and pubis.
16th to 17th ,,	Upper end of radius and ulna.
	Small trochanter of femur.
	External condyle of humerus with lower epiphysis.
17th to 18th ,,	Internal condyle with lower epiphysis of humerus.
18th ,,	Great trochanter of femur.
	Lower end of tibia.
	Acetabulum—union of its components.
	Lower vertebræ of sacrum.
19th ,,	Epiphysis of head of femur.
20th ,,	Epiphysis of head of humerus.
	Lower epiphysis of radius, ulna, and fibula.
21st ,,	Upper epiphysis of tibia.
25th ,,	Sternum, second and third pieces.
	Lower epiphysis of femur.
	Sacral vertebræ, union of first and second.
	Clavicle, epiphysis of.
40th ,,	Manubrium with body of sternum.

When ossification is complete in all the bones, it may be concluded that the individual was from twenty-two to twenty-five years of age. With every care, however, mistakes as regards age may easily be made. In many cases it is best merely to affirm that the body was that of a person who had not attained adult age, who was of adult age, or who had attained advanced years.

Stature as Calculated from the Bones.—If the whole skeleton be available, then the vertebræ should be placed in accurate position, and the skull, pelvis, and bones of the inferior extremity joined thereto. The extreme distance which these bones occupy is measured, and if from 1 to $1\frac{1}{2}$ inches be added for the soft parts, a fair idea of the height of the deceased will be arrived at.

A rough test of the stature of the individual may be obtained by measuring the length of stretch from the tip of the middle finger to the tip of the opposite. This in well-proportioned persons corresponds to the height. If one superior extremity be alone found, an approximation may be arrived at by doubling the length of the arm, and adding 12 inches as representing the clavicles, and $1\frac{1}{2}$ inches as the width of the sternum. It is stated that the measurement of the forearm from the tip of the olecranon process to the tip of the middle finger, is equal to $\frac{5}{19}$ of the height of the body.

From a *single bone* it is almost impossible to determine the stature with any degree of exactitude. Professor Humphrey has calculated the relative proportions of the bones, and by consulting the following table an approximation to the height may be arrived at.

If the full stature be taken as 100 : then the

Spine	= 34·15	Femur	= 27·51
Humerus	= 19·54	Tibia	= 22·15
Radius	= 14·15		

CHAPTER III.

EXAMINATION OF THE DEAD.

Signs of Real Death (Somatic Death).—It has to be remembered that death is never an absolutely instantaneous occurrence. The tissues of the body die slowly, and some more slowly than others. In other words, molecular death is a slow process; thus, the glycogenic action of the liver may persist for hours after death. Resuscitation of an apparently dead body is only possible because of this slow death of the tissues. The signs of death consist in (1) cessation of the vital functions, and (2) cadaveric changes. Although there is no single absolute sign of death (excepting putrefaction) yet a combination of signs, though each may be uncertain, enables one to give a decisive diagnosis of death.

I. CESSATION OF THE VITAL FUNCTIONS.

(*a*) **Cadaveric Appearance.**—This is, however, not confined to real, but may be found in apparent death. The nose is pinched, the complexion is of ashy whiteness, the eyes are sunken, and the jaw falls (*facies Hippocratica*); in some cases of death from intense pain or horror the agonised expression may be fixed. A phosphorescent appearance may sometimes be seen in the face at the time of, or subsequent to death. Certain poisons may alter these characteristic appearances; thus, in death from carbon monoxide gas or hydrocyanic acid the face has a healthy, rosy red colour.

(*b*) **Cessation of the Heart's Action.**—This is usually determined by feeling the pulse at the wrist. In many conditions where the heart beats feebly the pulsations are not perceptible in the radial artery; thus, in syncope no pulse can be felt at

the wrist. To determine whether the heart is contracting, it is necessary to have absolute quietness, and to auscultate over the cardiac apex for half a minute; very faint beats can be heard in this way. If one has doubts as to the certainty of death, then before giving a decision one ought to auscultate for five minutes continuously. This may be repeated every half-hour, and may require to be continued for two to three hours. If no cardiac contractions are heard during this period it may be concluded, in the majority of cases, that death has taken place. In stout people, in those suffering from fatty degeneration of the heart, myocarditis, or pericardial effusion, it is very difficult to detect heart beats. In one case an observer after auscultation affirmed that the woman was dead; she came to life, however, some hours later. A child was still-born, and its body was placed in a dead-house, fourteen hours later when the chest was opened its heart was found beating. In another case in Lancashire, a still-born child's body was placed in a drawer, and four hours later the infant was found alive. Quite recently in Leicestershire a baby eight months old was registered as dead, and after having been laid out for burial for several hours, was heard crying, and survived. In cases of beheading, the heart has been found beating one hour subsequently, and yet one would hardly be bold enough to state that the person was still alive. Absolute reliance cannot, therefore, be placed on the apparent cessation of the heart's action in diagnosing death.

(*c*) **Cessation of the Circulation.**—This can be tested by tying a ligature round the base of a finger. It must not be drawn so tightly as to occlude the arterial circulation. If the person be alive the finger becomes blue and turgid from the accumulation of venous blood in it, but if dead, then the finger remains white (Magnus's test). The circulation can also be demonstrated by injecting a solution of fluorescin deeply into the tissues (Icard's test). If the person be alive a deep yellow colour of the whole skin results, while the eye becomes green, but if the person be dead no change occurs. If it be a case of apparent death, as the person recovers his skin becomes yellow. The "*diaphanous test*" is a confirmatory test of life, but not an actual one. It is performed by looking at a bright light through the hand, or at a candle through the web between the roots of the fingers. During life the hand or web appears red when thus viewed; whilst after death it

appears yellow. In anæmia or syncope the hand may, however, also appear yellow, and in poisoning by carbon monoxide a red colour is observed.

The relatives may ask the medical attendant to verify death. This is most easily done by exposing the radial artery and dividing it; the vessel is whitish in colour, and no blood flows from the cut ends if the person be dead.

Post-mortem Bleeding may sometimes occur from the nose or mouth in death caused by typhus fever or hæmorrhagic small-pox. The blood is usually bright in colour.

During putrefaction the gases which accumulate in the cavities of the heart and blood-vessels may force the blood out of any cut vessels, and thus wounds may be found bleeding afresh. This may account for the conviction of alleged murderers through the "Trial by Ordeal" of ancient times. The accused was made to lay his hands on the dead body, and if the wounds bled he was accounted guilty. The clots at the divided ends of the vessels might easily become loosened if the hands were laid on roughly, and the more so if putrefactive gases were also present. The pressure of these gases may force the blood back to the face four or five days after death, causing it to redden, and thus simulate an apparent recovery (*post-mortem circulation*).

(*d*) **Cessation of Respiration.**—This is the most untrustworthy of all the separate signs. It is usually tested by holding a cold mirror in front of the mouth and nostrils; if the glass is dimmed the person is considered to be alive. A feather may be placed on the mouth, or a tumbler of water over the sternum; if the feather moves, or the surface of the water be agitated, then breathing is still going on. Respiratory movements are, however, absent in cases of suspended animation, and in real death a mirror may be dimmed by air expelled from the lungs through contraction of the diaphragm induced by rigor mortis.

(*e*) **Absence of Muscular Excitability.**—During life, muscle contracts readily under galvanic stimulation. This irritability persists for some hours (four to seven) after death, but the activity gradually becomes less and less, until the muscle is completely dead when no contraction follows stimulation.

Spontaneous reflex muscular movements continue for some time after death. Thus, the peristaltic movements continue in the intestine, and may lead to post-mortem intussusception;

movements of deglutition may persist for one or two hours after death. Violent muscular movements have frequently been observed in the bodies of persons who have died from cholera, flexion and extension of the arm having been seen to take place.

(*f*) **Flattening of Parts Pressed on.**—Those parts of the body which lie in contact with any hard surface become compressed, and take the mould of the structures on which they lie. If the body be lying on its dorsal surface on a floor, the occipital region, the back of the shoulders, hips, thighs, calves, heels, and the back of the arms, are all flattened. The blood is driven out of the skin of these areas, and they remain white. Any tight bands or tight clothing leave their impress on the tissues. An epileptic lad took a fit, and was strangled by his collar; the latter made an impression of its exact shape on his neck, and was at first mistaken for a ligature.

(*g*) **State of the Eyeball.**—During the moment of death the pupil dilates widely. After death, however, it takes "the position of rest," that is, a position midway between contraction and dilatation. The iris becomes flaccid, and pressure exerted on the eyeball may alter the round shape of the pupil, and this alteration may persist. If atropine or eserin be instilled into the eye after death they may exert their characteristic properties, but half an hour after death these drugs have little or no effect on the iris.

The intraocular tension is at once lost after death, and the iris becomes insensible to light. During life the ophthalmoscope shows that the retina has a red reflex, and the arteries can be distinguished from the veins by their colour. After death the retina becomes yellow, and both arteries and veins have a similar pink colour. The tension of the eye may be increased in cases of death by drowning.

The cornea soon loses its transparency after death, and takes on the appearance of dimmed glass; this may even be seen before death in such diseases as cholera. Later on, the cornea sinks and collapses. On the other hand it may retain its glassy lustre, as in death from prussic acid or carbon monoxide poisoning. No such appearance as a retinal photograph has ever been seen in the human being.

(*h*) **State of the Skin.**—The skin becomes pale and loses its elasticity, so that if an incision be made into it shortly after death the edges of the wound do not gape.

(*i*) **Coagulation of the Blood.**—The blood does not commence to coagulate in the large vessels until the lapse of at least four or five hours after death. Clotting takes place very slowly, allowing the blood to separate into two layers—the red clot being lowest, and the white one above it. The relative position of these indicates the position of the body when coagulation was in progress. The fibrin ferment derived from the leucocytes is the chief factor in producing coagulation, hence clotting takes place early, and is extensive in cases where there has been a high degree of leucocytosis, as after death from the infective fevers. On the other hand, coagulation of the blood may be greatly delayed or even absent in death from asphyxia, burns, poisoning by opium, hydrocyanic acid, or carbon monoxide gas. In such, oxyhæmoglobin is almost entirely absent, and clotting is very feebly developed.

II. CADAVERIC CHANGES.

(*a*) **Cadaveric Lividity; Post-mortem Staining; Hypostasis; Suggilation.**—This is a discoloration of the skin due to the gravitation of the fluid blood into the capillaries and small blood-vessels of the rete mucosum in the lower parts of the body according to its position. These blood-vessels are distended in consequence. The lividity appears first as small, dull red or purplish spots on the skin; these enlarge and become more numerous until they fuse together to form a uniformly discoloured surface which is of a mottled, purplish red colour. Hypostatic patches are irregular in size and shape, sharply outlined, and do not project above the surface of the skin. They constitute a certain sign of death, but do not appear for some hours after death. The distribution of the lividity varies with the position of the body. If it be on its dorsal surface, then the staining will be distributed over the whole of the posterior surface, with the exception of those parts of the skin which have borne the weight of the body. The latter will remain white, as the compression has prevented the dilatation of the capillaries by the gravitating blood. If the body has been laid on a hard level surface the unstained parts will be the occiput, the skin over the scapulæ and dorsal vertebræ, the skin over the sacrum and back of the gluteal regions, parts of the skin of the thigh, and back of calf and heel; the intervening parts are stained lividly.

If the body has been laid on its face, then the lividity will be found on the anterior parts.

The distribution of the staining is regular if the body has been lying on a smooth surface, but irregular if on an uneven surface. Anything which compresses the skin prevents the production of these stains, hence tight clothes, bands, or collars give rise to great irregularity in the staining, and white bands on the neck have been mistaken for marks of strangulation.

Two persons were condemned in 1764 for alleged murder on the evidence of a broad blue mark on the neck of the deceased, which was asserted to be due to strangulation. There is every reason to suppose, however, that it was really post-mortem lividity.

If the body be moved before the blood has coagulated, then the original staining of the skin may disappear, and new stains be formed on the now depending parts. On the other hand, if the body has been moved after the blood has coagulated, then the distribution of the post-mortem staining will not change from its original position, and will afford indications as to the position of the body before it had been moved. Staining is most marked in those cases where the blood has remained fluid for long. It is present, though feebly marked, and slow in development, in cases of death from hæmorrhage.

In deaths from cold and exposure, burns, or in poisoning by carbon monoxide or hydrocyanic acid, the post-mortem stains are of a bright red colour. In poisoning by chlorate of potassium, bichromate of potassium, phosphorus, or anilin, the post-mortem stains are brown in colour.

In the *internal organs* this hypostasis also takes place after death. The lowest lying one-third or half of each lung becomes of a deep purplish red colour, and this has to be carefully distinguished from congestion or inflammation. In the brain the vessels of the lowest lying part of the membranes, the lateral and occipital sinuses, and the posterior lobes of the brain, are the seats of this post-mortem staining, which affects also the cord and its meninges. In the intestines the depending loops become dark and livid, and have to be differentiated from inflammation and gangrene. In the case of hypostasis there is an absence of exudation or of constriction. If the loop of bowel be stretched out and held to the light, areas of reddening are seen to be separated by pale areas, and this is never seen in inflammatory conditions.

Period of Onset.—Hypostatic staining comes on while the body is still warm, or from six to twelve hours after death. It increases in extent and in intensity until the blood has coagulated. Rarely it may be present before actual death, as in cases of cholera, uræmia, typhus, lingering diseases, and asphyxia. When putrefaction is advanced the hæmoglobin diffuses through the walls of the veins, and causes a reddish discoloration of the whole tissues and skin. This must not be mistaken for post-mortem lividity.

Distinction Between Post-mortem Staining and Bruising.—The appearances due to a bruise produced during life and those due to post-mortem lividity have frequently been confounded. Persons have been accused of feloniously wounding, when in reality the apparent bruises were the result of cadaveric changes.

A bruise often reveals by its shape the nature of the weapon which has produced it; it is usually elevated somewhat above the level of the surrounding skin, and the cuticle is often abraded. The colour of a recent bruise is purplish red, and is not uniform. If it be some days old, the usual changes in colour are apparent at the margins. An incision should invariably be made into a bruise or hypostasis to verify its nature. This shows in the bruise that the whole of the subcutaneous tissues are infiltrated with coagulated and fluid blood, and there is no definite margin to the blood effusion.

The edges of a patch of hypostasis, on the other hand, are usually sharply defined, not elevated, and on incision fine little bloody points are alone seen on the cut surface; these correspond to the cut ends of the distended capillaries and small vessels. The tissues so cut appear normal, and are not infiltrated with blood.

(*b*) **Alteration in Reaction of the Tissues.**—Within a few hours of death the normal alkaline reaction of the muscles and internal organs gives place to an acid reaction as tested by litmus paper.

(*c*) **Cooling of the Body.**—When the temperature of the body has fallen from 15° to 20° F. below the normal, it may be taken as an almost certain proof of death. During the first few hours after death the body cools at a comparatively rapid rate; later, however, as the difference between the temperature of the body and that of the surrounding air becomes less, further cooling of the body takes place more and more slowly.

The extremities, having less mass while they expose a greater skin surface, cool more rapidly than does the trunk. Mere coldness of the skin to the touch is no test of death. During life the external surface temperature may be low, whilst the internal temperature may be above the normal. In certain exhausting diseases, as cancer or phthisis, the body may have lost much of its heat before death actually takes place. In cases of collapse the rectal temperature may fall below 90° F. before death. There may, however, be a great increase in the body temperature after death; this is known as **Post-mortem Caloricity**, and is due to early and rapid putrefactive changes induced by micro-organisms, or to intense chemical activity taking place in the dead tissues. Such a rise in temperature is found in death from cholera, where it may reach 115° F., small-pox (113° F.), yellow fever, tetanus, cerebro-spinal meningitis, rheumatic fever, poisoning by strychnine, alcohol, etc.

The Rate of Cooling depends on (1) age; (2) cause of death; (3) surroundings of the body; (4) temperature of the air.

A Rapid Rate of Cooling of the dead body is seen—

(1) At the extremes of life. The bodies of infants and of old thin people soon part with their heat as their mass is not great.

(2) In death from starvation or wasting diseases, the body cools rapidly. In fact, the temperature of the body has usually fallen to a low degree before death in such cases.

(3) Rapid loss of heat is seen after death from hæmorrhage, as in cut-throat. This is due to the fact that a large mass of the body substance has been lost, and this is the vital fluid which is most important in keeping the tissues of the body alive, and retarding their molecular death.

(4) An unclothed body cools more rapidly than one clothed.

(5) Free exposure to the air facilitates cooling.

(6) When the atmosphere is cold.

A Slow Rate of Cooling occurs in the bodies of—

(1) Young or adult persons.

(2) Corpulent bodies owing to the non-conducting layer of fat.

(3) Healthy individuals who have died suddenly.

(4) Those suffocated.

(5) Well-clothed bodies.

(6) Those in bed and covered up with bed-clothes.

(7) When the temperature of the air is warm.

(8) Those lying in small close rooms.

(9) Those whose ante-mortem temperature has been high, as in death from sun-stroke, where the rectal temperature may be 120° F.

On an average, the amount of heat lost during the first three hours after death is in the robust 3·5° F., while in the emaciated it is 4·5° F. During the second three hours it amounts to 3° F. in both conditions. If a body be in bed, and the temperature of the air be from 50° to 70° F., it will lose 1·6° F. per hour. An approximation may, therefore, be arrived at as to the number of hours which have elapsed since the person died by subtracting the temperature of the body from the normal body temperature, and dividing the difference by 1·6.

Example.—Normal body temperature . 98·4
Temperature of dead body in bed 87
1·6)11·4
7·1 hours since death occurred.

The temperature must always be taken by a thermometer placed in the axilla or rectum.

If a clothed dead body be found still warm on a road, while the temperature of the air is about 60° F., then death must have taken place within three hours. If the body be warm, and in bed, then probably ten or twelve hours have elapsed since death took place. As a rule, a body will have fallen to the temperature of the surrounding air in twenty-four hours after death. There are many exceptions to the above, however, and a body may retain a large amount of heat for many hours after death. It has frequently been observed that the internal organs have felt quite warm, and have even steamed, while the post-mortem examination was being made twenty-four hours after death.

(*d*) **Cadaveric Rigidity; Rigor Mortis; Death Stiffening.**—This consists in a hardening and stiffening of the muscles of the whole body which sets in some hours after death. This condition is found almost invariably present, though it may be overlooked on account of its slight degree and transient character. As the excitability of the muscles passes off rigor mortis comes on.

Cause.—The muscles become hard owing to the formation

of myosin in the sarcolemma sheaths through the action of an unorganised ferment upon the muscle proteid (myosinogen). Another less likely explanation is that during the death of the muscles lactic acid is formed, and this acts on the normal potassium phosphate present in the living muscle to form the acid potassium salt. This latter salt then causes a coagulation of the myosin within the muscle fibrils.

Order of Onset.—There is a definite order in which rigor mortis affects the various groups of muscles. The stiffness affects the muscles in the following order: (1) First the eyelids, hence the common practice of placing a coin over each eyelid of a corpse in order to keep them closed until they are fixed by rigor mortis. In certain forms of death the eyelids may even stiffen before the heart has ceased to beat. (2) The muscles of the neck and lower jaw are the next to become stiff. In laying out a dead body care is usually taken to tie up the lower jaw, and to place the head in an even position with the body, so that they may become fixed in a natural position. (3) The muscles of the face. (4) Those of the chest. (5) Upper extremities. (6) Trunk. (7) Lower extremities (exceptionally these may become stiff before the upper limbs). The nipples become contracted and hard, and so does the dartos muscle of the scrotum. Of the internal organs the heart is the first to undergo this change; the left ventricle may be found hard at the end of the first hour after death.

Rigor mortis passes away in the same order as it came on. This disappearance is again probably due to the action of unorganised ferments causing a solution of the myosin. A less tenable hypothesis is that sarcolactic acid is produced during early putrefaction, and that this dissolves the myosin into soluble syntonin. The distribution and extent of rigor present in a body may furnish us with an approximate idea as to the number of hours the body has been dead. At an early period after death, the head, neck, and upper limbs may alone be stiff, while at a late period the lower limbs may alone be rigid, the condition having disappeared from the upper part of the body.

Time of Onset.—This varies greatly in different cases, but on an average it may be said to commence two to four hours after death, and to persist until decomposition comes on, in from one to three days. When once the condition commences the stiffening goes on rapidly, so that in this

country, the whole body becomes rigid within two or three hours of the onset. The earlier rigor mortis comes on the sooner it passes off as a rule, and the later it comes on the longer time will it persist.

Rapid Onset of rigor mortis is seen under such circumstances as :—

(1) After great muscular exertion, as long forced marches, racing, fighting, etc. The bodies of hunted animals are often perfectly stiff almost immediately after death. A coursed hare may be held out horizontally by the hind limbs, the body having become quite rigid. The bodies of soldiers killed instantaneously after having endured great exertion may become rigid almost immediately. If death follows a series of convulsions (uræmic, strychnine poisoning), the body may never relax, but may pass at once into the state of rigidity.

(2) In those dying from infectious diseases rigor mortis may come on very rapidly, and in some cases it may supervene during the death agony.

(3) Exhausting or wasting diseases hasten the onset of rigor mortis (cancer, phthisis).

(4) In the newly-born post-mortem rigidity comes on very rapidly, and passes off equally soon. Hence the erroneous statement that death stiffening does not occur in the bodies of infants.

(5) In warm climates the onset is rapid, and so is the disappearance; this is due to the earlier commencement of decomposition in warm climates.

(6) After great nervous excitement, when death has occurred with great suddenness. The position which the deceased occupied at the time of death may be preserved; he becomes statuesque. If a person be holding a weapon or other article in his hand, and is instantaneously killed, "**Cadaveric Spasm**" may cause the weapon or article to be tightly grasped during and after death. Rigor mortis comes on very rapidly in such cases, and thus the attitude at death may be preserved for several days. A suicide is frequently found tightly grasping in his hand the weapon (pistol, razor, etc.) with which he has ended his life. A gentleman was walking over a frozen lake, and while in the act of striking a match to light a cigar was precipitated into the water through the ice giving way. His body was recovered several hours later, and was fixed in the same attitude in which he met his death, viz. cigar

between his teeth, match-box and match in either hand. As a soldier was mounting his horse, a bullet struck him in the cervical region, and instantaneously killed him; his rigid dead body still retained the attitude of mounting. Another soldier was drinking water by the side of a river, when a cannon-ball carried off his head. When found some hours afterwards his body was in a sitting position, and his right arm was extended, and in the hand a tin cup was grasped. The body of an anarchist who lately committed suicide in Paris, by discharging a revolver into his head, was found with the weapon tightly grasped in his right hand. Captain Nolan whilst riding in advance of the cavalry at Balaklava had his chest torn open by a shell. His arm remained uplifted, and his body retained its seat whilst his horse brought him back through his company.

The medico-legal significance of cadaveric spasm lies in the fact that pieces of clothing or hair may be tightly grasped in the hands of the deceased, and so may lead to the identification of a murderer. Cadaveric spasm is quite different from rigor mortis. The muscles must have been strongly stimulated by nervous influences at the time of death to produce spasm, and as rigor mortis is greatly hastened in its onset by nervous excitement, the primary condition of spasm becomes fixed by the secondary. Some cases have occurred where the murderer has placed the weapon in the hand of the deceased in the hope that the death stiffening would cause it to be grasped, so as to give the appearance of a case of suicide. This can never occur, however, for in such cases the weapon is not grasped, but falls out of the hand on the slightest touch. In two homicidal cases of cut-throat, where this had been attempted, an error had been made in placing the back of the knife or razor towards the person of the deceased. Whenever a weapon is tightly grasped it is almost certain that the person was alive at the time when he gripped it, and that his nervous excitement was great.

The onset of rigor mortis causes only a very slight contraction of the muscles without any alteration in their shape. The body becomes stiff in the attitude in which it was at death. It is, however, to a certain extent under nervous control, as it is slow in appearing in paralysed muscles. When once full rigidity has been overcome, as by forcibly bending the elbow, the muscles never resume their stiffness. In almost every case

there is a period of relaxation of the muscles after death before rigidity comes on. There is an exception, however, in the case of cadaveric spasm.

Delayed Onset of Rigor Mortis is seen in the following conditions:—

(1) Sudden death while in previous good health (apoplexy, pneumonia, etc.).

(2) Asphyxia.

(3) Narcotic poisoning (it is even said to be absent in such cases).

(4) Death from hæmorrhage. In cases of decapitation the body remains flaccid for long, and in an amputated limb rigidity is very slow in appearing, and is feebly marked.

(5) In paralysed muscles it is also long delayed, and may even be absent, when the nerves leading to the muscles have been cut.

Duration of Rigor Mortis.—It usually persists for two or three days, but in certain cases where its onset has been delayed it may continue for six or seven days, as in asphyxia.

In poisoning by strychnine or after death from convulsions, rigor mortis may persist for months. The colder the weather the longer will the rigidity persist because putrefaction is also delayed. In death from lightning the stiffness comes on very rapidly, and lasts a very short time. As regards season and duration, Devergie states that for winter and summer the figure is the same; in winter it represents days, and in summer hours.

The cardiac muscle soon becomes rigid after death, and as the muscle fibres contract somewhat during stiffening, a totally different condition may be produced from that which existed at the time of death. For example, the left ventricle may be found contracted and the cavity empty, whilst at death it may have been dilated. As the rigidity passes off the heart muscle may again relax, and thus no absolute statement can be made as to the condition of the heart at the time of death.

Rigidity of the facial muscles often leads to a great alteration in the countenance; even intimate friends may fail to recognise the deceased.

Distinction Between Freezing of the Body and Cadaveric Rigidity.—In the latter condition the skin remains soft and unaffected, whilst in the former the whole tissues are hard, and

the skin rigid, and when the joints are moved they give a crackling sound.

Estimation of Time of Death.—If a body be found cold, with well-marked post-mortem staining, the rigidity complete, but with no visible decomposition, then death has occurred within two days.

If the arms be relaxed, but the legs rigid, then four or five days have elapsed since death took place.

(*e*) **Putrefactive Changes.**—These form the first absolute sign of death. If there be any doubt as to the reality of death, the relatives may be advised to defer the burial until the evidences of decomposition manifest themselves. The changes which putrefaction causes in the body are of the greatest medico-legal importance. Grave errors have often been committed by medical men mistaking the changes in colour and appearance of the internal organs produced by decomposition, for congestion, inflammation, or other pathological condition.

External Phenomena Produced by Decomposition.

(1) The first evidence of putrefaction is the production of a sweet, sickly smell which soon pervades the room in which the corpse is lying, and is at first not unpleasant, but later becomes overpowering and nauseating. In cold weather this odour may not be perceptible until six or seven days after death, while it may be developed within a few hours in warm weather. As decomposition advances the smell becomes putrescent and disgusting.

(2) During the *first to third day* after death the skin over the abdomen becomes greenish-yellow in hue. This change of colour is developed at first over the iliac fossæ, and is due to the diffusion of sulphuretted hydrogen from the intestine into the tissues. This gas reduces the hæmoglobin into sulph-methæmoglobin, and produces the cutaneous discoloration. The eyeball becomes soft and easily compressible, the cornea white and milky, and either flattened or collapsed.

During the next three days (*third to sixth day*) this green colour extends over the whole surface of the abdomen, and involves also the skin of the genital organs. The tint becomes deeper, and in parts merges into a brown colour. Following closely on these changes, the skin covering the back of the

trunk, limbs, sides of the chest and neck, becomes green. A serous exudation is poured into the cavities, and at the same time the gases of decomposition accumulate in the intestine, and cause the abdomen to swell up. For the same reason a bloody froth is forced from the mouth and nose, and the blood having again become fluid, is driven by the intra-abdominal pressure towards the periphery, giving rise to the so-called posthumous circulation, and (it may be) causing a flushing of the face.

In *eight to ten days* after death the discoloration of the skin is much more widely spread, and deeper in colour; certain areas are deep green, while others are reddish brown. The odour is very strong and disagreeable. Not only the cavities, but the whole tissues of the body are distended with putrefactive gases; the body is thus very bulky, and when it occurs in the bodies of infants they may appear much older than they actually are. The eye has collapsed, and the whitened cornea has fallen in. The sphincters have relaxed, and urine and fæces have escaped. The subcutaneous veins appear as red lines traversing the discoloured skin.

In from *two to three weeks* the entire surface of the cadaver is of a greenish brown colour. The cuticle is raised into blebs and bullæ, which are filled with a reddish-coloured fluid. Many of these bullæ have given way, and the skin hangs in shreds, or is easily peeled off, leaving smooth areas. Copious blood-stained serous effusions are present in the body cavities, and the thorax and abdomen become still further distended with gases. The gaseous distension of the tissue may make the body enormous in size, and may cause the tongue to protrude between the teeth; the latter condition must not be mistaken for that due to strangulation. The eyes may be forced out of their sockets, and the rectum may be prolapsed through the anus owing to the accumulation of gases. In the case of pregnant women who have died when just about to be delivered, the fœtus may be forced out after death, and may be found lying between the thighs of the mother. In such cases the uterus may be prolapsed or even inverted, owing to the pressure of the gas. The gaseous accumulation may be so great that the abdominal wall may rupture, and this with a noise so loud that it has been heard at a considerable distance. The features become unrecognisable on account of the swelling; the penis and scrotum are enormously distended,

and the hair and nails become loose, and are easily detached. Numerous larvæ (maggots) may be present.

The progress of decomposition may be greatly hastened for various reasons ; in the case of a man who died from perforation of the bowel in the course of enteric fever, the whole body was in an advanced stage of putrefaction sixteen hours after death. It may, on the other hand, be greatly delayed ; the body of a youth who died during summer weather showed very little change for thirty-five days after death. Even in the bodies of several people killed by the same accident there may be great differences in the rate of putrefaction.

The change known as "**Colliquative Putrefaction**" takes place in bodies after the lapse of *two to five months*. At this stage the soft parts are more or less changed into a pultaceous green mass ; the thorax, abdomen, and skull are burst, and their contents have escaped ; the bones are exposed, and the orbits are empty.

Progress of Decomposition in the Internal Organs.

Caspar has drawn up the following table in reference to the internal organs :—

Those which putrefy soon.	*Those which putrefy late.*
1. Larynx and Trachea.	8. Lungs and Heart.
2. Brain of Infants.	9. Kidneys.
3. Stomach.	10. Bladder.
4. Intestines.	11. Œsophagus.
5. Spleen.	12. Pancreas.
6. Liver.	13. Diaphragm.
7. Brain of Adults.	14. Large Blood-vessels.
	15. Uterus.
	16. Muscles and Ligaments.
	17. Bones.

Blood.—This decomposes very soon. The hæmoglobin which has not been changed into its sulphur combination escapes into the serum, and reddens all the tissues into which it transudes. This staining of the internal organs must be carefully distinguished from inflammatory changes. In decomposition the microscope shows that the cells have undergone a cloudy swelling or granular degeneration. Superficial bruises disappear during decomposition.

Larynx and Trachea.—The mucous membrane of these structures being freely exposed to the air undergoes an early

putrefaction; at first it becomes brownish red in colour, and later olive green.

Brain of Infants.—In early age this organ soon decomposes owing to the thinness of the structures covering the fontanelles, and the delicacy of the cribriform plate of the ethmoid.

Stomach.—The mucous membrane and its glands soon become pulpy and peel off; this may occur within twenty-four hours, but usually within four to six days. The posterior wall towards the cardiac end is often found to be dark red in colour due to post-mortem staining. This has been mistaken for the result of irritant poisoning, so a careful inspection is necessary. In irritant poisoning the reddening is confined to the mucous membrane, while that due to putrefaction involves the whole thickness of the stomach wall.

Post-mortem Digestion of the stomach walls is frequently observed. This auto-digestion usually takes place at the posterior wall, and may be complete, a more or less ragged hole being present with the edges thinned away and fringed. In other cases only a partial solution of the mucous and submucous coats has been effected, and on carelessly handling such a stomach it may rupture at this weakened area. The condition is easily distinguished from a perforated gastric ulcer, for in the latter the edges are sharply cut, and it may be funnel-shaped.

Intestines.—These rapidly swell up from the accumulation of gases in their interior, and the mucous membrane undergoes changes similar to those seen in the stomach.

Post-mortem intussusception is sometimes met with, and must not be mistaken for intussusception produced during life. There are no evidences of constriction or peritonitis, and as the parts are easily separated, the diagnosis is easy.

Spleen.—This undergoes a very rapid decomposition, and especially after death from acute infectious diseases. Within two to three days the organ is usually reduced to a diffluent mass.

Liver.—The first putrefactive change consists in a softening of its substance. The upper convex surface soon becomes grey, and then green in colour. The organ becomes crepitant from the evolution of gas in its tissue, though it may remain somewhat firm for months after death.

Omentum and Mesentery.—These resist putrefaction for long.

Brain of Adults.—The first change is seen as a greenish discoloration of the pia and arachnoid membranes at the base of the brain; the discoloration is specially marked along the line of the vessels, and later it spreads over the convex surface. The grey matter undergoes putrefaction more rapidly than the white matter, and the cerebellum sooner than the cerebrum. As a rule the whole brain is diffluent in from two to three weeks.

Genital Organs.—These organs in the male soon decompose and disappear.

Heart and Pericardium.—These are slow in putrefying. Pericarditis has been recognised fifty-seven days after death.

Lungs.—The first change is seen on the surfaces, which become leaden, and finally dark green in colour. The gases of decomposition accumulate under the pleural membranes, and may be recognised as blebs of gas which can be forced from place to place (*putrefactive emphysema*). As the lungs consist mainly of connective and elastic tissue they are not subject to rapid decomposition. Many diseases of the lungs, as tuberculosis, may be recognised some months after death.

Kidneys.—The normal colour of these organs becomes replaced by a chocolate, and still later by a green colour. Their consistence remains for long comparatively unchanged, and pathological conditions, such as nephritis or cancer, can be detected long after death.

Bladder.—The urine which is present in the bladder at the time of death soon becomes albuminous through the transudation of serum albumen and globulin from the blood; it is, therefore, impossible to determine whether this was the condition of the urine before death. The presence of sugar in the urine after death denotes, however, that the deceased had suffered from diabetes mellitus.

Œsophagus.—This structure resists putrefaction for long, and may be found after the stomach has entirely disappeared.

Pancreas.—For many weeks after death this organ may be recognised as a dark red mass.

Diaphragm.—This also resists decomposition for many months.

Large Arteries and Veins.—As those consist mainly of fibrous and elastic tissues they are slow in decomposing.

Uterus.—So slow is this organ in undergoing resolution that it may be found even after the pelvic bones have fallen

apart, and may allow a determination as to whether deceased had been pregnant. In one case where the body of a young woman had been in a cesspool for nine months and was greatly putrefied, the uterus remained and exhibited virgin conditions. The uterus of another woman when examined six months after death showed that she had been delivered at full term.

Putrefaction in the Newly Born.—The intestinal canal of newly born infants contains no bacteria; these must, therefore, gain entrance through the natural orifices of the body. The anaërobic organisms do not invade the body, and the aërobic bacteria do not produce gaseous putrefaction. Putrefaction in such cases is slow, and commences on the surface.

As the conditions which favour or retard putrefaction are so varied, it is impossible to lay down any rules by which the period of death may be determined.

Cause of Decomposition.—There is a more or less definite succession in the bacterial invasion of the dead body; it is usually divided into three stages.

First Period is when the aërobic organisms flourish in the tissues. No matter what the cause of death may have been, the hæmoglobin is never entirely reduced, some oxyhæmoglobin is invariably present, hence aërobic organisms gain entrance, and begin the process of breaking down the complex tissues of the body into simpler compounds. These bacteria cause a reduction of the hæmoglobin into methæmoglobin, and this when united to sulphur gives rise to the green discoloration of the tissues; they are also concerned in the production of carbonic acid gas. As the oxygen becomes used up these organisms gradually disappear.

Second Period is when the facultative organisms flourish (either aërobic or anaërobic). These can grow either in the presence or absence of oxygen, as the *Bacillus coli communis.* During this stage carbonic acid gas and the hydrogen derivatives are produced (hydrogen, hydrocarbons, sulphuretted hydrogen, marsh gas).

Third Period is occupied by the growth of anaërobic organisms which live only in the absence of oxygen. These bacteria are ultimately destroyed by the accumulation of their own products. This stage is characterised by the production of many gases, the chief being hydrogen, nitrogen, and ammonia, which cause very great distension of the body in warm weather, and in the drowned. The hydrogen derivatives

are inflammable (*e.g.* H, H_2S, CH_4, CO), and if the skin be punctured these gases escape, and being ignited burn with a long bluish flame which may last for three or four days.

Phosphuretted hydrogen (PH_3) is also evolved in certain cases. This gas is spontaneously inflammable, and gives an explanation for the Will o' the wisp lights which have been seen to play round the dead, and which are known as "corpse candles."

The Bacillus Aërogenes Capsulatus is sometimes present in the body before death. The growth of this organism is associated with a great evolution of gas in the blood-vessels. After death such bodies swell up very rapidly, and attain an enormous size.

Order of Succession of Insects.—During the course of putrefaction many different species of insects are attracted. The varying odours which are evolved from the corpse at different stages attract different species as the corpse affords suitable food for each, and the sequence of their arrival on the body occurs in a more or less definite order. Meguin affirms that it is possible to determine more or less precisely the time when death had occurred by the presence of the larvæ (maggots) of certain insects in the cadaver.

(*a*) The common domestic fly is the first to deposit its ova on the mucous membrane of the eyes, nose, and mouth of the cadaver. These eggs occupy three weeks in their development into insects. If, therefore, their empty chrysalis cases be found, the body must have been dead for more than three weeks.

(*b*) Green and grey flies of the genus Lucilia and Sarcophaga are attracted three or four days after death.

(*c*) Three or four months after death those Coleoptera which attack fat (Dermestes) and Lepidoptera (Aglossa) are attracted.

(*d*) Eight months after death such flies as Piophila and Anthomyia, and such Coleoptera as Necrobia, appear.

(*e*) At later stages various kinds of beetles are found in the remains of the corpse (Silpha, Hister, Anthemis, Tenebris, Plinus).

Moulds may also hasten the process of decomposition. Ants, rats, or mice may attack the dead body, and in certain cases it may be reduced to the condition of a skeleton within three weeks. In the case of a woman's body which was found under some shrubs three years ago at Richmond, the body had been

reduced almost completely to a skeleton within two weeks; identification was only possible by the clothing, and by finding a hypodermic needle near it.

The great hindrance to putrefaction is the skin; this acts as a barrier, preventing the organisms from invading the tissues. When the skin surface is destroyed, as in bodies bruised or lacerated, putrefaction takes place much more rapidly than when it is entire.

The digestive tract is full of micro-organisms at the time of death, and these readily penetrate into the glands of the mucous membrane and destroy the latter. From this situation the passage of the organisms to the vessels and peritoneal cavity is easy. During their growth much gas is evolved, as well as a diastase-like substance which dissolves the tissues. When the limbs have been separated from the trunk in a case of murder and mutilation, they remain fresh long after the trunk has become highly putrefied.

In death by carbonic oxide poisoning, little or no oxygen is present in the blood and tissues. As the first or aërobic stage of putrefaction is prevented, putrefaction is greatly delayed. The usual progress of putrefaction may be modified under such circumstances as the following:—

MUMMIFICATION.

This means a drying up and preserving of the body while it retains much of its natural appearance.

In this country desiccation of the dead human body rarely happens, as the dampness of the air and soil militates against the process.

In warm climates, with dry air and dry sandy soil (as is met with in Egypt, or in dry currents of air) mummification of the dead body readily occurs.

Certain poisons (arsenic) when swallowed have the property of inhibiting decomposition, and if such a body be exposed in dry air mummification may result.

Desiccation is most likely to occur in the bodies of infants or of thin old people, and more especially if the bodies be buried naked in dry sandy soil. The walls of the vaults in the Capuchin monastery in Rome are lined with the mummified bodies of monks who have died in that institution. As each monk dies he is buried in his monk's robe in the dry soil of

the vault (soil said to have been brought from Jerusalem). After the lapse of some years his mummified body is dug up and placed with its fellows against the wall. Desiccation takes place readily in the dry, airy vaults of the convent of the Capuchin monks near Palermo, and at the present time thousands of bodies more or less perfectly preserved are exposed to view in these corridors.

The bodies of murdered infants are sometimes found completely dried up in boxes, cupboards, or dry outhouses.

Mummified bodies retain both their shape and form. The skin is dry, hard, and shrivelled. They have a musty odour, but not a disagreeable smell.

A practical point to remember is that dead bodies are preserved longer if covered only with a sheet, and kept in a small room with the windows and doors shut closely.

An exactly opposite condition may be met with in the dead body, viz.,

SAPONIFICATION.

This is a change which the fat as well as the other tissues of the body may undergo when exposed to very damp conditions. The tissues become changed into a soft, brownish white, greasy substance of offensive odour. From its resemblance both to fat and wax its name is derived (*adeps*, fat; *cera*, wax). When once it is formed it remains unchanged, but on exposure to the air it becomes hard, brittle, and yellow in colour.

Chemical Composition.—During the process of decomposition ammonia is formed, and may unite with the fatty acids (oleic and stearic) to form an ammonia soap (oleate or stearate of ammonium). This may be the composition of adipocere, but if there be much lime present in the soil then replacement may take place, and the adipocere may be an oleate or stearate of lime.

The formation of adipocere may be noticed in the dissecting room. Bones, after the limbs have been dissected, are often placed in a sink and covered with water for several weeks, during this time the fragments of tendon and ligament attached to the bones become soft and greasy, or in other words have become changed into adipocere.

The subcutaneous fat undergoes this change first of all, then the skin follows, and last of all the muscle. The breasts and

buttocks undergo this change soon; later, the peri-renal fat, and then the kidneys become saponified. The bodies of the young or of the corpulent become changed most readily on account of the large amount of fat which they contain. It is rare for the entire body to become saponified unless the conditions are very favourable. When an old cemetery was reopened in Paris some years ago, many hundred bodies were found excellently preserved; the dead had been buried in pits, and as the ground was very damp and clayey, the formation of adipocere was facilitated. The bodies retained all the characters of those recently dead. In certain cases the fœtus having died, and been retained in utero, has been changed into adipocere.

Conditions Necessary for the Production of Adipocere.—Before this substance can be formed certain conditions must be present:—

(1) Dampness of soil or clayey soils.
(2) Exclusion of the air.
(3) Presence of ammonia.

Such conditions are present in peat bogs where bodies have been found excellently preserved after the lapse of centuries. Submersion in water gives the requisite conditions; thus, the bodies of infants or old people have been changed completely into adipocere after having lain in running water for some months.

Length of Time Required.—Saponification commences in this country within three months after the immersion of the body in water, and is well advanced after the lapse of one year. When the body has been buried in damp, airless soil, the process is much slower, and may not be well advanced until the lapse of three years. In warm climates the formation of adipocere is in many cases very rapid, and the more easily affected parts of the body may be transformed into adipocere within three days.

Variations in the Rate of Putrefaction.

Certain conditions may modify the progress of decomposition. These may be (1) internal to the body or (2) external to it.

(1) **Internal Bodily Conditions.** (*a*) *Age.*—The bodies of infants undergo a rapid decomposition; the bodies of healthy

adults are slower in putrefying than are those of old people. When much emaciated, bodies tend to become mummified.

(*b*) *Condition of Body.*—The bodies of full-bodied or plethoric individuals decompose more rapidly than do those of spare, thin persons.

(*c*) *Cause of Death.*—Diseases which have caused death very often lead to a rapid putrefaction of the body. Especially is this the case when the disease has been due to specific organisms, *e.g.* anthrax, specific fevers, pneumonia, etc. In certain diseases decomposition may even have commenced before the person is actually dead, as in septicæmia or acute peritonitis. Dropsical bodies on account of the large percentage of fluid in the tissues putrefy rapidly. Those parts of the body which contain most fluids (eye, brain) decompose most rapidly. Bodies which have been much wounded decompose soon, as do also the bodies of those who have died after prolonged or severe exercise.

(2) **External Conditions.**—The conditions most favourable to rapid putrefaction are free exposure to the air, warmth, and moisture.

(*a*) *Free Exposure to Air.*—This hastens decomposition because of the easy access of micro-organisms. A naked body is more rapidly putrefied than a clothed one. The presence of boots greatly delays decomposition of the feet owing to the total exclusion of air. A body lying in a cold, close, small room remains fresh for a long period.

(*b*) *Warmth.*—Low temperatures retard, while moderately high temperatures promote decomposition. Bodies keep fresh for an indefinite period if the temperature be kept near the freezing point; if the temperature be high desiccation of the body is favoured. The most favourable out-door temperature for decomposition is between 70° and 90° F.

(*c*) *Moisture.*—Moist, warm air greatly hastens decomposition. The effects of "muggy" weather is well known in causing milk to turn sour in one or two hours, and in "tainting" meat in a few hours, but dry air tends to retard decomposition.

(*d*) *Medium in which the Body is Lying.*—The more loose, damp, and full of air the soil is, the more rapid is decomposition. Dry soils retard the process. Caspar states that if a body has arrived at a certain stage of putrefaction in one week when exposed to the air, it would have required immersion in water for two weeks, and burial in the earth for

eight weeks, to have attained a similar degree of putrefaction.

The sooner after death that a body is buried the more slowly will it putrefy, while if it be kept long before burial the progress of decomposition will go on rapidly after interment. Bodies buried in coffins do not decompose so rapidly as bodies buried naked in the earth. Hermetically sealed lead or zinc coffins render putrefaction a very slow process; even after six months the body may be fairly preserved in a lead coffin, but much of the tissues will have become changed into adipocere, while the internal organs will have deliquesced.

Rate of Putrefaction in Water.—As the temperature of water remains much more uniform than does that of the air, and as the body is protected from air, the rate of putrefaction is also much more uniform than when a body is exposed to atmospheric changes. The period which has elapsed since death occurred can thus be more accurately determined. A body requires to be twice as long in water as in air to reach a corresponding degree of decomposition. The greater the depth of the water the slower is decomposition, and the amount of clothing on the body has a similar influence. When once a body has been removed from water it rapidly decomposes, as the tissues have imbibed much fluid. The evidences of decomposition begin over the chest and head, and not over the abdomen as in ordinary putrefaction; these changes gradually spread downwards over the body.

In from Three to Four Days in water, the skin over the front of the fingers, and over the palms and soles of the feet, becomes bleached and wrinkled.

In Six to Seven Days this bleaching has extended to the backs of the hands, and to the skin of the face. Rigor mortis has disappeared.

In Twelve to Fourteen Days the skin over the whole of the hands and feet is bleached, and much wrinkled. The face is swollen and discoloured, with red spots under the skin. In drowning the head sinks lowest in the water, and as the blood flows to it decomposition shows itself early there. A green discoloration is seen in the skin over the sternum and neck. There may be a covering of algæ on the bare parts of the skin, and this must not be mistaken for mud or slime. This fungus growth is most marked in the angles of the body.

In Twenty-five to Thirty Days the skin of the hands and feet

appears as if it had been poulticed. The face is greatly swollen, and the skin covering it either green or reddish brown in colour. The green colour has extended widely over the chest, and the skin over the sternum is now brown. The scrotum and penis are greatly distended with gas. The growth of algæ may form a very thick covering to the body.

In Eight to Nine Weeks the face is still further swollen, and the skin over it and over other parts of the body is loose and detachable, the nails of the fingers and toes are loose or have fallen off, and the hair is also loose. The abdomen is greatly distended, but the skin over it is not discoloured to any extent. Saponification of the subcutaneous fat may be present.

In Twelve to Fourteen Weeks the features are unrecognisable, much of the skin is destroyed, the hair and nails are absent, and saponification has advanced.

In Eighteen to Twenty Weeks the skin of the face, neck, and axillæ has been destroyed ; the scalp is almost gone, the bones of the skull are easily separated, and adipocere is largely present. Much of the soft parts may have been eaten away by crabs or fish.

In warm summer weather the rate of putrefaction may be greatly hastened, thus, it may be three to five times as rapid as in the above statement.

A Body Floats from the accumulation of gases in ten to fourteen days in summer, and in six to eight weeks in winter. The buoyancy of a decomposing body is very great, and even though it be heavily weighted, the corpse may float on the surface. Putrefaction takes place more rapidly in running than in still water. A male body found in a stream was quite unrecognisable two months after death. A female body usually floats face upwards on account of the accumulation of fat in front, and the dragging down action of the hair of the head. A male body, on the other hand, usually floats face downwards. If possible, a body should be identified as soon as it has been removed from the water, as decomposition advances very rapidly on exposure to the air. The bodies of those found drowned in Paris are kept at very low temperatures in the Morgue. Dead bodies buried or exposed on *dunghills or manure heaps* decompose very rapidly on account of the heat, moisture, and number of organisms. The body of an infant may be in an advanced stage of putrefaction

after having been exposed on a manure heap for only twenty-four hours.

Privies or Cesspools.—If the body be wholly immersed in such, decomposition is slow, but if partly submerged and partly exposed, putrefaction is rapid.

Lime and Charcoal have been sprinkled over bodies with the idea of hastening decomposition. They have no effect whatever on putrefaction, but may absorb some of the gases evolved.

CHAPTER IV.

MEDICO-LEGAL POST-MORTEM EXAMINATIONS.

In police cases post-mortem examinations are made for the purpose of determining whether the deceased died from natural causes or from injuries alleged to have been inflicted. The question which the examiner has to decide is, "What was the real cause of death?"

No post-mortem examination should ever be made unless with the written authority of the Coroner, or warrant of the Fiscal. No medical man has any right to make such an examination on his own initiative, or even at the request of the relatives, if there has been any suspicion of foul play. If he has been the medical attendant of the deceased he is an interested party. The prosecution might allege that he himself had administered poison, and then in order to exculpate himself, that he had performed the post-mortem examination, and had either given an untrustworthy report, or had even got rid of the evidences of poisoning.

Usually an independent medical practitioner, or an expert, is summoned by the Coroner or Fiscal, and it is better to have two medical men associated in making the examination. On receiving notice to perform the autopsy, the medical man ought first to have the body identified, and to take down the names and addresses of those doing so. A photograph ought also to be taken, especially in the case of unknown or unidentified bodies. Only those authorised should be present at the examination; it has happened that persons implicated in the alleged crime have been admitted, and have thus been enabled to get rid of incriminating evidence. Dr. Palmer, who was found guilty of murdering Cook, was allowed to assist in the post-mortem examination; he endeavoured to spill the contents of the stomach so as to hide his guilt. The body must be carefully

conveyed on a stretcher to the mortuary or other suitable place; it must never be carelessly carried or doubled up, as slight injuries might by such treatment be greatly aggravated, and an erroneous impression might be conveyed. A simple fracture might be converted into a compound one, and parts which have been cut or lacerated are easily torn if roughly handled. The examination should be made as soon as possible after instructions have been received, because the further putrefaction has advanced the more difficult it is to interpret correctly the appearances. The clothes must be carefully removed, noting the number, position, and size of stains on them from blood, mud, or other material. If there are cuts on the clothing, these must be investigated to determine whether they correspond to wounds on the body.

1. **The Exterior of the Body** must be thoroughly examined, and a careful record made of the following points: (1) stature; (2) apparent age; (3) state of nutrition; (4) state of the skin; (5) presence and degree of rigor mortis; (6) presence and distribution of post-mortem staining; (7) the degree of decomposition; (8) colour and amount of hair; (9) presence and position of deformities, scars, tattooings, nævi, moles, etc.; (10) discolorations, *e.g.* bruises or abrasions, their distribution, extent, and changes in colour; (11) wounds, their situation, extent, and direction; (12) condition of eyelids; (13) eyeballs; (14) pupils; (15) nose; (16) mouth; (17) lips; (18) teeth; (19) tongue; (20) pharynx (wounds or foreign bodies); (21) ears; (22) neck (lividity, marks of ligatures); (23) chest; bruises, wounds, fractures of ribs; (24) abdomen, (distension, condition of inguinal canals, bruises, etc.); (25) genital organs; (26) anus; (27) description of injuries on each extremity in order; clenching of fingers, mud under nails, etc.

2. **Internal Examination.**—As a rule that cavity where the fatal injury has been received is examined first. The incisions which are necessary to open the cavities ought to be made free of any wounds which may be present on the surface. Wounds ought not to be roughly probed in order to determine their depth, because when the cavity is opened its inner surface can be examined, and it can then be seen whether the wound was a perforating one or not. If a probe is used it ought to be very blunt (as a bougie), and very gently handled.

The medico-legal post-mortem examination should be far more searching than an ordinary medical autopsy.

Every Organ and Structure of the Body must be Examined.—No part of the body must be left unexamined; if any organ or structure be overlooked, it will tell against the evidence, and the counsel for the prisoner will affirm that the organ or structure left unexamined was probably diseased, and was really the cause of death.

A man received a blow on his head; shortly afterwards he took a fit and died; his assailant was arrested on a charge of murder; the post-mortem examination showed only the presence of a bruise on the scalp, and that the blood-vessels generally were atheromatous. The medical man had, however, omitted to examine the kidneys; the prisoner's counsel made much of this, stating that disease of the kidneys was very often associated with arterio-sclerosis, and that in such cases death frequently resulted from convulsions. The prisoner was discharged. In another case a woman died from what was evidently acute irritant poisoning. The usual post-mortem examination did not reveal the cause, but a more careful inquiry showed that arsenic had been introduced into the vagina in a pledget of wool. The husband was arrested on a charge of murder.

A female prisoner was found dead in her cell. No cause of death could be detected, though the internal organs were greatly congested. The body was removed to a dissecting room, and while it was in process of dissection a small handkerchief was found stuffed into the pharynx, and this had caused suffocation.

Make a Careful Examination of the—

(1) Head.—In opening the skull, use the saw only, as a chisel might fracture the bone, and this might be mistaken for an ante-mortem injury; note the thickness of the skull cap; examine carefully for fractures; note adherence of the dura mater; the condition of the longitudinal sinus; appearance of brain (convex surface and base), its weight, and state of the cerebral vessels. Make vertical sections through the brain, and examine these carefully.

(2) Spinal cord and state of the meninges.

(3) Thorax.—Inspection of lungs; congestion on surface and on section; subpleural hæmorrhages; pericardium; heart (appearance, coronary arteries, veins); if injured, explore its conditions before removing the organ from the thorax; carefully examine its cavities, pulmonary artery,

valves, and myocardium; aorta (aneurism, bony plates). Remove trachea, œsophagus, tongue and stomach *en masse* in cases of poisoning.

(4) Abdomen.—Appearance, weight, and size of *every* organ. Pelvic organs: bladder, rectum, uterus, vagina.

(5) Note particularly the condition and colour of the blood.

Every organ must be removed, examined, and described as to its injuries or diseases. They may be preserved, and kept as articles of evidence in the trial (*real evidence*). In cases of suspected poisoning, six or eight large-mouthed and perfectly clean jars, with closely fitting lids, should be provided. Each of the internal organs (or a piece of each) should be placed in a separate jar, then the lid tightly closed, and fixed by means of parchment paper tied over it. The cord is sealed with wax and stamped. A label bearing the name of the person, organ, and date, must be attached to each jar. An inventory of these jars and their contents must accompany the written report of the autopsy.

AVERAGE WEIGHT OF INTERNAL ORGANS.

Brain (male)	49½ oz.	Stomach	4½ oz.
,, (female)	44 ,,	Liver	50 to 60 ,,
Lung, male, right	24 ,,	Pancreas	2½ to 3½ ,,
,, ,, left	21 ,,	Spleen	5 to 7 ,,
,, female, right	17 ,,	Kidney (each)	4½ ,,
,, ,, left	15 ,,	Suprarenal (each)	1 to 2 drachms
Heart	9 ,,	Uterus	7 to 12 ,,

In removing the stomach two ligatures should be placed at the lower end of the œsophagus, and other two at the pyloric end, and the structures divided between each pair. The stomach may be placed entire (in a suspected case of poisoning) in a jar and sealed up, or it may be placed on a large porcelain tray, and opened along its greater curvature. The intestines are removed after a ligature has been placed round the rectum as far down as possible; they may be examined at once or sealed in a jar.

These jars with their contents ought not to be allowed to pass out of your charge until you have conveyed them either to the analyst who has been appointed, and who will give a receipt for them, or to some representative of justice. After making the post-mortem examination, a formal report must be drawn up giving an account of all the evidences of disease or

injury observed, and finally, an opinion as to the cause of death. This report must be made "on soul and conscience," and is signed with the usual signature. If 2 medical men have made a joint examination, each of them signs the report. In many cases the examiner may not be able to find any cause of death, all the organs appearing healthy. The report must include such a declaration.

EXHUMATIONS.

When a body has been buried it cannot be again raised without an order from the Coroner, Fiscal, or the Home Secretary. It is a misdemeanour to disinter a body without such authority. Exhumation is usually requested in cases of supposed poisoning. It was only after the arrest of Dr. Pritchard on the charge of poisoning his wife that he was suspected of having poisoned his mother-in-law. Her body was exhumed four weeks after death, and on analysis, she was also found to have been poisoned by antimony.

Legal Limit of Time.—As long as any part of the body remains, evidences of poisoning may be found, and this is especially true if the body has been buried in a coffin. In Scotland, if an interval of twenty years has elapsed since the perpetration of the crime, the suspected person cannot be committed. This is called the *prescription of crime*, and is based on humanity, as after twenty years it would be difficult or impossible for the accused to obtain evidence in his favour, as most of his witnesses would be dead. In England there is no legal time limit. In France an interval of ten years since the crime, or since the last inquiry into the case, bars further proceedings against the accused.

Rules to be Observed.—After having received the order, the body should be exhumed as soon as possible, and the post-mortem examination performed in the open air or in an open shed. The body must be identified either from the name-plate on the coffin or by relatives. Deodorants may be employed freely, but must not be allowed to touch the body. The examination must be carried out as in an ordinary autopsy. If the coffin has decayed to any extent, then some of the soil in contact with the body must be preserved for analysis, as arsenic or antimony is sometimes present in the soil. The defence might allege that these poisons, if found in the body, had gained

entrance from the soil. In cases of murder and concealment by burial, the earth should be riddled, and everything found in it, such as buttons, paper, etc., should be kept, as they may lead to identification. It has to be remembered that undertakers are sometimes in the habit of burying still-born children in the same coffin with adults to whom they may be in no way related.

Embalming is the art of preserving the body after death; this was brought to perfection by the Egyptians, whose mummies three thousand years old yet retain their life-like characters. Without undertaking the duty of an embalmer, in certain circumstances it may be necessary to preserve a body for some time; this can be done by injecting into the blood-vessels an antiseptic fluid, such as formalin, perchloride of mercury, or arsenic. The femoral artery is opened, and a cannula having been inserted, about 6 to 8 quarts of the solution are injected slowly. The more perfectly this is done the better and longer will the body retain its normal characters.

EXAMINATION OF THE DEAD.

If the person is really dead, and if there be suspicions as to the cause of death (suicide or homicide), then the corpse ought not to be interfered with in any way, but information should at once be sent to a magistrate or police officer. If there be any friends or relatives in attendance they ought to be prevented from interfering with the body or any articles near it, as a homicide might be able to get rid of the proofs of his crime. It is better to lock the door, and on the arrival of some representative of justice to hand the key to him. The medical man is usually early on the scene, and as he has been trained to habits of observation, it is his duty to "notice everything" regarding the body, its surroundings, and any suspicious movements of persons.

(1) The body should be identified at once if possible. The deceased may be known to some of the spectators; if so, take down the names and addresses of both deceased and witnesses.

(2) Note the locality where the body is lying. Is it a place where death is likely to have occurred, or does it suggest that the body had been carried there? Are there any evidences of a struggle? In soft ground or grassy places such would easily

be seen, but they are often concealed by the footprints made by amateur investigators or sight-seers.

(3) Carefully examine the floor, ground, or surroundings, in order to see whether there is anything present which might have caused death. If the skull has been fractured, or if there is a penetrating wound, see if there are no sharp projections which might have caused the injury.

A man was taken up on suspicion of having murdered another whose body was found in a field. A penetrating wound was discovered on the occipital region of the skull; a careful examination revealed a sharp stump of a bush projecting 3 inches above the ground, and covered with blood and hair. The deceased had fallen backwards, and this stump had penetrated the skull and caused death.

(4) The attitude and position of the body may afford information. In death from natural causes, or from poison, the body is usually found in a natural position; in cases of murder, the body may be huddled together as if it had been thrown down.

(5) The hands may be clenched, and hair or fragments of clothing may be grasped in the fingers.

(6) In death from natural causes the expression is usually placid, while in death during great agony (*e.g.* angina pectoris), or from violence, it may be greatly contorted.

(7) The degree of warmth and of rigor mortis may give information as to the interval since death.

(8) Surrounding objects may give clues, as the presence of a bottle or vessel containing poison near to the suicide, or the hand may still tightly grasp a knife or razor in a case of cut-throat. The mere proximity of poison or lethal weapons to a body is, however, not presumptive of suicide.

(9) The condition of the clothes may show whether a struggle had taken place, and the hands may be scratched, bruised, lacerated, or cut in cases of homicidal assault.

(10) Spirtings of blood on walls or furniture are characteristic of arterial hæmorrhage, and are usually in the form of slanting exclamation points.

APPARENT DEATH OR SUSPENDED ANIMATION.

Great care must be taken to verify death, because such conditions as syncope, trance, catalepsy or partial asphyxia, closely simulate real death.

Syncope.—In this condition all the appearances of death are present; respiration cannot be observed, and the heart's action seems to have ceased. Cases of prolonged syncope have often been mistaken for actual death, and the cold air to which the body has been exposed during its preparation for burial has been the means of restoring animation to such. John Howard relates that one hundred and fifty years ago typhus fever was the scourge of overcrowded prisons, and that many prisoners who were supposed to have died from this disease recovered during the process of washing and dressing their bodies in the open prison yard. Unless active help be speedily given to persons suffering from syncope, death frequently supervenes. Ogston narrates the case of a young lady who was supposed to have died from pericarditis; she was left for dead, but four hours later recovered, and lived twenty-four hours longer.

Trance and Catalepsy.—All varieties of such conditions are met with. The person may appear as if merely sleeping, or he may exhibit very strikingly all the appearances of real death; the animal heat, however, remains unaffected, and rigidity is absent. There may be absolute unconsciousness, or (*horribile dictu*) perfect consciousness may be retained whilst there is total inability to move a muscle. No amount of stimulation in the shape of electricity, pricking, or irritating gases has any effect on such cases of trance. One individual in a condition of trance was saved from burial by his friends noticing a copious perspiration breaking out on his face as the coffin lid was being placed over his body. The author knows of a lady who was on two separate occasions prepared for burial. Sir William Gairdner records the case of a girl who remained in a trance for twenty-three weeks. In another case a woman aged twenty remained in a cataleptic condition for eight weeks during which her skin became quite cold. A woman eight months pregnant was supposed to have died, and was buried. Some servants dug up her body, and cut off the fingers to get the rings, but were so frightened at the bleeding that they left the body lying. The woman recovered and walked home, and in due time was delivered of a full time child. Colonel Townsend could inhibit his heart's action for as long a time as thirty minutes; he could voluntarily die to all outward appearance, and also voluntarily resuscitate himself; after his death disease of the kidneys alone was found.

Partial Asphyxia may be a result of short immersion in water, of the inhalation of irrespirable gases, or after accidental strangulation or hanging. It is a condition also found in many new-born children. Individuals have been resuscitated after having been immersed in water for more than an hour.

PREMATURE BURIAL.

The risk of mistaking apparent for real death is not so likely to happen in cold as in warm countries. In the latter, burial takes place a few hours after death, while in colder countries it is, as a rule, delayed for some days. Of late, however, the tendency is to hasten burial even in this country. Premature burial is, in spite of medical scepticism, a real danger; that this is so, is largely due to the looseness of death certification. Many deaths are registered without any medical certification, and medical men frequently grant certificates of death without having seen the dead body. Authentic cases of supposed dead persons rising from their coffins are numerous. In 1906, in Lancashire, while some women were holding a "wake" over a female friend, the corpse sat up so suddenly, and frightened them so much, that 2 women in their hurry to escape fell down the stair.

The Egyptians knew of the risk of premature burial, and their dead were kept under the observation of priests until they were certain that death had occurred, when the bodies were embalmed. The Greeks, before the body was cremated, cut off a finger to determine whether death had actually taken place. Pliny tells of those who recovered when about to be laid on the funeral pyre, and of others who recovered when enveloped in flames. In India many cases are recorded where persons have sat up in the midst of the furnace pyre, and have been beaten back under the supposition that the body had become the habitation of evil spirits.

Archbishop Donnet was supposed to have died, and was about to be buried; he was recalled to life, however, by hearing a familiar voice, and he states that he knew what went on during his supposed death. A clergyman was laid out for burial; his daughter was sitting by his side, when he suddenly asked, "For whom is that bell tolling?" and she answered, "For you, papa dear." Schwartz, the Indian missionary, made known that he was not dead by joining in

his favourite hymn which was being sung over his supposed dead body. In 1877 a medical man and the Mayor of Naples were sentenced to three months' imprisonment because they had certified as dead a woman, who, in her efforts to break out of her coffin placed in a vault, had fractured her limbs. In London in 1905 a woman who had been laid out for six hours after her apparent death, was resuscitated after artificial respiration had been practised; she had been subject to cataleptic seizures.

Before granting a certificate of death an inspection of the body should be made, and if there be any doubt as to the reality of death, then every known test should be applied.

CERTIFICATION OF DEATH.

In cases of death from natural disease, the medical man who attended the deceased during his fatal illness must furnish a certificate of death; if he refuses he is liable to a penalty of £2. In cases of sudden death, if the medical man knew that the deceased suffered from a grave malady, and if he is satisfied as to the cause of death, he may grant a certificate even though he may not have seen the deceased for some time previous to his death. Certificates of death must be forwarded to the Registrar within five days of the death. In Scotland it is customary to send the certificate to the Registrar. In England it is handed to the nearest relative or guardian as being the "qualified informer."

A medical man may refuse to give a certificate of death if he is not satisfied as to the cause, as, for example, in cases of unexpected death, or of death under suspicious circumstances, or from violence (accidental, suicidal, or homicidal). The Registrar of Deaths may, however, be satisfied with the explanation of the qualified informer, and may grant an order for burial, or he may refer the case to the Coroner or Procurator Fiscal. The latter if satisfied after inquiry may grant a burial order.

Many deaths are registered without any medical certificate as to the cause, as the deceased may never have been attended by any medical man. The birth of every infant born alive must be notified within thirty-six hours of its occurrence, and so must its death, no matter how short a time it may have lived. Still-births must also be notified. Great care should

be taken in filling up a death certificate. The primary cause must always be distinctly stated, as well as the secondary causes if any exist. Thus, dropsy is not a primary disease, but is secondary to disease of the heart, kidney, or liver.

DYING DECLARATION.

This is the statement of a person made in the immediate prospect of death relative to the manner in which he has been injured. Its value as evidence depends on the fact that the person making the declaration believes himself to be dying, that death is approaching, and that recovery is impossible. The individual believes that he is about to enter into the presence of his Maker; the conditions are quite as solemn as if he were on his oath; every motive to falsehood is silenced:

> Have I not hideous death within my view?
> What in the world should make me now deceive,
> Since I must lose the use of all deceit.
> (SHAKESPEARE, *Richard II.* Act II.)

It is very likely that when the medical man arrives he will find that the injured person has but a short time to live. It is better that the declaration should be made to a magistrate, Procurator Fiscal, or other police official, but in many cases there is no time to delay, so the practitioner must take down the deposition. One or two witnesses should be present if possible, and if the dying person does not state that he is dying, then the medical man must inform him of this fact, and that he has only a short time to live. The declaration should be written down as it is uttered, or as soon as possible; the exact form of words without comments should be employed. The declarant should commence with an unqualified belief in his impending death. Dying declarations have been disallowed because they contained such statements as "no hope of my recovery *at present*," or "he thought he should not get better." Let the declarant tell his own story as to the circumstances of the injuries, the names of the assailants, etc. No questions are to be put to him until he has quite finished, when if there be any dubiety as to his statements, one or two questions may be put in order to clear this up. If possible read over the declaration to the dying man, let him assent to

it, and if possible sign it. The witnesses should also adhibit their signatures. Such declarations are used as evidence against the accused if the declarant dies. Be careful to note the exact state of mind of the person making the declaration. Is he perfectly composed? Does he exhibit anger or vituperate against certain individuals? Remember that after much loss of blood, or after injuries to the head, mild delirium may come on, and false accusations and misstatements may be made. Even if the person live some days after making his declaration, it is still used as evidence if he die, because he made it under the belief that he was dying. In Scotland such a declaration is admissible even though the person making it is not conscious of the imminent danger of death.

Presumption of Death.—If an individual be not heard of by his relatives or friends for seven years, the law presumes that he is dead. This is done in the interest of his heirs and successors, otherwise they might never come into their rights. By the law of Scotland the heir of a person who has disappeared for seven years may uplift the annual income, and thirteen years later may take possession of the estates. If it can be shown that death is likely to have taken place, as for example in shipwreck, the Courts may curtail this period very much. In one case a ship captain sailed from Calcutta for Port Louis in the Mauritius, but the ship was never heard of again. The Court presumed that he was dead, although he had not been more than two years away from England. When the body cannot be produced, the onus of proof lies on the person who asserts the presumed death. The Courts are as a rule very unwilling to presume the fact of death, because many people go away voluntarily, and cease corresponding with their friends. In 1878 a gentleman left his hotel in a village in North Wales to bathe in the sea; soon afterwards his clothes, watch, and money were found on the shore, but his body was never recovered; his death was presumed to have occurred, and an assurance policy on his life was paid. Some months later he was recognised in South America, where he had gone to escape financial disgrace. In another case a Frenchman insured his life for 100,000 francs; he came to England, and it was alleged died there; his wife presented to the Assurance Company a copy of her husband's death certificate, but on inquiry it was found that he had certified and registered his own death, had bought a coffin, and attended his own funeral procession. When

the coffin was exhumed it was found to contain only a large mass of lead.

Presumption of Survivorship: Priority of Death.—When 2 or more persons perish in a common accident, it is important from the point of view of succession to determine which one died first. In civil law it is presumed that if parent and child die together, the child dies first. If, however, the child be above the age of puberty this presumption is reversed. If man and wife die together, the latter is considered to have died first. As a rule the stronger and more vigorous is presumed to have survived longest. In England evidence must be led to show which one died first. In France there are fixed rules (Code Napoléon) for determining the presumption. In coming to a conclusion look to—

(1) Age.—As a rule the parent will survive the young child; old people easily succumb in drowning, exposure, etc.

(2) Sex.—As a rule the male survives the female.

(3) State of health.

(4) Manner of death.—In conditions producing asphyxia, females usually live for a longer time than males. In drowning, cold, or starvation, the order of death is, children first, then females, and lastly males.

In cases of parturition, where both mother and infant are found dead, it is almost impossible to determine which died first. Many cases are left undecided by trial, the decision being that it is impossible to determine whether one survived the other, and that it must be presumed that both died at the same moment. A case recently tried in Philadelphia illustrates the difficulty of settling such claims. A Dr. Scott left a will settling his money on his nephew; while they were in a canoe, it was overturned, and both were swept over Niagara Falls. Dr. Scott's heirs affirmed that the nephew died first, as he was seen to strike his head on a rock when the canoe was upset; whilst all the evidences of drowning were present in the body of Dr. Scott. On the other hand, the nephew's heir stated that the latter was seen struggling in the rapids after Dr. Scott had disappeared.

MODES OF DEATH.

Life and health depends on the proper action of the heart, lungs, and brain. This has been called the "tripod of life."

Bichat (1798) considered that death might arise from a failure of each of these, and though this classification is by no means scientific, it deserves consideration because of its antiquity.

I. **Failure of the Heart.**—This may be sudden or gradual. Sudden failure is seen in syncope or in shock.

Syncope. *Symptoms.*—There is cardiac weakness and arterial anæmia; the person becomes extremely pale, staggers, is giddy, and so anxious for fresh air that he or she almost invariably endeavours to get out into the open air. There is a feeling of sinking and of impending death; nausea and vomiting may be present, the individual passes into a condition of unconsciousness and flaccidity. The pulse becomes gradually more and more feeble until it is imperceptible, and respiration is weak and gasping in character. When syncope results from loss of blood there is great restlessness with "*air hunger*," and before death, delirium or convulsions.

Causes.—(1) Heart disease in its various forms (aortic regurgitation, fatty disease, etc.). (2) Reflex inhibition of the cardiac centres in the brain may be produced from fright, joy, grief, or from slight blows over the area of distribution of some sensory nerve. (3) Profuse hæmorrhage, especially if sudden, may lead to fatal syncope.

The following is an example of death from fright. The janitor of Marischal College, Aberdeen, incurred the resentment of the students. At a mock trial he was condemned to be beheaded, and was made to kneel down, and place his neck on the block. The executioner raised his sword, and at the same moment a wet towel was brought down on the janitor's neck; he was then told to rise, but the fun was turned to sadness, for the servitor was dead. Lately, a woman who was embracing her husband on his release after a long term of imprisonment, fell dead in his arms. Individuals have frequently fallen back, and died instantly, on receiving slight blows on the epigastrium, or after having drunk copiously of cold water while overheated.

Shock.—The symptoms are very similar to those of syncope, but consciousness is retained, the voice is low, the eyes staring, the pulse rapid and weak, and the skin bathed in a cold sweat. The same causes which produce syncope may produce shock, though it more often results from the infliction of pain, as during the sawing through of the bone in amputation, after burns, etc. The stimulus may reflexly inhibit the heart's

action through the vagus nerve, or it may also paralyse the vaso-constrictor nerves, more especially in the veins of the abdomen, so that they become immensely dilated and filled with blood. In the latter condition it is very much as if a copious hæmorrhage had taken place.

Gradual Failure of the Heart.—This is seen in many asthenic conditions, as in exhausting diseases or old age.

II. **Failure of the Lungs** (Asphyxia) (symptoms, see page 155) may result from—

(1) *External or Violent Causes*, as suffocation, hanging, drowning, or irrespirable gases.

(2) *Natural or Internal Causes*, as diseases of the lungs or pleuræ, embolism of the pulmonary artery, paralysis of the muscles of respiration, or of the respiratory centre in the medulla.

III. **Failure of the Brain** (Coma).—This may be due to—

(1) Injuries or diseases of the brain or its membranes, as concussion, effusions of blood on or in the brain substance, depressed fractures, abscess or tumour of the brain, embolism.

(2) Circulation of poisons produced in the diseased body, as uræmia, diabetes.

(3) Certain poisons, as opium, alcohol.

Symptoms.—The person is unconscious, powerless, with stertorous breathing, the pulse is full and usually intermittent, and the skin is covered with a cold sweat.

SUDDEN DEATH FROM NATURAL CAUSES.

Syncope is the commonest cause of *instantaneously sudden death*, accounting for two-thirds of all such cases, and most usually results from fatty degeneration or infiltration of the myocardium.

Incompetence of the aortic valves, rupture of the heart, or of a valve, or of an aortic aneurism, embolism of a coronary artery, angina pectoris, may lead to very sudden death, either on exertion or from mental excitement. Both George II. of Britain and Philip V. of Spain died from rupture of the heart, the former while straining at stool, and the latter on hearing of the defeat of his army at Piacenza. Mere fright may lead to such a degree of shock that death may supervene at once. A hunter was knocked down by a panther, and although hardly injured, died next day in a condition of profound terror.

Less sudden but unexpected death is due to such causes as cerebral apoplexy (even in children), rupture of an abdominal aneurism, œdema glottidis; rupture of a varicose vein, extra-uterine gestation, or an enlarged spleen; embolism of the pulmonary artery, post-partum or from phlebitis; ulcerative endo- or peri-carditis may cause sudden death in apparently healthy individuals; laryngeal paralysis after diphtheria may lead to choking, or latent diphtheria may lead to syncope, as may also latent pneumonia, or the condition of grey hepatization often met with in drunkards.

Asphyxia may be rapidly produced, as from hæmoptysis in the course of phthisis, or from laryngismus stridulus or croup. A fatal attack of epilepsy closely resembles death from strangling. A man having seen his wife off by train, met a young girl and took her to his home, where he had intercourse with her; she retired to a water-closet, but, not returning, the door was broken open, and she was found lying dead with superficial wounds on her head and body. Other signs of death from epilepsy were present. The man was arrested on a charge of strangling the girl, but was acquitted. His wife divorced him, and he in remorse blew out his brains.

Mitral and tricuspid valvular lesions usually produce a slow exhaustion, but seldom cause sudden death unless the individual has greatly exerted himself, as in running for a car.

Arterio-sclerosis may lead to thrombosis, embolism, or aneurism, and sudden death may follow exertion or emotion, as the vessels are inelastic; if it affects the vessels of the brain, instant death may follow rupture of the basilar artery.

Such trifling procedures as making a vaginal examination, passing a uterine sound, or giving a vaginal douche, may induce syncope, and in several cases have led to death. Even playfully compressing the larynx has induced fatal inhibition, and the application of ammonia to the larynx for the treatment of asthma has induced instant death. A little boy playfully gave an old woman a flip with his hand over her *pomum Adami*, with the result that she instantly fell dead.

A hyperplastic condition of the lymphatic structures and spleen, together with the persistence of the thymus and other conditions met with in certain individuals (*Status lymphaticus*), is believed to predispose to sudden death, and especially if the individual be under an anæsthetic. Acute hæmorrhagic pancreatitis leads also to rapid death in certain cases.

CHAPTER V.

WOUNDS.

A WOUND may be defined as "a recent breach of continuity in the structures of the body, internal or external, occasioned by mechanical violence." Such a definition, therefore, includes not only cuts and stabs, but also bruises, fractures, dislocations, ruptures of internal organs, burns, etc. In surgery the term wound has a much more restricted application. The legal definition is vague—"that whereby the skin is divided either externally or internally" (Vict. 14 & 15, chap. 100). It would, therefore, not include injuries affecting the mucous membrane, *e.g.* injuries to the rectum, vagina, mouth, etc. Though not included under this statute, these injuries, as well as fractures and dislocations, are usually embraced under the term "wounds" in criminal law.

Wounds Dangerous to Life.—The medical witness may be asked by a magistrate to give his reasons for stating that a wound is dangerous to life. It is not sufficient merely to state in the formal report that a wound is dangerous to life, the reasons for believing it to be dangerous must also be given. Great care should be exercised in giving these reasons, as the medical attendant will be severely cross-examined on them by counsel for the prisoner, when he appears in the witness-box. The danger may be immediate, as a wound of a large blood-vessel, or a stab in the abdomen. On the other hand, wounds, *e.g.* of the limbs, are not necessarily dangerous, though they may become so later on from the supervention of erysipelas, septicæmia, etc. The former would be described as dangerous to life, but not the latter. The magistrate desires this information that he may admit the accused to bail if the injury be slight, but if dangerous no bail is allowed. The wound may result in "*grievous bodily harm*"; that is to say, it may confine the

assaulted person to bed for a time, place his life in danger, or result in permanent disablement or deformity. All that the medical man has to do is to describe the wound and its situation, and allow the jury to draw their own conclusions. The punishment for this offence is five years' penal servitude.

Assault.—(1) **A Common Assault** is an attempt or offer to do a corporal hurt to another. Although the assailed person may not be struck, yet the offence is an assault. Sufficient has been done by the assailant to show that he has a violent animus against the injured person. Thus, to menace one with the fist, or with a weapon or stick, or to point a gun at a person, is in law an assault. No words, however provoking, can constitute an assault; it requires the exhibition of intention. To throw water on an individual; to ride at him so as to make him run; to hound a dog on a person, are examples of assault. Such common assault cases are dealt with in the Police Court, and the penalty is imprisonment for any period not exceeding two months, with or without hard labour, or a fine not exceeding £5. Medical men have frequently to defend themselves against charges of indecent assault. For example, if you wish to examine the heart or lungs, and do not first ask the woman to unfasten her clothes, but proceed to do so yourself, you may lay yourself open to the charge. The same may happen if you make a vaginal examination without first asking the woman's permission. It is always a wise proceeding to have a respectable female present during any examination of a female patient. It is an assault to take indecent liberties with a woman even though she does not resist.

(2) **Aggravated Assaults.**—These, as a rule, show a greater degree of violence, or produce grievous bodily harm. The use of sharp or blunt weapons, assaults to the effusion of blood, and to the danger of life, fractures of bones, attempts to commit rape or murder, are all examples of aggravated assault. Such cases must be tried by a Superior Court (in Scotland by the Sheriff), and the punishment is imprisonment for a term not exceeding two years.

Battery is the actual accomplishment of an assault; violence, though usual, is not necessary. The least touching of a person in a rude insulting manner, constitutes the crime of battery.

Homicide.—(*Homo*, a man; *cædo*, to kill.) By this is understood the killing of a human being, without implying any criminal responsibility.

Justifiable Homicide means the killing of a human being without incurring legal guilt, as in carrying out a sentence of hanging, or where a person in self-defence kills another. If a prisoner in endeavouring to escape is killed by a warder or policeman, or if a person kills another to prevent him accomplishing an atrocious crime, justifiable homicide would be the verdict.

Excusable Homicide may be considered as almost the same as justifiable homicide. The following are examples: killing an individual in defence of one's wife, child, servant, or property; or when one is killed by mere accident, as being hit by a cricket ball, or being knocked down while playing football.

Felonious Homicide or Murder.—The unlawful and intentional killing of a human being by a human being constitutes the crime. Murder is unlawful homicide with malice aforethought. The person accused must be of sound mind and discretion, and above the age of fourteen years. To cause death by reckless disregard of consequences is also murder. If in trying to kill a person, another is killed, the crime is still that of murder; the felonious intention was present. The punishment is death by hanging. In former times the punishment was carried out on the second day after condemnation, and the body of the murderer was hung on a gibbet near the place where the crime was committed. At present the prisoner is not executed until fourteen days after his trial.

Attempted Murder, or an assault intended to end fatally, or to cause grievous bodily harm, amounts to a felony, and may be punished with penal servitude for life.

Manslaughter (England) **or Culpable Homicide** (Scotland). —This is unlawful homicide without malice aforethought. It may have been the result of negligence (as in the case of the captain of a steamer running down a small boat) or of hot blood. Should a man strike another with no intention of killing him, but if the injury prove fatal, he is charged with manslaughter. If the act of killing is done in the heat of passion caused by provocation the charge is that of manslaughter. The punishment may vary from a fine to penal servitude for life.

EXAMINATION OF WOUNDS.

The following points must be carefully investigated, and should be noted at the time. The number, situation, length, breadth, and depth of each wound; the presence of blood, whether in large amount, and coagulated or not; whether the edges of the wound are bruised, swollen, or everted, if there is lymph or pus present, if the wound is gangrenous, or if it contains any foreign body. The wound ought not to be probed, as it might readily be made into a penetrating wound, but if over any of the cavities, a blunt instrument, such as a catheter, may be used to determine its depth and direction. The wound should be very carefully inspected to make out what structures have been injured or divided, *e.g.* vessels, nerves, tendons, etc., and its external appearance must never be interfered with, as the question is often asked, "Could the weapon produced have inflicted this injury?"

Even though the wound may have undoubtedly caused death, it is necessary to make a very careful inspection of all the other organs of the body. Counsel for the prisoner may urge that the deceased died from natural causes, and the medical examiner must be able to refute his statements. Such an examination is specially necessary if there be any doubt as to whether the wound inflicted was capable of inducing death. The search for poisons must never be omitted; suicides have swallowed poison first, and have then inflicted wounds on themselves. A father thrashed his daughter severely for stealing, and she died shortly afterwards. He was arrested on a charge of murder. The autopsy showed that she had poisoned herself with arsenic, as she had feared discovery of her offence. In another case a young man swallowed corrosive sublimate, then divided the vessels in his wrist so as to bleed to death; finally he threw himself out of the window, but lived long enough to confess what he had done.

Incised Wounds.—The following characters are usually present in an incised wound: the edges are gaping and everted; fluid or clotted blood fills up the wound, and infiltrates the subcutaneous and muscular tissues around the cut; the escaping blood has flowed out of the wound on to the clothes, and, it may be, on to the floor, and thus coagulated blood is found in these localities. The wound is long as compared with

its breadth (spindle-shaped). The edges are smooth, and the sharper the instrument the more cleanly-cut are the edges. If a small artery has been divided there are spirtings of blood on the walls or adjacent furniture. If the wound is deep, and if muscular fibres have been cut across, it gapes very widely. As to the direction of the injury it is often difficult to give an opinion; as a rule the commencement of the wound is deeper, and it gradually becomes shallower towards the end. If the skin be loose and the weapon blunt, the former may be puckered up in front of the knife, and the presence of two or three incisions may indicate the termination of the cut. This is sometimes seen in "cut-throat," but homicidal injuries are often angled (not linear) owing to the assaulted person struggling. If the wound be made some hours after death, the edges lie close together, there is no vital retraction of the skin, there is little bleeding, and that only of a venous character; there is no cellular infiltration, or clots in or around the wound.

If the wounds are inflicted on a very recently dead body (say within one hour after death), the edges are slightly everted; there is very little hæmorrhage, and a few small clots only may be found in them. The question as to the ante- or post-mortem infliction of wounds is difficult to decide, and a guarded opinion must be given.

Exceptionally, a blunt instrument may produce effects similar to incised wounds; as where the blow has fallen on very tense structures covering bone, *e.g.* scalp, shin, malar region. A blow on the head from a stick may split the scalp as cleanly as if done by a knife, but on looking at the edges of the wound the hair bulbs are found projecting on each raw surface.

Incised wounds from their shape and character may enable one to determine what weapon had produced them. When healed, the resulting scar is linear or fusiform. Stab wounds often appear smaller than the weapon which caused them; this is due to the contraction of the elastic fibres of the skin.

Punctured Wounds.—These are produced by instruments whose length is much greater in proportion to their breadth. They penetrate deeply, and may injure important internal organs. A rapier thrust may transfix both the lungs and the heart. Such wounds are much more dangerous than incised wounds, and may be produced by bayonets, files, scissors, etc.

Like stabs, the wounds in the skin are usually smaller than the weapon which produced them, and their shape will depend not only on the form, but on the way the instrument was held. The edges are usually everted. In examining punctured wounds, note if the edges are clean cut as if caused by a sharp instrument, or irregular as if produced by a rough weapon. The defence may allege that deceased fell on some projection, as an iron railing. Such wounds are characterised by profuse hæmorrhage, which may be internal, and due to the wounding of the heart or large vessel. In one case a woman committed suicide by thrusting an ordinary pin $1\frac{1}{2}$ inches long into her heart, the pericardium being found full of blood.

Perforating Wounds.—These wounds perforate the part of the body on which they are situated. The entrance wound is as a rule larger than the exit wound; this is due to the shape of the weapon, which is usually thicker towards the handle; if the weapon be rough and rusty the edges of the entrance wound are everted. Though there is only one entrance wound several internal wounds may be found; this shows that the instrument had been partially withdrawn, and thrust in again in a new direction, and indicates brutal violence. Such injuries have been inflicted on females by thrusting a stick, red-hot poker, or other weapon, into the vagina.

Lacerated, Contused, or Torn Wounds.—Such injuries may be produced by falls from considerable heights, being ridden over, being crushed by machinery, by bites, tears from projecting nails, blunt weapons (clubs), etc. The edges of the wound may be torn into rough, irregular flaps which are greatly swollen. The skin beyond the seat of injury is ecchymosed; there is usually little or no bleeding, even when large vessels, such as the axillary artery, have been torn through. The coats of the artery give way at different levels, and natural arrest of hæmorrhage takes place. A drunkard had his arm torn out from the shoulder, yet went about for five days without receiving any surgical attention, and exhibited the wound to any one who would stand him a drink. If the parts be very vascular, there may be fatal hæmorrhage. Thus, kicks on the female pudenda may result in fatal hæmorrhage. Contused wounds of the scalp may result in division of the temporal artery, and as this vessel is firmly bound down it cannot contract, and may continue to bleed for long.

Wounds from Glass or Earthenware are very irregular

(stellionate injuries, *stellio*, a lizard). Such accidents may occur by a person falling while carrying glass or earthenware vessels; by women using a cracked *pot de chambre*, and these injuries may prove fatal from hæmorrhage. The pieces of glass or china are in part very sharp, in part blunt, and the resulting injuries are either lacerations or contusions. The edges of these wounds are very uneven, some parts are cleanly cut, others torn and bruised, and in the wounds fragments of broken glass or pottery may be found.

Healing of Incised Wounds.—A knowledge of the rate of healing of wounds is of the greatest medico-legal importance as it affords information as to when the injuries had been inflicted. The edges of an incised wound commence to swell up, and become tumid in from eight to twelve hours after the injury. At the end of this time a discharge of blood-stained serum commences, and continues more or less for the succeeding two days, becoming, however, by degrees sero-purulent until by the third day the discharge is entirely purulent. This discharge of pus lasts for four to five days. Small red granulations are present on the surfaces, and gradually fill up the wound. The cicatrix at the same time grows in from the edges until the wound is entirely healed in from the twelfth to the fifteenth day. If the wound be absolutely clean, and if the edges be closely approximated at once, healing by *first intention* may take place. In such a case the wound is cicatrised in a week, and little or no mark may remain.

Certain Conditions may Modify the Rate of Healing, *e.g.* great vascularity of the part induces rapid healing. Thus, wounds of the face, tongue, or mouth, heal within a few days. On the other hand, want of rest, or too free movement of the part, greatly retards the process of healing; thus, wounds over joints and flexures are very slow in cicatrising.

Contusions, Bruises, Ecchymoses.—Such injuries are inflicted by blunt weapons, *e.g.* fists, feet, stones, falls, etc.; they may be of any degree of severity from a black eye to great lacerations of the deep-seated tissues. A slight injury causes the rupture of the subcutaneous capillaries, while a more severe accident leads to the rupture of larger blood-vessels. In any case blood is extravasated under the skin if the injury has been slight, so leading to the immediate production of a blue-black discoloration. If the deeper tissues alone have been injured, several days may elapse before the altered hæmoglobin filters

through to the skin; in the latter case the bruise never appears blue, but only greenish yellow. Thus, a blow over the thigh may give rise several days subsequently to the production of a green colour just above the knee. In the same way a blow on the forehead may cause an ecchymosis in the lower eyelid of that side. The bruised part is usually raised above the level of the surrounding skin, owing to the effusion of blood and lymph. The shape of the bruise often corresponds to the instrument which has inflicted it, as a claw hammer will leave a bifurcated mark, and the marks of the fingers may be found on the neck in cases of throttling. A mere squeeze of the arm in some people (usually females) may give rise to bruising.

The presence of numerous bruises on the body, and more especially if they be of different ages, as shown by their colour, indicates that ill-usage has been practised for some time. The bodies of children often exhibit such a series of bruises, but one must carefully distinguish these from the hæmorrhagic extravasations which are associated with scurvy or purpura. Badly nourished children, often the offspring of depraved parents, may suffer from such blood diseases, and hence the danger of mistaking the one condition for the other. In scurvy, the fœtor of the breath, spongy condition of the gums, looseness of the teeth, and deeply seated hæmorrhagic extravasations are usually to be found.

Changes in Colour During the Absorption of the Bruise.—Gradually the colour begins to change at the edges, and spreads inwards to the centre. Thus, the whole bruise has become greenish in colour from the fifth to the sixth day, and then changes to a deep yellow from the seventh to the twelfth day. This yellow colour slowly fades in tint, till the fourteenth to the fifteenth day, when the skin resumes its normal appearance. If there be any change of colour whatever from blue, then the bruise must have been inflicted some time before death. Subconjunctival extravasations may result from sneezing, coughing, etc.; they are bright red, and undergo no colour changes, but fade to a yellow tint and disappear. Bruises sometimes appear spontaneously in certain individuals, or they may result from great muscular exertion, as after severe epileptic seizures; in the latter the bruises are usually numerous but small in size. Injuries which have been inflicted just before death may not appear as bruises until after death.

When very severe blows are inflicted on the recently dead

body, they may produce appearances similar to slight bruises produced during life, and these usually soon turn to a pink or scarlet colour. Such injuries may be found on the bodies of people drowned in a dock or harbour, as a result of blows from propeller blades or paddles of steam-boats. Severe blows may cause the rupture of internal organs while producing no ecchymoses on the skin. The mode of distinguishing an ecchymosis from post-mortem staining has already been indicated (p. 55).

Were the Bruises the Result of Accident or Homicide?—This question is often not easy to decide. In falls from a height the injuries are usually multiple, and mud, sand, or gravel, may be found in the wounds. In cases of murder, bruises may be on the vertex, or if on the body, they are usually on the front, and their shape may indicate that they resulted from kicks or certain weapons.

Agonal Injuries.—Injuries sustained by an individual through a fall at the time of death are termed "agonal injuries." Thus, for example, a man who suddenly fell dead from the rupture of an aortic aneurism, received severe bruises on the right cheek and forehead, a lacerated wound of the lower lip, and a fracture of the lower end of the right radius. Such injuries are sometimes thought to have been the actual cause of death. A careful inspection, however, will reveal vital reaction in these wounds, thus, pointing to their infliction during life. The post-mortem examination will also, as a rule reveal the real cause of death.

"Parchmented Skin."—By this is meant a hard, dry condition of the skin on certain parts of the dead body; it results from an obliteration of the capillary blood-vessels leading to a drying of the integument. Severe external violence applied to the skin of the recently dead body may produce such a change. Thus, for example, parchment skin is found under the ligature in death by strangulation or hanging, or after severe blows or stripes. If a recently dead body be dragged on its back along a rough floor, this condition will be found as patches on the shoulders, back of neck, arms, etc. The presence of "parchment skin" indicates that considerable violence has been inflicted.

Fractures, Dislocations.—Such are classified as severe injuries or aggravated assaults, and the accused cannot be tried in the ordinary Police Court, but must appear before a

superior tribunal (in Scotland before the Sheriff). It is difficult to determine whether a fracture or dislocation has been produced just before or immediately after death.

Reparative Changes in Fractures.—The periosteum, blood-vessels, and muscles are lacerated by the broken ends of the bone, and much blood is effused between and around the fractured ends, and in the torn muscles. This extravasation having undergone coagulation, remains until the end of the first week. The more fluid part, as well as the hæmoglobin, become slowly absorbed. Within eighteen hours of the injury a sero-fibrinous exudate commences to form, and this, together with the gradually diminishing blood extravasation, remains for about two weeks as a medium binding the bones. At the end of the second week cartilaginous callus commences to replace the fibrinous exudate, and this continues to increase until, at about the twenty-sixth day, the bones are united by an entirely cartilaginous callus. This is gradually transformed into true bone within two months from receipt of the fracture. If bones be fractured two hours or later after death, little or no extravasation of blood takes place between the broken ends. Falls or blows may produce fractures or dislocations, and superficial ecchymoses may indicate their mode of origin. Excessive muscular exertion may also cause fracture of bones, thus, the patella may be broken across in trying to save oneself from falling, or the olecranon process of the ulna in delivering a heavy blow. It has to be remembered also that certain diseases or conditions cause the bones to acquire an excessive degree of fragility, as for example, syphilis, scurvy, cancer, old age. In certain diseases of the nervous system, and notably in general paralysis, the bones may be fractured by the simplest movement of the patient in bed, thus, the ribs or neck of the femur may give way. Asylum attendants are frequently accused of inflicting excessive restraint on such patients, while in reality they may be quite innocent.

CHAPTER VI.

GUNSHOT INJURIES. BURNS AND SCALDS.

GUNSHOT INJURIES.

THESE form a variety of contused wounds. The appearance of such a wound depends on (1) size and shape of the projectile; (2) its velocity; (3) distance from firearm; (4) angle of impact.

The force of the impact is equal to the resultant of the velocity multiplied by the weight of the projectile. If the bullet be travelling at a very high velocity, then it acts merely as a punch, cutting a clean hole through the intervening tissues. If, on the other hand, its velocity be slow, it causes a far greater destruction of the tissues through which it passes, and the slower its velocity the greater is the damage inflicted. This is well shown by firing a rifle at a thick book. The bullet makes a perfectly clean punched-out hole for perhaps a third of the thickness of the volume; then as it loses its velocity, the hole becomes more and more irregular, and the destructive effects greater, leading to a widespread tearing of the leaves.

Death from gunshot wounds may be due to (1) Shock. (2) Hæmorrhage; this may be due to division of a large artery, as the femoral or aorta, or injury to one of the vascular internal organs. (3) Injury to important nervous structures, *e.g.* bullet wound in basal part of brain or cervical cord. The bleeding from an ordinary gunshot wound is seldom severe, and generally takes place from the exit wound, unless a large vessel has been divided. Along the whole tract of the bullet the tissues are so devitalised that they form sloughs which separate later.

Wounds made by Round Bullets.—Weapons for firing these are obsolete in the armies of most civilised countries. They are still used in country districts of our own land (the old

muzzle-loaders), and by less civilised races. The use of flint-lock guns has not by any means died out in such countries as Africa and Australia. The entrance wound is as a rule small, round, with the edges inverted and dry, and deeply ecchymosed; fragments of clothing may be carried in with the bullet. The wound of exit is usually larger, with very ragged, bloody, raw, everted edges, due to the slower velocity of the bullet; often fragments of bone are found adherent to the exit wound.

If a bone be large, and the velocity of the bullet high, a more or less round hole is punched out, but many fissured fractures radiate from it. If, however, the velocity of the projectile be slow, any intervening bone is more or less completely smashed up.

Distance from which the Gun was Fired.—If quite near at hand, the edges of the entrance wound are torn, lacerated, and slightly inverted. They are blackened not only from the excessive bruising, but from the particles of carbon carried in with the explosive gases (tattooing) and on the bullet. In rare cases blackening may not be present even in suicidal gunshot wounds. The skin around the entrance wound is ecchymosed from the impact of the gases of explosion, and often scorched. Hair, if present, or clothing may be ignited. If farther away, the edges are less torn, and the opening is more circular in form. If the bullet strike the skin obliquely, then the opening is oval or channelled ("seton-wound"). If still farther off (above 6 feet) the wound caused by the bullet is round, the edges are slightly ecchymosed and inverted, but there is no tattooing. The exit wound is large, ragged, and often everted. The skin may contract after a bullet has pierced it, and so the impression is given that the bullet produced could not have caused the wound.

When a round bullet passes through dense structures, as fascial bands or muscles, it leaves merely a tract. Round bullets not having a very high velocity are somewhat easily caused to deviate out of their course, as by encountering dense bone, thick fascia, or tendons. This is especially apt to happen if the weapon, *e.g.* a pistol, be held firmly pressed on the skin. The bullet may break into fragments in the tissues, and much more damage is then inflicted.

In some suicidal cases where the pistol has been held very firmly against the skin, the bullet has not even penetrated;

this may be due to the air in the barrel acting as an air cushion, and so preventing the bullet from leaving the weapon, a bruise corresponding to the bore of the pistol being alone found. In other cases when fired near at hand the bullet may not traverse the body, but may lodge in it.

Conical Bullets presenting a far smaller surface area produce much less laceration than do round bullets. In most of the modern army weapons the bullet is in the shape of an elongated cone (Lee-Metford, Mauser). The barrel is also rifled so as to give a rotatory motion to the projectile, and so increase its velocity. With the new explosives employed, such projectiles attain a high velocity, and usually pass through the body. The entrance and exit wounds are very much alike, the latter perhaps being slightly larger. The entrance wound is often extremely small, and may resemble an incised wound; it is blackened by smut from the bullet. Unless they traverse a vital part, they seldom do much injury to the internal organs, as the limit of their destructive power is practically confined to their tract. A small bore bullet may make its way through a bone without breaking it up. Wounds of the lungs or intestines produced by such bullets often run a perfectly normal course. As such projectiles are practically aseptic, there is no need for hurry in their removal; in fact, recent military surgery has shown that it is much better not to operate on such cases as most of them recover.

If sepsis ensues it is almost invariably due to pieces of clothing carried in by the bullet. If the bullet be of soft lead, and more so if the apex be hollowed, it is apt to become mushroom shaped, and as a result great damage is done to the tissues (Dum-dum bullets). Little or no change takes place in the wound for eight to ten hours; the edges then become intensely congested, and almost black. In the clothes, the exit wound is always larger than the entrance, and its edges are much torn. When a revolver is discharged in close proximity to the body, the clothing may be ignited.

Is the Wound Suicidal, Accidental, or Homicidal?—The chief points to attend to are (1) position of the wound, (2) direction of the tract, and (3) any surrounding circumstances.

Suicide.—All the characters of a gunshot wound inflicted at close range are found. The suicide usually selects "vital sites," as the heart or the brain. When gunpowder has

been the explosive, carbon particles may be carried out by the escaping gases, and may blacken the hand which grasped the pistol. If the left hand has been employed to steady the weapon, its palmar surface will likely also be blackened. The weapon may be found tightly grasped in the hand of the deceased (*cadaveric spasm*). Corroborative evidence is often present, farewell letters may have been written, the door may be locked on the inside, strings may have been attached to the trigger, and so on.

A fatal result is not always attained at once by the suicide, hence two or more fatal gunshot injuries may be found present. An injury may be a fatal one though it may not be so immediately, and thus a suicide may be able to reload his gun several times. Many cases are recorded of suicides discharging weapons into the brain, and subsequently into the heart. In one case, a man discharged a sporting rifle charge into his left side, this caused great laceration of the colon and stomach; he then discharged the gun into his mouth, and destroyed the whole of his brain without, however, injuring his scalp. In another case a man shot himself in the brain; the bullet destroyed the anterior part of the right hemisphere, and lodged in the fourth ventricle; the individual thus injured journeyed from the country to the town, where he played billiards and drank freely of whisky, and only succumbed to the injury after an interval of eighty hours.

Accidental Gunshot Wounds.—These injuries happen very frequently to sportsmen or game-keepers while climbing over or through a fence or hedge. In some cases the site of injury may be such that one can hardly believe the injury was accidental. While cleaning a fowling-piece the charge exploded, and blew off the greater part of a man's face; his beard was found adhering to the ceiling, and his teeth on the floor. The man survived.

Accidental injuries to others than the owner of the weapon are also not infrequent. Thus, a gun may be discharged at the head of an individual, as he is just appearing over a ridge, in mistake for a rabbit or hare. Almost daily accidents occur from the senseless practice some people have of pointing and firing a gun "in fun" at a person, when it is supposed to be empty. A bullet may strike on a rock or wall, and rebounding may strike an individual. Thus, an officer in trying to shoot a dog hit a wall, and the ball rebounding killed himself. In another

case the ball rebounded from a wall, and lodged in the back of the neck of a girl who was passing.

Homicide.—In cases of murder the gunshot wound is usually on the back or side; this is, however, by no means invariable, as the person may have been attacked while in bed.

Explosive Charges.—Formerly gunpowder was the only explosive substance employed, and even at present it has a large range of usefulness. It is a simple mixture of charcoal (carbon), sulphur, and nitrate of potassium. It does not really explode, but on ignition it burns with great rapidity evolving large quantities of gases, chiefly carbonic acid gas and carbon monoxide gas. The unburnt particles of carbon may cause tattooing of the skin.

Of recent years other explosives have largely replaced gunpowder in military and naval practice. These mainly consist of nitro-powders, such as nitro-cellulose, nitro-glycerine, picric acid, and various picrates (ammonium picrate). These are chemical compounds, and explode when ignited. Such powders cause no blackening of the skin even when fired near at hand.

Wounds from Sporting Charges ("Small Shot").—For sporting purposes the cartridge consists of two compartments; the one nearest the hammer being filled with gunpowder, whilst the distant chamber is filled with small shot. This is sold in different sizes, 0 to 9, and hence the particular size may lead to the identification of the assailant, if shot of similar size be found in his possession. When such a charge is *fired near at hand* ("point blank") the shot travel together in one compact mass, and resemble to a great extent a solid bullet. In such a case there is one large opening with an irregularly indented margin which is deeply ecchymosed and blackened. The skin surrounding the opening is bruised and pigmented. When the weapon is discharged from about the distance of 1 *foot* the mass of shot is not quite so compact on reaching the body; there is a large central opening, but the edges are more irregular, and much lacerated; they are also blackened as in the preceding instance. As the distance is increased the central hole becomes more ragged, and its edges more lacerated; separate shot holes pepper the margins. Beyond this distance (2 *to* 3 *feet*), though there is a fairly compact mass of shot, scattering has taken place to a great extent; there is now hardly a central opening in the skin, though many shot holes are closely

approximated towards the centre of the field; the shot are now widely scattered over the surrounding surface. At greater distances the shot have scattered so much that only a few strike, and penetrate any individual part. This is the condition of affairs in shooting game. The entrance wounds of such shot are liable to be overlooked, as they are very small and slit-like; the edges are, however, blackened from smut adhering to the shot. Small shot as a rule lodge in the body. It is impossible to mistake wounds from sporting charges for bullet wounds.

Wadding and Powder Wounds.—Even though there is no bullet or other projectile in the cartridge (blank cartridge), severe injuries may be produced if the weapon be fired close to the body; the wadding, or unconsumed grains of carbon, and even the force of the onward rush of gases, may cause very severe laceration of the tissues, and even death. Pieces of clothing, or the wad of the charge, may be carried into the wound. In the case of muzzle-loading guns, paper is often made to do duty for a proper wad; this may be carried, by the force of the gases, a considerable distance into the body.

Examination of Gunshot Wounds.—Everything which may help to trace the assailant must be carefully kept, the bullet, shot, pellets, wadding, etc. If there be any peculiarity about these, and similar articles be found in the possession of a suspected person, it would strengthen the suspicion. If the wad has been made of a piece of newspaper, then the remaining part of that paper may be found in the possession of the accused. Dickens describes how such a piece of printed paper led to the conviction of the murderers of Mr. Tulkinghorn (*Bleak House*). The weapon should be most carefully examined as to its lock, barrel, and stock.

Experiments with Weapon.—Careful experiments should always be made with a weapon similar in every respect to the one produced. It should be loaded, and fired from varying distances at a sheet of white blotting-paper fixed over a box of sand. It may also be necessary to experiment with the carcases of sheep or pigs to determine the nature of the injuries.

When was the Weapon Fired?—Little positive information can be gained by an examination of the firearm. Nitro-powders leave only a slight yellow deposit in the barrel. Gunpowder in a very recently fired gun leaves a coating of carbon, and the barrel smells strongly of sulphuretted hydrogen. Any

further information is inconclusive. At later periods oxides and sulphate of iron are formed in the barrel.

Direction from which the Gun was Fired.—If a straight line be drawn between the entrance and exit wounds, and prolonged in front, it will point to the direction from which the weapon was fired, provided that the position of the person when struck is known. Thus, if the entrance wound be on the right side of the chest, and the exit on the left side, and the person was walking along a road, then the weapon must have been fired from a point to the right of the deceased.

Restriction in the Sale of Firearms.—(Pistols Act 1903). It is illegal for any person to sell a gun, or other firearm, to any one who has not a gun license, or who cannot give a reasonable proof that he is entitled to carry such firearms. If the purchaser, however, gives a written statement signed by himself, by a justice, or by a police inspector, detailing the purpose for which it is required, then a firearm may be sold.

BURNS AND SCALDS.

These are very often the result of accident, and are especially common amongst women and children on account of their loose garments. If a door be suddenly opened while a woman wearing a light dress is standing near a fire, the draught may carry her skirt into the flame, and in a moment the flimsy material may flare up, and inflict a widespread burn. The careless habit of throwing lighted matches on the ground or on the floor has often led to death from the clothing catching fire.

In the same way children clad only in their nightdresses may receive extensive burns through this garment catching fire. Flannelette is, when new, a light fluffy material made of a mixture of wool and cotton; cheap varieties are remarkably inflammable, and hundreds of children meet their death from this accident every year. One of the London Coroners had to inquire into eleven such deaths in one week. The pity of this lies in the fact that flannelette can be rendered non-inflammable by a cheap chemical process. Absence of a fire guard leads often to such disasters. Articles made of celluloid break into flame when brought even for a moment in contact with a naked light, and women often receive very severe burns from their celluloid combs bursting into flame. Children may receive very severe scalds by pulling over teapots or kettles filled with

boiling water; such injuries are usually situated on the front of the chest, abdomen, and arms. Sometimes they inhale the steam issuing from a kettle, and severe scalding of the mouth, throat, and larynx, or œdema glottidis may supervene, and death result. Steam escaping from a burst boiler pipe produces scalds of a very severe nature.

Burns from molten metals and boiling oils cause great destruction of the tissues. Whilst the engineer of the Eddystone Lighthouse was gazing at the destruction of his work by fire, the molten lead ran down, and entering his mouth caused his death.

Dry Heat produces various degrees of burning.

(1) Simple redness of the skin (hyperæmia or erythema).

(2) Redness and blistering of the skin.

(3) Charring and shrivelling of part of the true skin, which becomes dark and horny, and very painful from exposure of the nerve endings.

(4) Charring and total destruction of the skin; surrounding this the skin is less burned, and is white and horny. Outside of this at the junction between the burned and healthy skin there is a line of intense inflammation which gradually merges into the normal skin.

(5) Destruction of the whole of the skin, subcutaneous tissues, and even muscles.

(6) Total destruction of part or whole of the body.

Scalds.—Boiling liquids cause a widespread, red, soft, sodden condition of the skin. There is little loss of tissue; blisters of large size may form, and the superficial layers may slough off. In cases where an individual falls into a vat of boiling liquid, the tissues may be almost wholly destroyed, and fall away from the bones when the body is recovered.

The intensity of the burn depends on (1) the degree of heat applied, and (2) on the duration of exposure.

Fatal Terminations often follow burns, especially at the extremes of age or in nervous females. After severe operations, hot-water bottles placed in the patient's bed may produce extensive burns. Large sloughs of dead tissue may separate, and the patient may suffer for weeks or months from the effects.

Prognosis after Burns.—This depends on I. The extent of the burn. II. Its situation. III. Age of the patient. IV. Whether septic or not.

I. The extent of surface involved is of far greater value in prognosis than the degree of burning. A man may fall against a fire while in a fit, and one arm may be charred almost to a cinder; in all probability he will recover, whilst another who receives a widespread but superficial burn will succumb. As a general rule it is safe to affirm that if one-third of the skin surface of a body be destroyed, death is likely to ensue. If there is mere redness (erythema) covering two-thirds of the skin surface, death usually follows in forty-eight hours.

II. Situation.—Burns over the serous cavities (abdomen, thorax, skull, or over the genital organs) are much more dangerous than those of the limbs.

III. Age.—Young children succumb readily to shock, but withstand prolonged suppuration better than adults.

IV. Septic conditions render the prognosis grave.

Death may Result from—

(1) Shock. The severity of the pain may cause inhibition of the heart's action and immediate death; such accidents may happen from the clothes catching fire or from the explosion of inflammable gases. In the days of religious persecution, martyrs were often burned at the stake; as a rule women were strangled by twisting a noose round the neck before the faggots were ignited; but in the case of men this was not done, and death either resulted from the intensity of pain produced by the flame, or from suffocation by the gases of combustion.

(2) Suffocation in many cases causes death before the flames have time to reach the person. In combustion oxygen is used up while poisonous gases (carbonic acid and carbon monoxide) are produced. In houses where fire has broken out, the inmates may be unable to help themselves through these gases gaining access to their rooms, and causing suffocation; this accounts for dead bodies being found unharmed by fire, after the conflagration has been subdued.

(3) Œdema glottidis, acute bronchitis, or broncho-pneumonia may cause death when boiling water, steam, or caustic solutions have been sucked into the mouth.

(4) Stupor and coma may be a sequence of severe burns, especially in the case of children. After the injury they remain pale and quiet (shock), and gradually pass into a condition of coma. It is, therefore, advisable not to give opium or morphine to children in a state of shock, lest the drug be considered to have produced the comatose condition.

(5) Inflammation of the serous surfaces or internal organs may result from burning of the skin over them, and the individual may die in a few hours or days from meningitis, peritonitis, enteritis, bronchitis, or pneumonia. Perforating ulcers of the duodenum may cause the death of the patient during the second week after the accident.

(6) The burn may continue to suppurate for weeks or months, and the person becomes gradually exhausted from the discharge or from waxy disease of the internal organs. In other cases gangrene may supervene, and death follow.

(7) Injuries received from falling beams, bricks, etc., during the conflagration.

Were the Injuries Inflicted before or after Death.—Slight burns cause an erythema on the living body, but not on the dead. When blisters are formed during life, the inflammatory reaction shows itself in the form of a dark red line surrounding the vesicle. When the raised cuticle is removed, the entire base of the blister is found to be markedly inflamed, the papillæ stand out as red swollen elevations, and small points of intense redness are seen which correspond to the inflamed sweat glands or hair follicles. If the contents of the vesicle be caught in a test tube and heated, it will solidify as a mass if the blister has been formed *during life*, the exudation consisting entirely of serum albumin; chlorides are also present in large amount. If the blister has been produced *after death*, then it is either filled with gas or with the more watery constituent of the blood; if heated in a test tube this fluid merely becomes milky, but does not solidify; chlorides are absent or present in very small amount, and the contents are often bloody. Blisters can be raised with difficulty on the skin of the recently dead body (up to twenty-four hours after death) by the application of either dry or moist heat, but more easily if the body be already dropsical; but in such there is no inflammatory reaction as is produced during life. If soot or particles of carbon be found in the larynx and trachea, it points to the individual being alive at the time when the burns were inflicted. If vital reactions are not present, it will be difficult to affirm whether the person had been alive or dead when the burns were inflicted, as death might have taken place almost immediately, and before there had been time for inflammatory reaction. If the blood spectrum is that of HbCO, it may be presumed that the person was alive when the burns

were received, as blood only unites with carbon monoxide during respiration.

When were the Burns Inflicted?—If well-marked signs of inflammatory reaction, as redness of the skin, or vesication, be found, then in all probability the person has lived two to three hours, or longer, after the injury. If suppuration of the burn be present, then he must have survived two to three days. The formation of granulation tissue, or the separation of sloughs, indicates that the person had lived for several days. After burns have cicatrised, great deformity may result; thus, in burns of the front part of the neck, the chin and the lower lip may be dragged down on to the chest.

Post-mortem Appearances.—If the burn has been caused by radiant heat (as from a furnace) the skin is whitened. If, however, a flame has actually played on it, it is raised into blisters, and blackened by the soot; a sharp red line will be found separating the burnt skin from the uninjured skin. The skull may burst from the intensity of the heat, and subdural hæmorrhages may be produced. There may be deep cracks through the skin and tissues, owing to the intensity of the heat; these resemble incised wounds, but there is neither blood-clot in them nor infiltration of the cellular spaces with blood, and the blood-vessels often escape, and may be seen stretching across the crack. When the entire body has been exposed to great heat, as in falling into boiling vats, the whole albuminous constituents of the body undergo coagulation, "heat stiffening" occurs, and causes a certain amount of flexion of the limbs (so-called "pugilistic" attitude). The blood is often cherry-red in colour from HbCO. The blood-cells undergo very ready destruction by heat; they lose their biconvex shape, and become globular or pear-shaped; a condition of poikilocytosis results with polymorpho-nuclear leucocytosis. This destruction of the blood leads to the formation of an immense number of minute thrombi. The lymphoid tissue throughout the body is profoundly affected. The lymph follicles of the intestine are greatly enlarged, and so are the lymphatic glands generally. The internal organs are found deeply congested. A condition of cloudy swelling is present in the cells of the liver and kidney.

Nephritis often results, and the tubules may be found filled with thrombi, and extravasations of blood are found in the centre of the kidney. The *lungs* are often shrunken, and the

mucous membrane of the bronchi congested; sooty mucus may be present in the tubes; subserous hæmorrhages are usually found on the surface of the lungs. Signs of asphyxia are present if the person has been suffocated.

The Intestinal Mucous Membrane is also congested, and in parts inflamed. This inflammation especially picks out Brunner's glands in the duodenum, and if the person survive for a sufficient length of time, small ulcers form at the site of these glands.

The Spleen is softened and enlarged.

The Brain and Spinal Cord are often found shrunken and hyperæmic; this specially affects the grey matter of the cord. The posterior cornua are deformed and chromatolysis is present in the cells. These cells undergo other degenerations, and their processes may lose their connection with the cells. Burning seems to produce a toxin in the blood which gives rise to the pathological conditions present in death from burning.

It is often difficult to identify burnt bodies; parts of the clothing, keys, watch-chains, etc., may be found. In many cases the sex may be recognised, as the sexual organs with the pubic hair often persist, though the extremities may have been perfectly carbonised. If the body be entirely consumed by fire, the teeth are usually found intact, and the bones retain their shape though they become so powdery that the least handling causes them to fall into fragments. Total carbonisation of the body may occur if the individual fall into molten metal. If the body be reduced to ashes, there is much calcium phosphate present. It requires at least eight hours to consume a body by fire. A careful examination of burnt dead bodies must be made. Murderers have killed their victims by blows or bullet wounds, and have then set fire to the furniture or house in order to hide their crimes. Recently a baby farmer was sentenced to a year's imprisonment for burning the bodies of infants who had died while under her care.

Röntgen or X-ray Burns.—Experience has shown that X-ray photographs (skiagrams) are not to be implicitly trusted. Thus, in the case of a man who was supposed to have swallowed a set of false teeth, the skiagram appeared to show that the plate had lodged at the lower end of the œsophagus. The man was anæsthetised, and the stomach opened, but the plate

of teeth could not be found anywhere; at this moment the man's wife arrived with the artificial teeth, which she had found under the bed. The unfortunate man, however, died from the operation. The presence of atheromatous plates in the thoracic aorta has given rise to erroneous diagnosis. X-ray photographs have also shown the presence of fractures in bones while in reality none existed.

X-ray burns are due to faulty exhibition, and are not nearly so often met with now as they were when this treatment was first introduced, investigators being then ignorant of the intense action of these rays. The idiosyncrasy of the patient exerts a marked influence on their action, and the symptoms may not show themselves until a week has elapsed. Certain individuals are injured by a very short exposure, whilst others are able to stand comparatively long exposures without receiving harm. Bad results from X-rays may be: simple dermatitis; the epidermis and the hair may be shed; blisters may form on the skin, and are very slow to heal; the skin and subcutaneous tissue may slough, and an indolent ulcer may remain. Gangrene may supervene on burns of the extremities; this necrosis may spread deeply, and amputation of the digits or of the limbs may be necessary. X-ray burns over the abdomen have been fatal. Actions for damages for injury received by X-rays have often been raised against the operator; he has been accused of carelessness, negligence, or ignorance. Radium may produce burns very similar to X-ray burns.

X-ray workers have in several cases developed cancer of the parts exposed, and the action of the rays so frequently induces sterility that the use of leaden aprons has been advocated.

Burns from Oil or Petroleum Lamps.—Very severe burns are inflicted when a petroleum lamp explodes, or is thrown at a person. The clothes become saturated, and the injuries are extensive as well as deep; from the insufficient amount of oxygen, the flames are very sooty, and the skin is much blackened. Explosions in *coal mines or of gunpowder* produce widespread burns with blackening of the skin and tattooing.

Burns Caused by Corrosive Liquids.—These may be accidental, as by the breaking of a vessel containing the corrosive, or intentionally produced as in "vitriol throwing." The cast-off mistress or the jilted sweetheart may find a certain satisfaction in causing the disfigurement of the face of her former lover or of her own supplanter; this is

usually attempted by throwing strong sulphuric acid in the face of the person assailed. Unless the acid be immediately washed off, or neutralised, it destroys the skin, and especially the conjunctiva and deeper tissues of the eyes. Sight may be lost either from the formation of corneal opacities or from the anterior chamber being opened into. The skin destroyed by the acid sloughs off, and scars and unsightly deformities are left when the wound has healed. Sulphuric acid causes brownish black burns on the skin, while it chars the clothes, and produces a red colour. Nitric acid causes yellow stains to be formed on both skin and clothing. The caustic alkalies may be thrown on the face, and produce intense inflammation, and even destruction of the eye. The mere throwing of a corrosive liquid at a person is a felony; the infliction of actual injury is not necessary to constitute the crime. Any person throwing any corrosive fluid or any destructive substance with intent to disfigure or disable, or to do grievous bodily harm, is liable to penal servitude for life or to imprisonment for any term not less than three years.

Molten Metals, red-hot solids, resins, etc., cause a limited destruction of the tissues, which become dry, charred, or even completely destroyed. Recently 24 men were completely incinerated through the bursting of a furnace containing molten metal.

Boiling Oil causes burns resembling those produced by dry heat.

Spontaneous Combustion (Empresmus).—It is well known that spontaneous combustion may occur in the holds of vessels owing to the evolution of inflammable gases; thus, a cargo of coals may, through slow oxidation, give off much marsh gas, olefiant gas, carbon monoxide, etc. If phosphuretted hydrogen be also evolved, it will cause ignition of the other gases, and thus, the cargo of coal may be set on fire. Arguing from the spontaneous inflammability of certain organic compounds, it has been affirmed that similar conditions might arise in the bodies of certain individuals, and so might lead to the sudden ignition of their bodies, and total consumption by fire. It is said that such a concatenation of suitable circumstances is most likely to be met with in the bodies of those addicted to alcohol, or in the bodies of very fat bloated people; such individuals are usually past the prime of life, and the alcohol has led to abnormal metabolic processes. The abdomen is the

usual locality where the combustion first commences, as it is there where the spontaneously inflammable gases are most abundantly evolved. Theoretically, it is possible that if the body of a very stout person were thickly clothed, and if the clothing caught fire, the fat might be raised to such a temperature that it would act as fuel in keeping up the flame in the same way as the tallow in a candle feeds the wick. The human body is composed of four-fifths of water, and even with the added probability of spontaneity, it is difficult to believe that such could be reduced to ashes by combustion without the surrounding objects being also set on fire. The older authors narrate many cases of what they call spontaneous combustion in elderly individuals of both sexes, and lay stress on the fact that the bodies were entirely consumed whilst the furnishings of the room remained untouched.

Charles Dickens was a firm believer in spontaneous combustion, and in *Bleak House* (chapter xxxii.) he gives a most graphic description of the unctuous, oily vapours which oozed on the window frames, and of the discovery that the ragshop keeper Krook had disappeared leaving only a carbonaceous writhing mass on the kitchen floor, at which the horrified cat was staring.

Captain Marryat makes Jacob Faithful's mother disappear in a similar fashion.

Practically it is very difficult to explain many cases where the body alone seems to have been consumed. So great an authority as Professor Dixon Mann asserts that there is a preternatural combustibility in certain individuals, and that their bodies are capable of burning alone when once ignited. He narrates the case of a man who suffered from faulty digestion accompanied by foul eructations. These consisted largely of marsh gas. This individual got out of bed one night to see what time it was; he struck a light, and his breath took fire with a report so loud that his wife was awakened.

A case which seems to fulfil all the usual conditions of spontaneous combustion was related in the medical papers some months ago. An elderly, very intemperate woman, who lived alone, was last observed alive reading a paper by candle light; next morning smoke was seen issuing from the closed shutters of her sitting-room. On breaking into the house, the upper part of the walls and ceiling of the room were much scorched,

but the furniture was intact; at first no trace of the occupant could be found, but a small heap of black debris was noticed on the floor; this heap consisted of the broken calcined bones of a human body, with the skull on the top. Every particle of soft tissue of the body had disappeared, and yet a table covered with a baize cloth within 3 feet of the remains was unharmed. The jury were decidedly of the opinion that this was a case of spontaneous combustion. Many cases of so-called spontaneous combustion have really been murders in which the criminals have endeavoured to conceal their crime by setting fire to the body.

CHAPTER VII.

MEDICO-LEGAL EXAMINATION OF WOUNDS.

EXAMINATION OF THE DRESS.

This must always be carefully examined in order to determine whether there are stains of blood, mud, or other substance on it, or whether it has been cut or torn. In the latter case the cuts on the dress may not correspond to the wounds on the person, and this would suggest to the examiner that the wounds had been self-inflicted. In the clothing the first cut is usually free from blood, but the second and following may be blood-stained on account of the knife becoming bloody. In one case a man was apprehended on the charge of murdering a woman who was found dead in bed with a fracture of the parietal bones of the skull; a careful examination of the bonnet, however, showed that a part was deeply indented and covered with mud; the depressed part corresponded to the fracture in the skull. On inquiry it was found that the woman had been knocked down, and that the wheel of a cab had come in contact with her head; she had quickly recovered from the shock, walked home, undressed, and gone to bed; extravasation of blood had taken place on the surface of the brain as a result of the fracture caused by the wheel, and the woman died during the night.

Self-inflicted or Imputed Wounds.—These are wounds inflicted by the person on himself in order to bring a charge against another. This may be done merely in the hope of obtaining notoriety, or it may be done to annoy, or actually to cause a charge of assault or attempted murder to be brought against another person with whom he has had some dispute. Such wounds may be inflicted so as to screen himself from a charge of robbery or even murder. When a man is in

financial difficulty, he may sell his jewels, and then inflict such injuries on himself, stating that he has been robbed and half murdered. Listen to the story and note any discrepancies between it and the wounding. Self-inflicted wounds are always situated over the front of the body in localities easily reached. They are seldom over vital organs, and are always superficial in character, rarely penetrating farther than the true skin. The wounds are usually numerous, and more or less parallel. They are seldom present on the hands, while in cases of attempted murder the hands very frequently receive cuts while the individual is defending himself. The wounds on the body have to be compared with the cuts on the clothing. In some cases the stupid individual has entirely forgotten to make any stabs in his garments. In other cases the cuts in the coat do not correspond with those in the vest or under-garments. It is rather unlikely that an individual would be rash enough to stab himself through his clothing as he might inflict more severe injury than he intended. It is much more likely that he would hang up the clothes and make slashes through them, and then make the cuts on his naked skin. It must be observed whether the cuts on the various articles of dress correspond in their position to the wounds on the skin. In imputed wounds the outer clothing is often stained with blood, whereas in actual assaults the inner garments are those which are wetted with the escaping blood.

SUICIDAL, HOMICIDAL, OR ACCIDENTAL WOUNDS.

It is not always an easy matter to determine whether an individual had met his death from suicide, homicide, or accident. In the elucidation of these questions, however, help may be got by the evidence obtained from the wounds as to (1) their position, (2) nature, (3) direction, (4) extent, (5) number of wounds, (6) condition of locality.

(1) **Position or Situation of Wound.**—The suicide, as a rule, chooses the front of the body, and inflicts wounds over vital organs. Thus, he either cuts his throat or stabs himself in the heart. If he select a gun or pistol, this is discharged into his mouth, forehead, temple, or heart. Though these are the usual sites, suicides may select many others. Thus, a woman

cut through the walls of her vagina, and when the intestines protruded she pulled down several feet, and cut them off. A man filled his mouth with gunpowder, and blew off the greater part of his head. A lunatic drove two chisels into his brain; one chisel was 8½ inches long, and was driven by means of a mallet weighing 2½ lbs. right through the temporal region from one side of the skull to the other, and projected 1½ inches on the opposite side; he drove the other into the centre of the frontal bone; notwithstanding these severe injuries he walked a considerable distance, and was quite conscious. A woman in an asylum took a blunt knife, and cut her head almost off from behind. One man stabbed himself three hundred and eighty-five times in the body, while another recovered after driving three 3-inch nails "home" into his skull. A workman heated an iron rod until it was red hot, and drove it into his abdomen. Another individual applied the muzzle of a pistol to his anus, and discharged the weapon. While in delirium, a man tore away nearly the whole of his anterior abdominal wall. Many suicides exhibit much ingenuity in the mode of taking their lives, as in fixing guns or pistols, and firing them by strings attached. One man arranged a guillotine so that the blade would fall only after a certain amount of water had flowed out of a cistern; he placed his head in position with his mouth over a saucer containing ether; at the appointed time the blade fell, and decapitated him.

If, however, the position is such as to have been very difficult or even impossible of access for the person, then homicide may be presumed. This conclusion must be arrived at cautiously, however, as suicides often manage to wound themselves in apparently inaccessible localities; a man inflicted thirty severe wounds on the back of his skull with a cleaver.

Accidental Wounds are as a rule met with in exposed situations. Exceptions to this are frequently met with. Thus, a young girl was found with a severe wound of her vagina; she had been sitting on a hay-stack, and slipping down fell on a concealed pitchfork.

(2) **Nature of Wound.**—Suicides, as a rule, make use of incised wounds (as in cutting the throat) or gunshot wounds. There may be several more or less parallel incisions, the first being tentative and slight; then as the blood begins to flow the suicide becomes desperate, and makes the final deep incision. In the case of suicidal cut-throat, the blood flows down the

inside of the clothes, and this indicates that the person was standing when he inflicted the wound. Butchers who are in the habit of "sticking" sheep may commit murder by driving the knife in at the side of the neck, and so severing both carotid arteries. The wound may show that it could not have been produced by the weapon found near the deceased. Contused wounds are generally the result of accidental violence; occasionally, however, an insane individual will butt at a wall so as to fracture his skull.

(3) **Direction of Wound.**—In cases of suicide the incision is usually said to be inflicted in a direction from left to right, and sloping downwards; in the case of stabs that they are inflicted in a direction from above downwards. It has to be remembered, however, that many people are left-handed, and consequently the wounds would be on the right side. Some individuals are able to use each hand with equal ease (ambidextrous). In homicide it is said that the stabs are usually directed from below upwards, and that incised wounds undermine the edge of the wound at its commencement. The instrument with which it is alleged the wounds have been inflicted must be compared with the wounds, to determine whether it is possible that such a weapon could have produced the injuries. Thus, a narrow-bladed knife, if driven into the tissues at right angles, makes a small wound in the skin; if, however, it be held on the slant, it will inflict a much longer cut, and resemble an incised wound.

(4) **Extent of Wound.**—In murder the wounds are usually much deeper, more extensive, and more numerous than in suicide. This is not invariable, however, for in a case of determined suicide the throat may be cut backwards as far as the spine, and the vertebræ or intervertebral discs notched. As a rule, homicidal is much deeper than suicidal cut-throat. In murder, very often the throat is only stabbed at the side, so dividing the jugular veins and the carotid artery on that side. If the person so assaulted has been awake, then probably struggling will have taken place, and the hands and arms may have been cut.

(5) **Number of Wounds.**—The presence of several mortal wounds as a rule indicates that murder has been committed. This is subject to many exceptions, however. Suicides have inflicted several mortal wounds on themselves; it is not unusual to find that a man has discharged a pistol into his

heart, and again into his brain. Numerous stabs may be inflicted in the heart, and the person may ascend stairs, or walk a considerable distance, before death ensues. An officer endeavouring to commit suicide inflicted twenty-six wounds over his left breast; not having succeeded in wounding his heart, he took his sword, and holding it against a wall, drove it into his abdomen so forcibly that it transfixed him and projected through his back. He withdrew it, and in doing so cut his hands severely. Finally, before his death he once more drove the sword into his abdomen.

(6) **Condition of Locality.**—This may clearly show that suicide has been committed. Thus, the door being locked on the inside, the finding of farewell letters, the evidence of design, etc., all point to self murder. If, however, no weapon be found with which the injuries had been inflicted, or if attempts have been made to wash up blood-stains, or if evidences of a struggle are present, then the probability is great that murder had been committed. It may have been an accident that has led to death, and in such cases everything will be in order, and there will be no evidence of design. Thus, an individual may have been standing on a chair for some purpose; the chair may have overturned, and the person may have fallen and struck his head on some sharp edge. He may be found dead with a fractured skull, but everything will point to an accidental cause.

The position of the body may afford some information. Thus, for example, if a body be found in bed with the clothes unstained, and tucked under the chin, it is a manifest case of murder, for the individual must have been quite unable to do this for himself, unless he had taken a narcotic poison. The weapon is, as a rule, close to the body in a case of suicide, in fact it may be tightly grasped in the hand through cadaveric spasm. On the other hand it may be flung far away: thus, a knife or pistol may be found many feet off, doubtless in an endeavour to hide it; in some cases it is flung into a water-course or into the sea. There may be distinct evidences of a struggle having taken place, and homicide is consequently inferred.

Condition of the Weapon.—The instrument employed for cutting or stabbing may be found perfectly clean; if so, it must have been wiped, and if it be a case of suicide, then the towel or handkerchief on which it has been cleaned ought to

be forthcoming. Look carefully in the depressions of the lettering, or at the lock, for any traces of blood on the knife; a slight stain of blood on a steel blade appears as a pale yellow film; if in larger amount and fresh, it appears as a red stain or as red jelly-looking masses. If the weapon has stood for one or two days with the blood on it, then the steel will have become rusted, and the stain then appears yellowish red. Blunt instruments, such as mallets, hammers, or bludgeons, are often free from blood; if they have been used to batter the deceased repeatedly, then they are bespattered with blood, and frequently they have hair sticking to them.

Articles to be Kept.—Everything found upon or near the deceased must be kept (weapons, clothes, bedding, phials, utensils, etc.). They must not be given up without a receipt being taken from the receiver or expert, because in capital charges the identity of these (*corpora delicti*) must be proved with absolute certainty.

Identification of Hairs, Fibres of Clothing, etc., on weapons, in blood-clots, or in the hands of deceased.

Hair.—The colour of the hair is important as it may lead to the identification of the murderer. Hair resists decomposition for long. In examining hairs by the microscope, look to (1) Imbricated scales on the surface; (2) The cortex and medulla; (3) Pigment granules in the medulla; (4) Change in structure from the shaft to the root, and also the root sheath.

To prepare hairs, they should be washed, dried, steeped in turpentine, and mounted in Canada balsam. It is a question of great difficulty in many cases to determine whether the hairs produced belong to the deceased or to the alleged murderer. Hairs from the body are, as a rule, fine with no pigment cells. Those from the beard and moustache are very thick. Those from the eyebrows and eyelashes taper gradually to a fine point. If the hair has been pulled out by the roots, then the microscope will show that the growing root has a concave surface which fitted over the root papilla. A fatty layer is also present at the end of the hair when it has been forcibly pulled out. If a bundle of hairs be found, all with concave extremities, and ruptured bulb sheaths, it indicates that they must have been torn out. If the ends are rounded and atrophic, it is probable that they have fallen out. Human hairs have to be distinguished from those of the domestic and

lower animals; this can only be done by comparing the hair of any particular animal with the hair under observation, or by comparing it with an atlas of hairs. Human hairs are more delicate than those from lower animals, and the cross striations are more numerous. The hairs of the dog and cow most closely resemble human hairs. A woman was convicted of the murder of her daughter, because sticking to a knife in her possession were squirrel hairs, and the child had worn a squirrel-fur tippet.

Microscopical Examination of Fibres from Clothing.—Wool fibres are coarse and very curly, and the surface is striated indicating the cortical cells. Cotton fibres appear as flattened bands twisted on themselves into spirals, and having thick borders. They are without structure. Linen fibres are round, and have transverse jointings at frequent intervals. Silk fibres are solid, and highly glistening. Flax, jute, hemp, all exhibit vegetable structure.

Blood-stains on Floor, Furniture, or Clothing.—Wherever there is a great quantity of blood it is likely that death has taken place at this spot. The blood forms about one-thirteenth of the entire body weight. Wounds of the large vessels near the heart usually prove instantly fatal. If deceased has walked or crawled from the place where the injuries were inflicted, then a trail of blood will lead from it. If he has been carried, the trail will be present, and probably also bloody foot-prints. Bloody finger-prints on furniture or walls must be carefully preserved, as they may lead to the identification of the prisoner.

Marks of Blood on the Assailant.—It is by no means a necessary consequence that the assailant show any stains of blood; if he has cut the throat of the deceased from the side or behind, while the latter was standing or lying, then he will entirely escape the outflow of blood; the absence of blood on his hands or clothes is, therefore, no proof of his innocence. The assailant may have changed his clothes, or may have washed them; the latter proceeding is often done so hurriedly and imperfectly that blood may be detected on the clothing both by inspection, and by appropriate tests. Unless very thoroughly done, washing makes the stain larger though fainter in colour. Blood-stains are much more soluble in cold than in warm water.

EXAMINATION OF BLOOD-STAINS.

The investigation must determine the following:—(1) Whether it is a blood-stain. (2) If it is blood, whether it has belonged to a mammal, bird, fish, or reptile. (3) If it be mammalian blood, to what species it has belonged.

Naked Eye Appearances.—A recent blood-stain on a white article of dress has a bright red appearance, has abrupt margins, and stiffens the cloth. After the lapse of twenty-four to thirty-six hours, according to the temperature, it becomes chocolate-brown in colour from the production of methæmoglobin, and this is permanent. If the stain be thick and recent the surface is more or less shining, and a jelly-like material may be seen by a magnifying glass between the fibres of the cloth. If a needle be drawn across an old dry stain, a cinnabar-red streak is left. On dark clothing blood-stains are not so readily made out; oblique illumination or artificial light may reveal them better than ordinary daylight. It is almost impossible to state whether stains have been caused by ordinary or menstrual blood; an acid reaction, and the presence of squamous epithelial cells from the vagina, singly or in clumps, may afford information as to the latter. The number, size by measurement, and position of stains on articles of clothing or furniture, must be carefully detailed in the report.

Arterial blood escapes from small vessels in jets, and may be projected for 3 to 4 feet. On a flat surface these spots appear as elongated pear-shaped marks with a round droplet at the stem end; these have been likened to points of exclamation. Large arteries when divided do not spirt blood to any distance, as the blood-pressure is almost immediately lost. The direction from which the blood has been projected can be determined from the appearance of the blood splashes on smooth flat surfaces.

Method of Detecting Blood.—Chemical, optical, microscopic, and biological tests may be applied in the detection of blood. The stain on clothing, wood, leather, etc., must be cut out, and suspended in a little distilled water for some hours, so as to obtain a solution of hæmoglobin; the fragment of cloth should be gently pressed with a glass rod from time to time. In old stains the blood pigment becomes changed into hæmatin,

and this is very slowly dissolved in water; the addition of a trace of ammonia to the water hastens its solution.

Chemical Tests.—(*a*) If a little of the solution be boiled in a test tube, the red colour disappears, and a grey coagulum of serum albumin is obtained. If caustic potash solution be added to this, the coagulum is dissolved, and a dichroic solution is obtained, green as seen by transmitted light, and red by reflected light. If nitric acid be then added, the coagulum reappears. These are merely tests for the presence of serum albumin, and are not characteristic of blood.

(*b*) The addition of ammonia to the original solution produces no change.

(*c*) *Guaiacum Test.*—To a little of the solution of the stain, a drop of fresh tincture of guaiacum is added, and the mixture shaken. A little ozonic ether (or other solution of peroxide of hydrogen) is then poured in, and at the junction of the fluids a blue line is formed if blood be present. This is a delicate test, and will reveal blood in clothes even after they have been washed apparently clean. Saliva, milk, and pus unfortunately give similar reactions. The test is applicable to a minute drop on the stage of the microscope. In the case of nucleated blood corpuscles the nuclei stain a deep blue, while the rest of the cell is violet in colour.

(*d*) *Sodium Tungstate Test* is also applicable to stains which have been washed. The stained piece of cloth is soaked in a dilute solution of potassium iodide and squeezed with a glass rod, the solution is filtered and acidulated with acetic acid. A small quantity of a saturated solution of sodium tungstate rendered acid with acetic acid is added. If blood be present, a light coloured precipitate forms, and this, if boiled, yields chocolate brown flocculi. The residue after filtration may be tested by the following test, or after rendering it alkaline with ammonia the spectroscope will show alkaline hæmatin.

(*e*) *Hæmin Crystals.*—This test often fails, and so a negative result does not imply the absence of blood. A positive result is, however, conclusive of its presence. A fragment of the stain is placed on a slide together with a drop of water containing a minute crystal of sodium chloride or potassium iodide; this is evaporated to dryness over a gentle heat. A cover glass is placed in position, and a drop of glacial acetic acid is allowed to run in; the slide is gently heated until bubbles

appear; it is examined with the high power of the microscope, and Teichmann's crystals are seen as dark brown rhombic prisms (hæmatin hydrochloride or iodide) if blood is present.

(*f*) *Chlorohæmatin Crystals.*—To a fragment of blood-clot on a slide a drop of chlorine solution, a drop of pyridine, and a drop of ammonium sulphide are added, and a cover glass applied. Rhomboidal red crystals of chlorohæmatin and clusters of hæmochromogen are seen, if blood be present.

Spectroscopic Test.—This affords the most delicate means

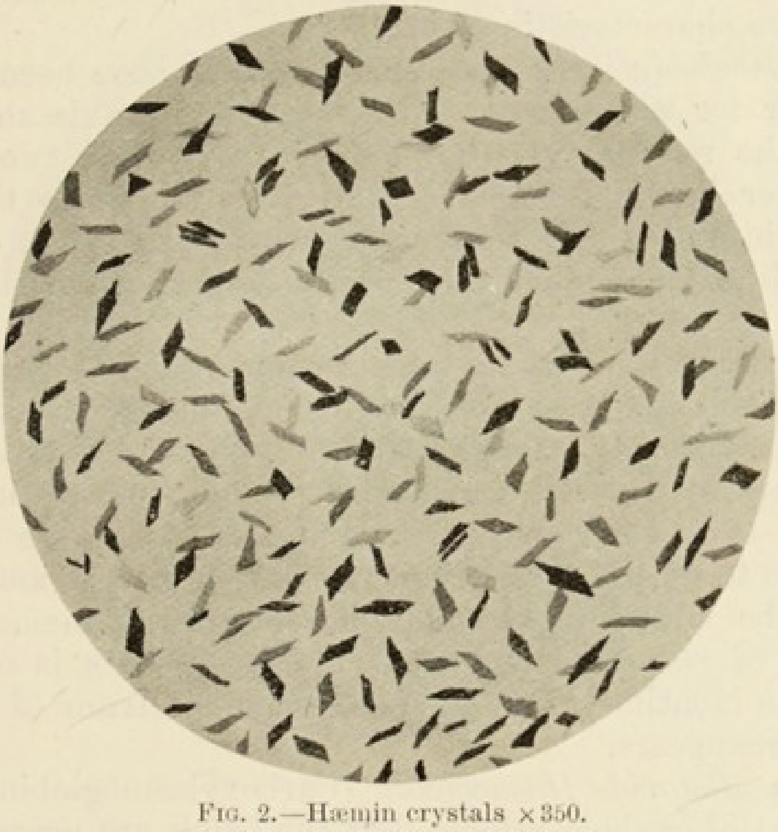


Fig. 2.—Hæmin crystals ×350.

of detecting blood, and the age of the stain is no hindrance. A good hand spectroscope answers well for the purpose, but a table spectroscope with divided circle is better for exactitude. With very minute quantities of blood a spectroscope which can be fitted into a microscope must be employed (micro-spectroscope).

A recent blood-stain gives a solution of *oxyhæmoglobin*, and this causes the absorption of two bands from the solar spectrum between Frauenhofer's lines D and E, the one nearer E being double the breadth of the former. The position of D may

easily be made out by burning a fragment of sodium carbonate on a platinum wire in a flame in front of the spectroscope. The test can be made still more decisive by the addition of a little ammonium sulphide to the solution of the stain; this reduces the oxyhæmoglobin to reduced *hæmoglobin*, which gives but a single broad absorption band placed intermediately between the two former ones. By agitation the hæmoglobin may be again oxidised, and the first spectrum will reappear. Further tests to identify the stain are made by adding a little ammonia to the original solution, and so producing alkaline hæmatin, or dilute acetic acid producing acid hæmatin, both of which have characteristic spectra.

Methæmoglobin is formed in stains which have been exposed to the air for some days. The spectrum of this shows one band in the red between the lines C and D, and two thinner and fainter bands between D and E. The older the stain the more insoluble it becomes. A saturated solution of borax or very dilute ammonia renders the colouring matter more soluble.

Hæmatin is the form in which hæmoglobin is found in old stains. If ammonia be added to this solution the spectrum of *alkaline hæmatin* is obtained as a well-defined broad band leading up to D. If acetic acid be employed instead of ammonia, the spectrum of *acid hæmatin* is seen as a broad band close to C, and a wider one ending at E. If ammonium sulphide be added to the alkaline solution of hæmatin, the spectrum of *reduced hæmatin or hæmochromogen* is obtained, and can be identified; if well shaken the spectrum of alkaline hæmatin reappears.

Carbon Monoxide Hæmoglobin (Carboxyhæmoglobin) is not unlike that of oxyhæmoglobin, but the bands are nearer to the violet end; it is not reduced by the addition of ammonium sulphide.

In using the spectroscope as a test it has to be remembered that different strengths of the blood solutions give somewhat different spectra, but the changes produced by the reagents are common to all. No other substance but hæmoglobin gives a spectrum which undergoes such changes on the addition of reducing agents. Comparison with the spectrum observed and with standard diagrams should always be made.

Microscopic Characters of Blood.—The red blood corpuscles

of all mammals are non-nucleated, while in all other vertebrates they are nucleated. Microscopical examination of dried blood corpuscles affords no means of determining from what mammal they have been derived. In stains of blood the corpuscles become dry and shrivelled, and it is almost impossible to restore them to their original size or condition. Numerous solutions have been devised in which to soak the stains in order to make the corpuscles assume their normal characters; the best of these is perhaps a mixture of glycerine and water

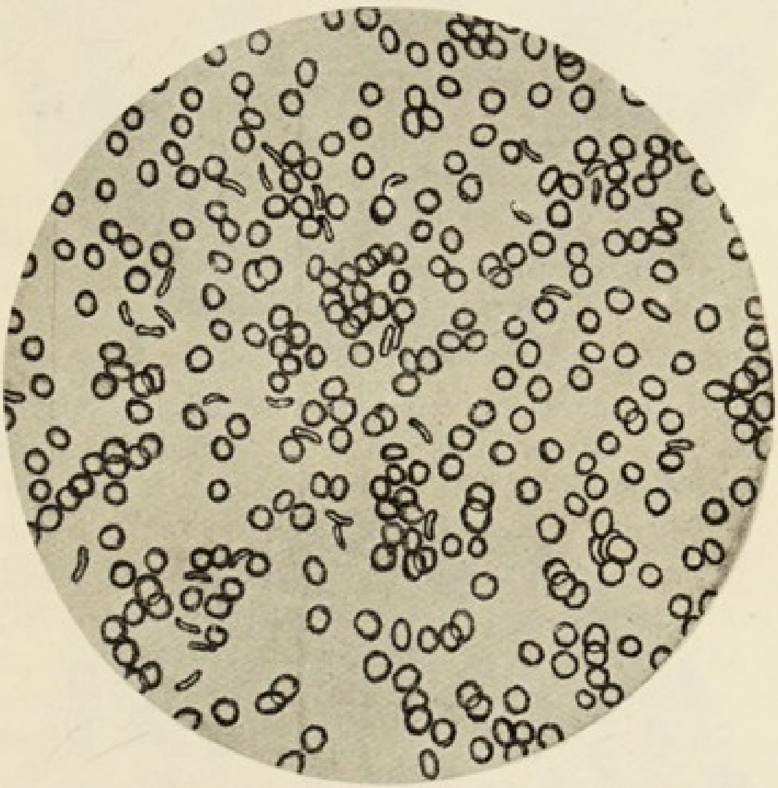


FIG. 3.—Human red blood corpuscles. × 350.

(1 part to 7) of specific gravity 1030. As a rule, however, the corpuscles swell up rapidly in such fluids, and soon become invisible or burst their cell envelopes. In medico-legal work one cannot place any reliance on the measurement of the corpuscles, as it is impossible to affirm that the cells have resumed their normal size. The most that can be asserted is that the stain has been produced by mammalian blood. In the rare event of a stain being due to the blood of a camel or one of the llama tribe, the corpuscles would be oval in shape. The corpuscles in all other vertebrates (birds, reptiles, amphibia, fishes) are larger than in mammals, are

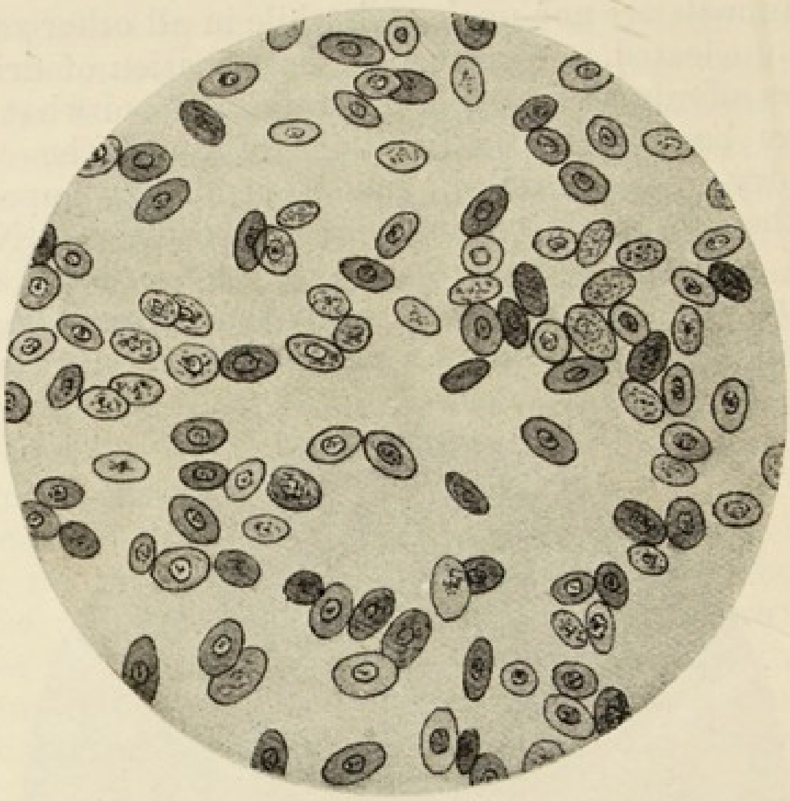


Fig. 4.—Oval nucleated corpuscles of blood of fish. × 350.

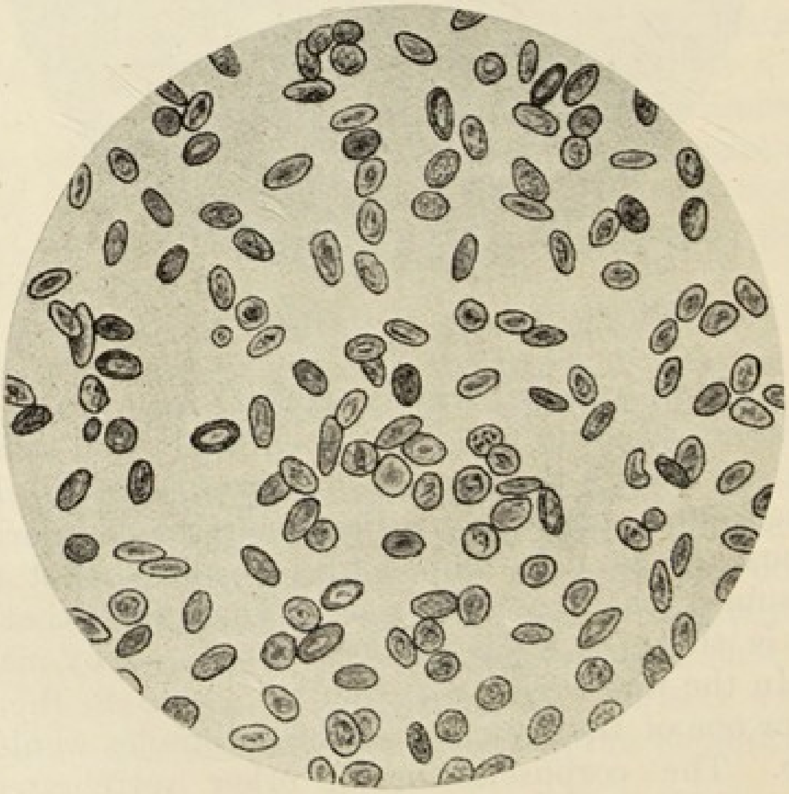


Fig. 5.—Oval nucleated corpuscles of blood of bird. × 350.

oval in shape, and have a well-marked nucleus. These characters are easily made out in stained blood films.

Biologic, Serum, or Precipitin Test (*Uhlenhuth's Test*).—This test allows of the determination as to whether a stain is from human blood or not. A rabbit must be prepared to give the specific serum in the following way: 10 c.c. of human blood is injected into its peritoneal cavity at intervals of seven days, until three to five injections have been given. The rabbit is then killed, and its blood allowed to escape into a sterile vessel. The serum of this blood will give a precipitate only with dilute solutions of human blood (1 per cent), but not with the blood of any lower animal. In the case of minute stains the piece of cloth should be soaked in normal saline solution for some hours; a capillary tube is then applied, and some of the solution sucked up; its end is then plunged into a drop of the precipitating serum, and at the point of contact a whitish ring of precipitated albumin will form if human blood has been present in the stain.

Blood-stains on Iron or Steel Weapons.—When the film of blood is very thin only a slight yellow glaze may be observed on a blade. In larger amount a yellow or red discoloration may be present, and readily scales off. Blood-stains are often associated with rust, and it is not easy to tell the one from the other. The presence of rust hastens the change of oxyhæmoglobin into hæmatin; make a solution of the stain in water and filter; the insoluble iron salt remains on the filter, and the solution of blood passes through.

Rust-stains on Linen (iron-mould).—These are insoluble in water, and are yellowish red in colour; they do not stiffen the cloth or make it glossy. The iron salt may be dissolved out by the addition of hydrochloric acid, and if ferrocyanide of potassium be added to this solution the deep colour of Prussian blue is produced.

Fruit-stains on clothing are seldom so intense as blood, but have more of a pink colour. Solutions of these do not change colour on boiling, the addition of ammonia changes the colour to blue, green, or rarely crimson; acids brighten the original colour, and chlorine water bleaches them. Fruit-stains on iron or steel knives often produce salts which closely resemble blood-stains. Dissolved in water they give yellowish solutions of citrate or malate of iron, and afford the characteristic reactions of iron.

Brain Substance on Weapons.—When fresh this has the well-known characters, but when dried it becomes greyish brown in colour, and horny in consistence. When soaked in normal saline solution and teased, it may show the presence of nerve fibres, and, if stained properly, nerve cells may be seen.

CHAPTER VIII.

REGIONAL INJURIES.

Head.—Wounds of the head require careful attention, and a cautious prognosis should always be given. Death may follow from slight wounds of the scalp. Thus, erysipelas or septic infection from pyogenic organisms may supervene on trivial wounds. It is not always possible to diagnose fracture of the skull: the individual may appear well, and later may die suddenly from an abscess in the brain, the result of septic absorption through a fissured fracture.

Fractures of the Skull.—These may be fissured, depressed, or compound. Some parts of the skull (temporal bone, orbital plate of the frontal bone, etc.) are easily fractured. In certain cases the skull is preternaturally thin, and so is more vulnerable, and in rare cases certain areas of the cranial bones remain unossified, the brain being only protected by a fibrous covering. In old age the diploë becomes absorbed and the bones brittle. In many epileptics the skull is greatly thickened. The inner table of the skull is always much more broken up than the outer in cases of fracture. Fractures of the vault of the skull are almost always the result of direct violence. A fracture may indicate by its shape the instrument which caused it; thus, round holes are produced by a hammer, and longitudinal depressions by an axe or sword. If the force has been great a clean cut is made in the bone, but with less force only a fissure results. When the skull is compressed on either side the fracture runs directly between the opposing forces. There may be no fracture at the seat of the blow, but the skull may be injured at the opposite point (counterstroke). Fractures of the base may result from extension of fractures of the vault, or may be due to indirect violence, as in falls on the feet or buttocks, or from a blow on the chin.

Brain.—Injuries to the brain may lead to immediate or remote results, and may or may not be associated with fracture of the skull.

Concussion of the Brain may be produced by direct blows on the head, or by jarring of the whole body, as happens in falls from a height, or in being thrown down unexpectedly.

Symptoms.—Consciousness is usually lost for a variable period, it may be only momentary or may last for days. In slight cases the person is stunned, staggers, and stutters in speaking as if drunk; the face is pale, the skin cold, the pulse feeble, respiration is irregular and sighing, the pupil is dilated

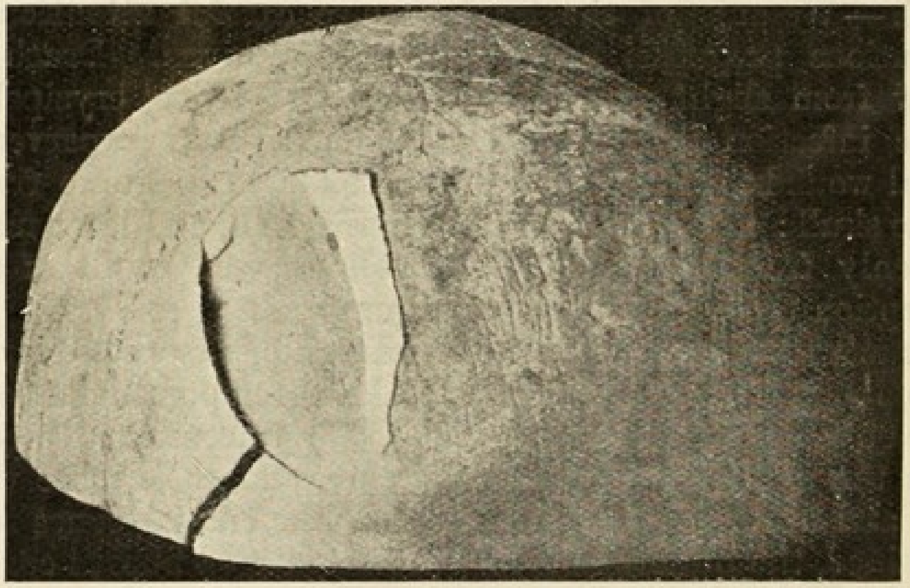


FIG. 6.—Depressed fracture of left half of the frontal bone caused by a blow from a long angular bar of iron.

and irresponsive; the individual may be roused to answer questions; there is no paralysis. Death may take place at once or not for many days. Nausea and vomiting may be present during recovery. In certain cases the symptoms may be delayed in their onset for hours or even days. This is common after railway accidents.

Post-mortem Appearances.—Nothing abnormal may be seen by the naked eye; slight hyperæmia of the brain may exist, and minute capillary hæmorrhages may be found in the brain and spinal cord.

Compression of the Brain may result from depressed fractures (compression fractures), or from the pressure of extra-dural hæmorrhages, or inflammatory products. A fracture of

the temporal or parietal bone may cause rupture of the middle meningeal artery, and this may lead to fatal compression. Death need not be instantaneous even with very large hæmorrhages.

Symptoms.—Total insensibility is present, and may supervene at once, or it may not come on for several hours even with extensive depressed fractures; the pulse is slow, and the breathing slow and laboured; the pupils are irresponsive and often unequal. The two conditions of concussion and compression are often associated. In the case of ruptured vessels a partial recovery may take place; this is due to the temporary arrest of hæmorrhage in the vessels produced by clotting. If the individual excite the heart's action, however, by severe exercise, a large meal, or by indulgence in alcohol, these clots may be loosened, and hæmorrhage will again take place. An almost every-day occurrence is that an individual is knocked down by a vehicle and rendered insensible, after a time he recovers, walks home, eats a good supper, retires to bed, and is found in the morning either comatose or dead.

Contusion of the Brain.—This may be circumscribed or diffuse, and may be confined to the site of the blow, or may be distant from it (*contre coup*). The base and the middle lobes of the brain are the parts most liable to contusion.

Symptoms.—These are indefinite, and depend to a large extent on the part of the brain which has been injured. As a rule there is restlessness, unconsciousness, and convulsions of a tonic or clonic character may be present. The contusion may be slight, and symptoms may not manifest themselves for several days. In such cases inflammation of the brain or its membranes has been set up.

Extravasations of Blood on to or in the Brain.—In quarrels there may be fighting; a man may be thrown down, he remains unconscious and may die. The question naturally arises, Did he die from injury to his brain, or from the excitement leading to rupture of a blood-vessel in his brain?

Apoplexy.—Certain pathological conditions may be present, and these may predispose the person to spontaneous rupture of his blood-vessels. Thus, advanced age, atheroma or arterio-sclerosis, syphilitic endarteritis, cardiac hypertrophy, aneurisms of the cranial vessels, chronic nephritis, alcoholism, may all lead to a giving way of the cerebral vessels (apoplexy), and especially is this apt to occur during excitement. There may

be a small bruise of the scalp produced by the person falling after the hæmorrhage has occurred; the extravasation in such cases is most likely to be *within* the substance of the brain, and is invariably single. The ascending branch of the middle cerebral artery is very often the seat of rupture. The results of a severe apoplexy come on at once, there is usually complete unconsciousness, the face is flushed, conjugate deviation may be present, the pupils are dilated and unequal, the pulse is full and the tension high, respiration is stertorous, hemiplegia is an outstanding feature, and may be present with retention of consciousness.

From Violence.—On the other hand, if the individual has been young and healthy, it is most likely that the vessel has been ruptured by violence. Thus, the middle meningeal artery or the lateral sinus may be divided by the sharp edges of a fractured bone. The extravasation is usually *extra-dural*. The torn ends of the vessels will be found on dissection, and the brain and blood-vessels will be found healthy. The quantity of blood effused is usually much greater from violence than from disease, and the hæmorrhages may be in more than one locality (multiple). There may be much difficulty in determining the true cause of death if the blood-vessels of the brain are found diseased, and if only a slight degree of violence had been employed. Blood-vessels in or on the brain may, however, be ruptured as a result of counterstroke, without there being any fracture of the cranial bones, and thus it is well that an opinion as to whether a hæmorrhage has been caused by violence or natural causes should not be too dogmatic.

A man aged thirty-four while intoxicated fought with a policeman, who gave him a blow on the temporal region; he continued to struggle, and was placed in a cell, but next morning was found dead. The post-mortem examiner found no fracture of the skull, but in the anterior part of the right cerebrum a hæmorrhage was present, which had been, in his opinion, caused by the blow. The policeman was apprehended. A more careful autopsy by an experienced medical jurist demonstrated that the blood-vessels of the brain, as well as those of the kidneys and liver, were in a condition of fatty degeneration, and that the extravasation had resulted from natural apoplexy.

Age of Cerebral Hæmorrhages.—It is impossible to be precise in stating the age of such effusions. When quite

recent, a red, purple, firm clot is found which becomes brown after some days. In from two to four weeks it has changed to a yellowish colour, and the clot has become much smaller, firmer, and drier. Hæmatin crystals may be found at the seat of former brain injuries months after the accident has occurred.

In lunatics layers of organised and unorganised blood-clot may be found on the surface of the brain (*pachymeningitis interna hæmorrhagica*); this must not be confounded with extravasation, the result of violence.

Wounds of the Brain.—If the basal ganglia be injured death is usually instantaneous. Fractures of the base of the brain may not, however, give rise to serious symptoms. A broken fly-wheel carried off half of the frontal bone, and a large part of the prefrontal lobes of a workman, yet he recovered. While a quarryman was inserting a charge it exploded, and drove the tamping-iron, which was 13 lbs. in weight and 3 feet 7 inches in length, completely through the anterior part of his left brain. The lateral ventricle and the longitudinal sinus were opened into. The man never lost consciousness, and lived for many years after the accident.

Wounds of the cerebrum are apt, however, to lead to inflammation of the brain or its meninges, or to the formation of a cerebral abscess. The onset of the symptoms may therefore be delayed for several days or even weeks, in the case of abscess.

Remote effects of cerebral injuries may be seen in epilepsy, paralysis, or insanity. Bullets have remained embedded in the brain for years without giving rise to great inconvenience.

Intoxication or Head Injury.—Mistakes in diagnosing these conditions may frequently happen, and when the cases end fatally blame is thrown on the medical man or on the police because of their negligence. A man may be found lying insensible, and his breath may smell of alcohol. The police naturally think he is drunk, and lock him up. In the morning the man may be found dead; his death having probably been due to injury to his brain from a fall or blow. If a medical man be asked to see such a patient, he ought to be very chary in diagnosing drunkenness. Slight concussion of the brain closely simulates drunkenness, and, in this country at least, the first restorative which is thought of is brandy or whisky, and hence the breath may smell strongly

of these stimulants, and an error in diagnosis may be made. A differential test is often employed, *i.e.* compression of the supra-orbital nerve as it passes over the supra-orbital notch. If drunk, the person winces or scowls, but there is no reaction in cases of concussion or compression. In alcoholic poisoning the pupils remain contracted, but dilate slowly if the individual be stimulated, as by pulling his hair or slapping his face. Severe apoplectic seizures closely resemble profound alcoholic poisoning. Drunkenness and injury to the brain often co-exist; when intoxicated the person may fall heavily, and may injure his skull and brain. If there be any doubt as to the diagnosis it is better to treat the case as one of head injury, and have the patient conveyed to a hospital. In a few hours a correct diagnosis can be made, and even if the case is one of alcoholic poisoning, surely the patient requires treatment before his incarceration.

Traumatic Neuroses.—Any violent nervous excitement, or slight injuries accompanying great nervous excitation, may lead to the development of such functional nervous diseases as neurasthenia, hysteria, or hypochondriasis. Thus, a strong robust policeman passed very quickly into a condition of neurasthenia, as a consequence of trying to stop two runaway horses.

Shock from accidents is very severely felt by the aged, sick, pregnant, or alcoholic persons. Certain races of people, as Russian Jews, lose all control over themselves and become perfectly frantic if an accident happens, such as a collision between vessels or trains.

Injuries of the Spine.—These constitute an important group, as they form a large proportion of the cases of civil actions for damages.

Sprains of the intervertebral ligaments and muscles of the spine are frequently met with, and are very troublesome to treat; they give rise to more or less indefinite symptoms, but the patient will frequently insist that he has disease of the spine, of the cord, or kidney, and it is not easy to reassure him. The spinal cord is not nearly so liable to concussion as the brain; it lies in a strong yet flexible bony canal, and is suspended freely in the cerebro-spinal fluid, which acts as a water-bed and protects it from sudden shocks. A fatty layer still further acts as a safeguard.

Concussion of the Cord may, however, follow severe blows,

jars, or falls from heights. The same injuries may produce hæmorrhage into the substance of the cord or into its meninges, with resulting myelitis. Multiple minute hæmorrhages may be thus produced, and give rise to actual disease of the cord. If the concussion be severe, paraplegia may ensue, but this, as a rule, passes off soon. In very severe concussion death may follow instantly.

Compression and Contusion of the Cord may be due to fractures or dislocations of the vertebræ, or, what is more common, a combination of these two conditions (*fracture-dislocation*). Fractures may be caused by direct violence, as blows, or by extreme bending of the trunk, as when a man is doubled up by a weight falling on his shoulders. Extravasations of blood into the meninges may also compress the cord.

Symptoms.—When the cord suffers compression through such injuries there is sudden loss of power, severe pain is complained of, both at the seat of injury and spreading along the nerves which arise from this injured segment. Spasms, tonic or clonic, may be observed. More or less complete paralysis results from this injury.

Wounds (incised or punctured) may injure the cord and its membranes, and may lead to a varying amount of paralysis according to the segment which is wounded, and extent of the injury. If the injury affects the cord high up the risk to life is great, but this risk diminishes the farther down the injury is situated. If any of the upper three cervical vertebræ be dislocated or fractured, instant death follows as a rule. Thus, in judicial hanging in this country, the sudden jerk which the weight of the body gives to the neck causes dislocation of these vertebræ and immediate death. It is by no means difficult to dislocate the odontoid process of the axis vertebra from the atlas, and if so the cord suffers compression near its root, and the person falls dead.

A female lunatic, who was being forcibly fed, drew her head back suddenly to avoid a spoonful of food, and so dislocated her neck, and died instantly.

A young man was teasing some children. He suddenly took hold of one of them by the ears from behind and lifted her up; in doing so he dislocated the cervical vertebræ, and the child fell dead. The parents, terribly upset at the result of the young man's play, asked him what he had done. To

illustrate his act he seized hold of another child in the same way, with a similar disastrous consequence.

In rare cases fractures of the upper cervical vertebræ are not attended with fatal results, and the person may survive for many months. If the cord be injured below the origin of the phrenic nerves the person may continue to live, as the important nerves take their origin higher up in the cord, but there will be total paralysis of both trunk and limbs. If the cord be injured in the dorsal region there will be paralysis of the lower limbs, and of the sphincters of the bladder and rectum. If the deep reflexes do not soon return, and if there be vaso-motor paralysis, together with motor and sensory paralysis, it must be assumed that the cord has been completely divided or destroyed.

A careful examination of the vertebral column must be made in all cases of alleged injury to the spine, as it may have been the seat of previous disease. Thus, tuberculous disease or cancer of the bodies of the vertebræ may make slight injuries terminate seriously to the patient.

Traumatic Neurasthenia. "Railway Spine."—This may be a sequela of any violent shock to the nervous system, or of a sudden jar or fall. Such cases frequently arise after railway collisions, and are often the subject of actions for damages. As the symptoms are entirely subjective such cases occasion opportunities for fraud, and it is very difficult for the medical practitioner to determine the truth of the symptoms complained of. Individuals may be severely injured in railway accidents, and may from the first suffer from the symptoms of cerebral and spinal concussion. On the other hand, the symptoms may not come on for some weeks after the accident, and may then gradually increase in severity.

Symptoms.—The patient becomes restless, excitable, and emotional. He suffers from insomnia; exhibits great indecision of character, is unable to concentrate his attention; the sight becomes impaired; the limbs weak, and the gait staggering. There is tenderness over the spine, and feelings of numbness, formication, or twitchings are complained of in the limbs. Unfortunately, in many cases the above symptoms, though very severe, have entirely disappeared soon after damages have been awarded, and hence a good deal of doubt has been cast over the whole subject of "railway spine." A few instances may help to show the difficulties which such cases present.

A workman had to be carried into Court wrapped in a blanket; his nervous system had been completely shattered by a railway accident, and he could only answer in a whisper. Six medical experts alleged that he was a perfect wreck, and his wife swore that the accident had made him a victim to frequent and violent convulsions. He was awarded £750 in damages. A week later he was able to indulge in sea-bathing and in climbing. He was, however, convicted of perjury, and sentenced to fifteen months' imprisonment.

A commercial traveller was rendered so helpless by a railway accident that he had to be carried into Court on a stretcher. He was awarded £1500 as solatium, and within a year was fit for his work. Curiously enough two years later he was again in a railway smash, and once more received a similar sum as damages. Neither did this second accident incapacitate him for long, and he soon resumed his ordinary avocation.

In a trifling railway accident, out of 250 passengers, only one, a clergyman, suffered nervous shock. But after receiving the handsome sum of £1800 he was soon able to resume his ministerial duties.

The modern view of such cases is that most of them are really cases of extraspinous injury associated with traumatic hysteria or neurasthenia.

Injuries to the Face.—Wounds of the face are apt to cause "grievous bodily harm" by leaving disfigurement. The surgical investigation of these is, therefore, important in actions for damages.

Fractures of the upper jaws or of the nasal bones almost always cause deformity of the face. An individual rejoicing in an aquiline nose may, on recovery, find he possesses a pug-nose.

Wounds in the orbit frequently prove fatal. The great English poet, Christopher Marlowe, died from a stab in the orbit. Thus, in fencing, if the button comes off, the foil may penetrate the thin bony plates of the orbit, and injure the brain; a septic meningitis or cerebral abscess may result, and cause death. The eye is easily injured. A blow on the eye may cause dislocation of the lens or detachment of the retina.

The condition known as "hæmatoma auris" often occurs spontaneously in lunatics. In those predisposed a slight blow on the ear may lead to a large extravasation of blood.

Erysipelas is a common sequence of facial injuries. The

question may then arise, "Was the injury of the face treated properly?"

Wounds of the Throat. "Cut-throat."—Wounds of the throat are, as a rule, very fatal. If the wound be at the side of the neck, and especially if at the upper part, the damage is very great on account of the great blood-vessels and nerves which lie on either side. If one of the carotid arteries be severed death is almost certain to occur. Division of the internal jugular vein is almost as dangerous, both from the amount of hæmorrhage, and from the suction of air into the proximal end of the vessel. If the larynx or trachea be alone cut there is usually no immediate danger of death; some blood may flow, however, into the trachea and bronchi, and if in sufficient amount may cause death by suffocation. The most of this blood is usually coughed up, but what remains is prone to decompose, and the individual may die in a few days from septic pneumonia. In a few cases lunatics have cut out the thyroid and cricoid cartilages, and have not succumbed until the lapse of from one to four hours. When the larynx or trachea has been cut, ability to make a sound ceases instantly, and hence in cases of murder the assailed person is unable to cry out.

Suicidal Cut-throat.—*Situation of Wound.*—As the person is usually right-handed, the cut is made in an oblique direction downwards from left to right above the thyroid cartilage or across it.

Character of Wound.—The incision is usually deep at its commencement, but becomes shallower, and tails off to its termination on the right side. This is not by any means invariable, and both ends may be tailed off.

Condition of Edges.—If the skin of the neck be lax, and the knife not very sharp, the integument is dragged in front of the weapon, and the edges of the wound are frequently notched.

Number of Cuts.—The suicide may not be very determined at first, and hence one or more tentative cuts may be present. These run more or less parallel with the supreme cut, and are strongly indicative of suicide. The individual may make one or two attempts, and then as he sees the blood flow, he becomes desperate, and makes a third and deep gash.

Extent of Wound.—In very determined cases of suicide the throat may be cut widely almost from ear to ear. The cut may also be very deep, and many cases are recorded where the

cervical vertebræ have been notched, or the discs cut into by the weapon.

Condition of Hands.—In suicide the weapon may be found tightly grasped in the hand of the deceased by cadaveric spasm. The inside of the hand holding the weapon is usually free from blood, whilst the outside may be covered with it.

Homicidal Cut-throat.—*Situation of Wound.*—This is usually much lower than in suicides, being below the level of the thyroid cartilage. It is, as a rule, more or less horizontal in direction.

Character of Wound is more extensive and deeper than in suicidal cases.

Condition of Edges.—The ends of the wound are often undercut, the weapon having been driven into the neck.

Number of Cuts.—If the assailed person was asleep at the time, then probably only one deep gash will be found. If, however, he had struggled, then there may be several cuts, and these will not run in a parallel direction, and will be of varying degrees of severity. The hands are also often found cut.

Extent of Wound is wide and deep as a rule. There may, however, only be a stab at the side of the neck severing the great vessels and nerves on one side. When butchers commit murder they may cut the throat, as in sheep, by "sticking" the knife in at the side of the neck.

Condition of Hands.—If the murdered person has struggled then both the fronts and backs of his hands will be blood-stained.

Ability to Perform Volitional Acts after the Throat has been Cut.—Even after very severe injuries to the throat the person may perform certain acts. Thus, a man who had both the carotid arteries cut was able to run many yards, and climb a fence. A suicide may wipe the razor, and place it in its case before he succumbs to the injury he has inflicted.

Larynx.—Blows or manual compression of the larynx may lead to severe fractures of the thyroid or cricoid cartilage. This is more likely to happen in old age when the cartilages are calcified. Even slight compression may then lead to extensive fractures.

Chest.—*Wounds of the Chest.*—Blows on the chest may cause rupture of the capillaries in the lungs, with resulting hæmoptysis. Severe blows may also produce a condition

known as "*Concussion of the Chest*," where there is a great fall in the blood pressure, due not only to stimulation of the vagi, but also to direct pressure on the heart. Pleurisy or localised pneumonia may ensue on injury to the lung through blows or bruises. The ribs may be fractured either at the point of impact of the injury, or at their angles. In the former case the fractured ends are driven inwards, and are very likely to injure the lungs. Where the ribs give way at their angles the fragments are driven outwards, and thus the lung is more likely to escape injury. The fifth, sixth, and seventh ribs are the ones which suffer fracture most easily and frequently. The lungs or even the heart may be ruptured by severe blows or crushes without fracture of the ribs. If the internal organs are ruptured, hæmoptysis and pneumo- or hæmothorax may result; the individual may succumb at once, or may die from resulting inflammation. Being "ridden over" by a cab, van, or bus, leads in many cases to the above injuries. If the upper ribs or sternum be fractured the prognosis is very grave. These are the strongest structures in the chest wall, and if fractured the important structures which they guard suffer severe injury.

Wounds of the chest wall may be merely superficial or penetrating. If the latter are small wounds, they are still very dangerous on account of the risk of injuring the heart and lungs. Rapier thrusts or stiletto wounds are thus often fatal when inflicted in the chest. An intercostal or internal mammary artery may be divided, and very free hæmorrhage may take place into the thoracic cavity.

Lungs.—When these are wounded severely, hæmorrhage alone, or together with respiratory embarrassment, may cause death from suffocation. The wound in the chest wall may be very small, and there may be no bleeding from the skin wound, but if a large vessel in the lung be divided death takes place rapidly from hæmorrhage. The blood which escapes from the mouth and nose is bright red and very frothy, and causes coughing. If the person recovers from the immediate effects of the injury he must be kept at absolute rest for a prolonged period. Death may result during convalescence from excitement or exertion producing renewed hæmorrhage. Septic pneumonia may supervene, and cause death some days subsequent to the injury.

Wounds of the Heart.—Penetrating wounds of the chest

wall are most apt to injure the right ventricle of the heart, as it exposes the widest area to the front of the chest. Wounds penetrating to this cavity are the most fatal of all cardiac injuries; the left ventricle comes next in point of frequency of being injured; on account, however, of the thickness of its walls, and the peculiar crossing arrangement of the muscular fibres which make up its substance, wounds are not so often followed by death. The right auricle comes next in order of frequency of being injured, and it is the least dangerous locality.

Penetrating wounds of the heart prove fatal in a few minutes. This is, however, subject to many exceptions. If the wound happens to be valvular, or if it be in the thick wall of the left ventricle, the muscular fibres contracting in different directions may to a certain extent seal up the wound, or if the weapon remain in the heart, the outflow of blood will be prevented, and the person may live several hours. If the wound in the heart be small, there may at first be but slight hæmorrhage, as the cardiac action is rendered feeble by direct injury. On exertion, however, severe hæmorrhage may ensue, and death may rapidly follow. After receiving mortal injury to the heart the individual may perform many volitional acts; thus, he may run or walk a considerable distance, may mount stairs, or climb a fence.

A mason received a stiletto wound on the left side of the sternum. He completely recovered from the injury, and died ten years subsequently. The post-mortem examination showed that the pericardium was adherent to the heart throughout, and sealed up a large wound in the right ventricle. There was also a wound in the septum ventriculorum.

A soldier lived thirty-seven years with a bullet embedded in the muscular tissue of his heart.

Lunatics have succeeded in committing suicide by thrusting needles into the heart. Infants and young children have also been murdered in this way. The wounds which these leave in the skin are so minute that they may readily escape observation.

An ordinary pin 1½ inches long caused the death of a man in a few hours. It had transfixed a large vein beneath the epicardium, and 17½ ounces of blood had been effused into the pericardial sac.

If the wound in the heart is large, as when it is produced

by a broad-bladed knife or sword, then death takes place rapidly. Many cases of heart injury have been treated surgically and with success. Crushes of the chest may lead to severe contusions in the heart.

Rupture of the Heart may be caused by external violence (as by being "ridden over") without there being any appearance of external injury on the body. In such cases the heart is usually ruptured towards the base, and on the right side. In making a post-mortem examination, one ought never to remove the heart from the thorax until the position and extent of the rupture has been exactly made out. If the heart be already the seat of disease, as fatty degeneration or aneurism, then rupture may readily take place if the individual exert himself suddenly, especially when in a constrained attitude. The blood pressure is suddenly raised under such circumstances, and rupture may follow. A similar accident may happen during fits of violent passion. In rupture from disease the lesion is usually in the left ventricle, and near the apex.

Arteries and Veins.—Penetrating wounds of the aorta or pulmonary artery prove rapidly fatal. If a large vein be divided, as the external or internal jugular or axillary, then death may result from the entrance of air. This is sucked into the right heart, and accumulates there, so preventing the normal circulation of the blood through the lungs, and producing air embolism. Varicose veins in the leg when ruptured often lead to death from hæmorrhage.

Diaphragm.—Rupture or extensive wounds of the diaphragm are, as a rule, fatal, as they presuppose great injury to the adjoining organs. Railwaymen are sometimes caught between the buffers of waggons or carriages, or carters may be crushed between a cart and a wall. In such accidents, the abdominal organs may be driven into the thorax, or the thoracic viscera into the abdomen through a great rent in the diaphragm. During respiration these organs are alternately pushed down or driven up, and the process is accompanied by loud gurglings. The central tendon of the diaphragm is the part most usually ruptured, and this may ensue on a fall when the stomach is distended, and without injuring other organs. If the individual recover, the cicatrix in the diaphragm constitutes a weak spot which may give way at any subsequent time, and hernia and strangulation of the viscera may result.

Wounds of the Abdomen.—If wounds of the abdominal wall extend deeply, hernia of the bowels may take place subsequently through this weakened area. Fatal hæmorrhage may also be due to division of the deep epigastric artery. Penetrating wounds of the abdomen often heal well without treatment. The surgeon should, therefore, be very chary of operating in criminal cases. If it appears, however, that the patient will obviously die from the injury, and if the operation will afford a reasonable chance of saving life, the surgeon should operate without hesitation. If he does not operate and the person dies, then he may render himself liable for not saving the patient's life by operating.

Blows on the Abdomen.—Fatal results may be due to (1) Shock. Even a slight blow on the abdomen may, through the nervous ganglia, cause paralysis of the heart. Rupture of viscera may also cause shock by the pain produced. (2) Hæmorrhage as a result of rupture of vascular organs or blood-vessels. (3) Peritonitis may or may not be associated with rupture. Within a few hours after the injury an exudation of lymph may be present in the abdomen. There may be no evidence of external injury on the abdominal wall.

Rupture of the Liver.—Severe crushes, falls, blows, or even muscular exertion, may cause rupture and laceration of the liver; the usual site is the upper convex surface towards the anterior margin, and the rupture, as a rule, runs antero-posteriorly. Death may take place immediately from hæmorrhage; if this does not happen, then an effusion of lymph takes place, and death may follow in two or three days from peritonitis. If the gall-bladder be ruptured a very intense and rapid peritonitis is set up.

Spleen.—This may be ruptured from kicks. So slight an injury as compression of the organ by muscular exertion, or by falls, may cause rupture of an enlarged and softened spleen. A fatal result often follows from hæmorrhage.

Kidneys.—These organs are so well protected that great force is required to injure them; if injured a fatal result is usual. Blood and urine are extravasated either into the perirenal tissues or into the abdomen. Death may take place later from suppuration or peritonitis.

Stomach.—When this viscus is distended, rupture easily follows blows or falls, and still more readily if it is diseased (ulceration, cancer). Death is due to shock, hæmorrhage, or

peritonitis. The site of rupture is usually near the greater curvature, and towards the pyloric end.

Intestines.—These may be ruptured from wounds or kicks. The person may suffer little inconvenience, and may continue his ordinary work for some hours. Previous disease of the bowels may predispose to rupture.

Bladder.—Like the stomach this organ, when it is full, is readily ruptured by falls or kicks. The accident is not infrequent in drunken men, the site of the rupture being usually at the upper and posterior part. The urine escapes intraperitoneally, giving rise to peritonitis, or into the cellular tissue of the pelvis or perineum. In the latter position a fatal result often follows from the suppuration and sloughing. Several hours may elapse before any symptoms develop; in one case eight hours passed before the man made any complaint, though there was a rupture $2\frac{1}{8}$ inches long in the bladder.

In homicidal wounding, the defence may be that the bladder ruptured from disease or paralysis; practically this is a very rare event, even in cases of tuberculosis, cancer, or syphilis.

Genital Organs.—Blows or kicks on the male organs cause great shock, and wounds may be fatal from hæmorrhage. Lunatics sometimes cut off the penis and scrotum, under the idea that these organs cause their misery. A jealous paramour cut off a large part of a man's penis; while the penis of a man aged sixty-four was pulled off by a young woman with whom he had attempted intercourse. Wounds of the labia in the female are accompanied by great bleeding, and especially if the veins be varicose. Such wounds of the pudenda are often accidental; thus, they may be caused by the bed-chamber breaking under the weight. While a woman was urinating into a broken ewer, a sharp projection on the handle penetrated the vagina, and severed the internal pudic artery, causing her death from hæmorrhage. If the wounds in the pudenda be deep and numerous, brutal violence has been used. Severe and even fatal hæmorrhage has resulted from a rupture of the hymen, or from the laceration of vulvar vessels during labour.

Rupture of the Pregnant Uterus or Tubal Pregnancy.—This accident may be caused by blows or kicks, and death may be due to hæmorrhage, peritonitis, or septicæmia. The uterus

may be ruptured during obstetric operations, and legal questions may arise, such as, Was the operation necessary? and if so, Was it performed skilfully?

Pelvis.—This may be fractured from blows, crushes, or indirectly by a person falling on his feet, and so causing the head of the femur to be driven through the acetabulum. Great injury is usually inflicted on the pelvic organs.

Sprains or Strains of Muscles.—A sprain or contusion of the deltoid muscle may lead to paralysis, and subsequent atrophy of the muscle. In "rider's strain" the adductors of the thigh become contracted. "Lawn-tennis arm" is a strain or spasm of the pronator radii teres. The gastrocnemius and soleus muscles may become contracted after sprains, and may cause lameness from the raising of the heel.

Cause of Death after Wounds.

To prove culpability it must be shown that the wound was certainly the cause of death; no mere probability is allowed in law. Even though the individual is dying from some disease or other injury, it is criminal to hasten his death. Death may follow a wound (1) directly or (2) indirectly.

(1) **Direct or Immediate Causes of Death**—(*a*) *Hæmorrhage.*—A loss of from 5 to 8 lbs. of blood is almost certainly fatal, though children or aged people succumb to the loss of much smaller amounts. A sudden loss of blood is much more dangerous than a slow, continued loss. Even trivial injuries (tooth extraction) may end fatally in those with the hæmorrhagic diathesis; this condition, if it were present, would mitigate the punishment. The blood may not escape externally, but may be effused into one of the cavities of the body, or into the tissues (as in severe beating). While dying from hæmorrhage there is extreme restlessness.

(*b*) *Shock.*—Mental or physical stimuli, causing cardiac inhibition.

(*c*) *Injury to Vital Organs.*—Heart, brain, etc.

(*d*) *Natural Causes.*—A person often attempts suicide on account of some disease (such as cancer) from which he may be suffering. A careful examination of the dead body must, therefore, be made in every case of wounding. During a quarrel a man may be knocked down, but the autopsy may show that his death was due to apoplexy or heart disease.

(*e*) *Poison* may be taken after wounding.

(*f*) *Death may take Place Long After* the wounds have been inflicted, but may yet be directly due to them. If it can be proved that nothing has been done to influence the wound, or that it has not been badly treated, then the accused is held guilty, just as if the person had died at once. If the assaulted person survives for a year and a day in England, or in Scotland, if he has attended "kirk or market," then the accused cannot be tried for murder.

(2) **Indirect Causes of Death.**—Even a slight wound may prove fatal from the onset of erysipelas, tetanus, gangrene, pyæmia, or long-continued suppuration. Some of these diseases are more likely to attack alcoholic individuals, and hence the latter condition may form a ground of acquittal.

Contributory Negligence of the Wounded Person.—He may not give proper attention to the wound, may become intoxicated, or may refuse medical attention, and may die in consequence. The accusation is the same though the punishment would be mitigated. The wounded person may have suffered from some disease or condition which rendered the injury much more serious, *e.g.* unossified cranial bones, hernia, aneurism, etc. The accused would still be charged with murder if the injured person died, though the sentence would be mitigated.

Example of a Certificate as to Injuries.

EDINBURGH, 30*th March* 1908.

I hereby certify, on soul and conscience, that I have this afternoon at 4 o'clock examined James Thomson at 240 New Street. He has sustained severe injuries, including a compound fracture of the right thigh, and fractures of three ribs on the left side. His condition is so serious that I have ordered his removal to the Royal Infirmary, where his deposition should be taken without delay. He is, in my opinion, fit to undergo a judicial examination.

Malpractice. Malpraxis. Malum Regimen. Medical Responsibility.

By this is understood that the physician or surgeon fails in his duty to the patient, and does not bring to bear on the case that degree of care, skill, knowledge, or judgment, that the law

expects of him in his treatment. (*a*) Actions for damages may be brought against the medical man in the Civil Courts on account of negligence or incapacity in his treatment of the plaintiff, as for example, leaving a pair of forceps in the abdomen after an operation; producing extensive X-ray burns; treating a fracture of the arm for a dislocation, etc. (*b*) In criminal cases counsel for the prisoner may try to throw the blame on the medical practitioner on account of his failure to treat the deceased, or of his faulty treatment of him; thus, it may be shown that a wound was not treated on antiseptic principles, and that suppuration ensued. A wound may render an operation necessary, and if the latter is properly performed, then, if the assaulted person dies, the accused may be charged with murder or manslaughter. If it can be proved, however, that the operation was unskilfully performed, or that some unforeseen accident had happened afterwards (*e.g.* secondary hæmorrhage), then the accused might get the benefit. In cases of criminal wounding it is better before performing any operation to get the opinion of some surgeon as well as his help. An operation ought not to be performed unless it is absolutely necessary, because if the injured person died it might be alleged that he would have recovered if no interference had taken place. A medical man must be able to prove that he used reasonable and ordinary care to the best of his judgment. He is, however, not liable for an error of judgment. The Court expects that a medical man must bring to the practice of his profession that degree of skill and diligence which a well-educated practitioner ought to have. A medical man is not bound to attend to any patient no matter how urgent the case may be. If, however, he undertakes the case he must give it all needful attention, as he has entered into a contract with the patient. A charge of *manslaughter* may be brought against a medical man, and he may be found guilty on account of (1) gross ignorance or of improper treatment, such as overlooking a fracture of the neck of the femur, cutting off prolapsed intestines when attending a parturient woman, or of (2) criminal neglect so great that the patient has died, as leaving the placenta in utero.

The charge of malpraxis is often brought against surgeons who have removed a greater part of the plaintiff's body than he or she gave sanction to. Thus, a surgeon may remove both ovaries though the patient may only have agreed to the

removal of one. It is no excuse for him to say that both were diseased; the patient might prefer to have even a diseased ovary rather than none. Hysterectomy has been performed without the patient's sanction. It is always well before operating to have a written permission from the patient, allowing the operator to perform what he considers necessary for the entire benefit of the patient.

Professional Secrecy.

Information which a medical man receives from a patient either in conversation, in writing, or by direct examination (such as syphilitic rashes), must be kept secret. A mistress may suspect a servant of being pregnant, and may ask her medical attendant to make an examination; before doing so he must explain this to the servant, and obtain her permission. Unless the servant allows the doctor to tell the mistress of her condition, he has no right to divulge any information he has received. Even when called in to a woman after abortion has been practised, or immediately after she has been confined, it would appear that medical men are left to act as their conscience approves in giving information to the police or withholding it. It would be wise to call in a brother practitioner in either case, lest suspicion should fall on the sole medical attendant.

If the practitioner gives utterance to any information so obtained, and if this do hurt to the patient, then the latter may sue him in an action for damages. A few years ago a well-known medical man had to pay £12,000 as damages for revealing a secret obtained in his professional capacity.

In giving evidence in the Law Courts, however, in this country, everything which a medical man has learnt from his patient must be revealed. The law allows no professional secrecy.

Compensation Cases. Accident Insurance.

The Courts are frequently called upon to decide as to the liability of the defendants, or to assess the damages claimed for injuries the result of railway or other accidents. Workmen or workwomen may raise actions under the Employers' Liability Act, or policyholders in Accident Insurance Companies may do so. Medical men are often called upon to give their skilled opinion in contested cases of injury to workmen or servants.

Injuries from accident may be classified as follows :—

(1) Slight injuries which do not incapacitate for a longer period than three weeks.

(2) Serious, or those which incapacitate for a longer period than three weeks: (*a*) Completely curable; (*b*) Incompletely curable.

In determining compensation it is usual to consider the working capacity of the individual as 100, and his subsequent loss of earning power from permanent disability as a percentage of this. Thus, the loss of one eye may cause a loss of wage-earning power of 30 to 40 per cent; total deafness, 75; loss of the right hand, 75; left hand, 65; paralysis of ulnar or median nerve of right arm, 75; paralysis of radial nerve of right arm, 50; loss of right arm, 80; of left arm, 70; ankylosis of right shoulder, 50; of left shoulder, 40; a single inguinal hernia, 10; double, 15; femoral hernia, 15; double femoral, 20; large hernia with escape of intestine, 50 to 100. Both lower extremities are considered equal; amputation above knee-joint, 80; below, 60; all affections of the lower extremities requiring the use of a stick or crutches, 50 to 75.

Many contested cases are very difficult to decide. The claimant may be only very slightly if at all injured, and may make a fraudulent claim. Recently a man was found to have been living for some years on the proceeds of accidents which he had voluntarily brought upon himself by falling over ropes on the pavement or defective mats. He had an affection of his knee which was easily made to appear as a recent injury.

Feigned Diseases. Malingering.

It is a common practice for soldiers, sailors, prisoners, or patients in hospitals to feign diseases, or aggravations of disease in order to escape duty, or with the object of being admitted to, or kept longer in the hospital ward. After trifling accidents, malingering may be practised in order to obtain payment from accident or sickness insurance companies. Soldiers have been known to shoot off their fingers so as to be discharged from the army or navy. Before the old-fashioned cartridge could be fired it was necessary to bite off the end. In order to disqualify themselves for service, soldiers often broke off their front teeth to render themselves incapable of biting the cartridges.

Classification of Feigned Diseases.—(1) Feigned Affections. —These are almost always nervous, *e.g.* epilepsy, vomiting, headache, paralysis, insanity. Insanity may be feigned by the criminal to escape punishment, or by an individual to repudiate a contract (such as marriage); in such the onset is sudden, while in real disease it is slow.

(2) Factitious Affections, *e.g.* the ulcer on the beggar's leg. —This is artificially produced by binding a copper coin tightly on the skin. The verdigris formed under the coin through the action of the sweat on the copper causes irritation and ulceration of the skin. Another method of exciting sympathy is to bind the arm tightly to the side, and present an empty sleeve. Irritation of the eyes is also practised.

(3) Exaggerated Affections.—Almost any disease may be greatly exaggerated as to its symptoms. Thus, after railway accidents it is common to find some of the passengers complaining of many subjective nervous phenomena long after the injuries were inflicted. It is exceedingly difficult in many cases to determine whether a disease is feigned, exaggerated, or actual. An expert malingerer may take in the most careful observer. It is, however, better to err on the side of leniency, as less danger will accrue than if an individual be certified as fit for work when he may really be suffering from disease. A strong miner was in the habit of presenting himself at frequent intervals to his doctor. He complained of indefinite but intolerable pains in his liver, although the practitioner could find nothing amiss even on the most careful examination. Six weeks later the miner sent for the doctor, who found him suffering from advanced malignant disease of the liver.

In the diagnosis of such cases listen attentively, but ask no questions. Note whether he gives a correct sequence in the symptoms of his disease. Ridiculous symptoms may be suggested in order to see if he affirms them, and so commits himself. Examine the case very thoroughly, as the person may be suffering from actual disease. If the examiner is not sure, then before leaving, he may suggest drastic means of cure, such as the actual cautery, repeated blistering, etc.; these may suffice to stop the malingering.

CHAPTER IX.

ASPHYXIA.

Any cause which prevents the oxygenation of the blood in the lungs brings on asphyxiation. The *signs and symptoms* are divisible into three groups.

(1) Increase of respiratory activity.—This is seen shortly after deprival of air; the face has an anxious expression; fulness in the head, and ringing in the ears are complained of; the eyes protrude; the veins of the head are engorged; lividity may be present; the respirations are deep and laboured, and consciousness is soon lost.

(2) The second period is shown by an exaggeration of these symptoms; convulsions of the whole body take place, and the sphincters relax.

(3) The third period is gradually passed into, and now the respirations are slow, irregular, and gasping, convulsions are feeble and of a stretching character, and death takes place. The heart continues to beat for from two to four minutes after respiratory movements have entirely ceased, the pulsations becoming more and more irregular and feeble until they cease. The right side of the heart ceases to contract first, and thus the lungs become engorged with blood.

The above stages may occupy five minutes before death takes place. A total deprival of air for two consecutive minutes is usually fatal, but asphyxiation due to absence of oxygen is more likely to be recovered from than that due to submersion.

Post-mortem Appearances.—External.—Cadaveric lividity is well marked, and especially so in the nose, lips, ears, etc., which may be almost black; patches of greater lividity are scattered over the body. The tongue may be protruded or

normal in position; the eyes may be prominent; the expression may be placid, and there may be no undue lividity of the face, or it may be greatly congested, with much frothy and bloody mucus escaping from the nose and mouth. In asphyxia slowly induced (as in croup) there may be an entire absence of lividity, and the face may be extremely pale.

Internal.—The blood is dark and remains fluid; its spectrum is that of reduced hæmoglobin. The venous system is engorged; this is especially seen in the large veins of the abdomen and thorax, and in the right side of the heart; the left side of the heart is usually empty (this may be a result of rigor mortis). The lungs, as a rule, are dark purple in colour from being filled with venous blood, and on section much bloody froth escapes; the mucous lining of the trachea and bronchi is injected, and of a cinnabar red colour, and the air tubes are filled with a bloody froth. The air cells of the lungs are distended or even ruptured (emphysema). Numerous small hæmorrhages (many being punctiform) are found not only on the surface, but in the substance of the internal organs. These are due to the rupture of capillaries produced by the increased intravascular pressure, and are known as **Tardieu's Spots.** They are present beneath the pleura, pericardium, conjunctiva, meninges of the brain and cord, and generally under all the serous membranes, as well as under the skin of the neck and face, and in the substance of the lungs, heart, liver, brain, and cord (*puncta cruenta*). Though they are found in other forms of death (as in poisoning by CO, pertussis, or scurvy), they are very important in helping to a diagnosis of asphyxia. The internal organs are greatly congested. Asphyxiation may be *caused* by various accidents, as suffocation, drowning, inhalation of irrespirable gases, narcotic drugs, etc., as well as by such diseases as œdema glottidis, membranous croup, diphtheria, paralysis of respiratory nerves, embolism of the pulmonary artery, etc.

SUFFOCATION.

This is the term applied to asphyxiation due to—

(1) Foreign bodies introduced into the air passages.—This condition is usually accidental, as in choking or vomiting; but may be homicidal or suicidal. It may result from disease, as membranous croup, hæmoptysis, capillary bronchitis, etc.

(2) Compression of the chest preventing the expansion of

the lungs.—It may be accidental, as in overlying infants, from the pressure of crowds, or it may be homicidal.

(3) Smothering or occlusion of the nose and mouth.—Accidental smothering may result from falling asleep with the face pressed into a soft pillow, or it may be homicidal.

Choking means the occlusion of the respiratory passages by foreign bodies, either in or pressing upon the entrance. It is usually *accidental*, and is often caused by "bolting" the food; a large piece becomes fixed in the gullet, and either presses on the glottis, overlies it, or even gets into it. Choking may result from vomiting, especially in the intoxicated, a large piece of food being ejected and drawn into the larynx during inspiration. A small body, such as a cherry stone, may also lodge in the rima glottidis. False teeth often produce suffocation; in feeding lunatics by the tube choking may follow, and death may take place almost instantaneously. It may be *homicidal*, as by a foreign body being forced into the throat. A woman was found dead with a cork in her throat; the defence affirmed that the woman was drawing the cork with her teeth when it had slipped back; this was disproved, however, by the fact that the waxed end was uppermost, Rarely it may be *suicidal*; lunatics sometimes force handkerchiefs, rags, etc. into the throat. A female prisoner forced a small handkerchief into her throat, and a lunatic did the same with a stocking. The treatment is to invert the person, and to remove the obstruction by the finger guarded by a towel. If this cannot be done, it is better to perform tracheotomy below the foreign body rather than to force it down, and to continue artificial respiration.

Overlying of Infants.—This is the most common cause of suffocation in this country owing to the dissipated habits of the lower classes, and to the practice of having the infant in bed with the parents. The weight of the mother's arm on the infant's chest will cause slow asphyxiation. In all large towns many children are found dead on Sunday mornings from this accident. Smothering and overlying are often associated. One must bear in mind that infants are often asphyxiated from the pressure of an enlarged thymus gland.

Compression of the Chest may be *accidental*.—In densely packed crowds asphyxiation may be caused by the impossibility of expanding the chest and inflating the lungs. In 1883 during a children's matinee at a Sunderland theatre a cry of fire was

raised, there was a great crush to get out, and the door being shut, 202 children were suffocated. In May 1896 during the coronation fêtes in Moscow, a free feast was provided for the people. Enormous crowds assembled, and in a mad struggle for food 1500 persons perished from suffocation, alone or associated with other injuries. The accident may happen to workmen during excavations of soil or sand. A fall takes place, and the individual may be buried up to his neck; before a rescue can be effected he may have been asphyxiated by the weight of material on his chest. Infants and children are sometimes tightly wrapped up in shawls, and if the weather be cold, slow asphyxiation takes place. The chest may be compressed *homicidally*. The murders committed by Burke and Hare were effected by kneeling on the chest of the victim (who had been rendered more or less helpless by drink), whilst one hand was employed in compressing the nose and mouth, the other being used in holding the lower and upper jaws firmly together ("Burking").

Smothering means the prevention of the access of air through the nose and mouth. It may occur *accidentally*, as during birth from the membranes coming down as a bag over the face of the infant (*the "caul"*), or from the child being expelled, and lying with the face pressed into the bedclothes wet with blood or discharge. It may happen to a weakly child while being suckled, if the mother presses the infant's face too closely against her breast. If the bedclothes be too heavy, or if they cover up the child's face too much, it may be smothered, or if it be laid with its face pressed into a soft pillow. The latter accident may happen to intoxicated adults or to epileptics. If an individual falls into mud or into a light powdery material (flour, cement, grain, sand) smothering may result. *Homicidal smothering* is not infrequent in infants, and even in adults when helpless from alcohol, narcotics, or age. Formerly wet plasters were held over the nose and mouth. As an excuse it is often alleged that the infant died in a fit.

The Post-mortem Appearances in the preceding are those of asphyxiation; powdery material may be found inhaled into the nose, larynx, trachea, or lungs. In homicide, the nose and lips may be found compressed, and the latter congested and indented by the teeth or gums; the cartilages of the nose may be broken. In children the lungs are often covered with small vesicles (emphysema), and punctiform hæmorrhages are very

numerous over the thymus gland. The person may die from shock, so that the usual post-mortem appearances of suffocation may be wanting. Where there has been a great struggle for air, the face may be puffy and deeply cyanosed, the eyes protruding, and numerous punctiform hæmorrhages over the face and neck. The membrana tympani may be ruptured. A careful distinction must be made between death from asphyxia, and from that due to alcoholic or opium poisoning. The chief external signs of death from suffocation consist in the marked lividity of the lips and buccal mucous membrane, and of the nails on the fingers and toes.

STRANGULATION.

This means that the access of air is prevented through pressure on the throat, either manually (throttling) or by a ligature.

Cause of Death.—This may be due to (1) Asphyxia alone; (2) Arrest of the cerebral circulation through pressure on the vessels in the neck,—this leads to deficiency of arterial, and retards the outflow of venous blood, so inducing coma; (3) Shock or syncope; (4) Interference with the vagi and sympathetic nerves in the neck leading to inhibition of the respiratory centre. The spinal cord may even be injured in homicidal cases.

Post-mortem Appearances will, as a rule, be those of asphyxia, but the causes of death may be several, and hence the appearances may not be characteristic. The face may be very swollen, and both it and the neck are usually dark purple in colour, and very livid; punctiform hæmorrhages are numerous over the face and neck; the eyes are usually open, and the eyeballs prominent.

A greater degree of lividity, protrusion of the tongue, bloody froth at the mouth, and clenching of the hands, are more characteristic of strangling than of hanging. If great violence has been used blood may escape from the nose, mouth, and ears; if the ligature be very tight much blood may escape in this way. Blood escaping from a box led to the discovery of the body of a woman who had been strangled by a rope drawn very tightly round her neck.

Mark of the Ligature.—The depression in the skin usually corresponds to the ligature; if the latter be very soft, and if

soon removed, little or no mark may be left. If it be a rope then the skin is depressed, abraded, and marked by the strands; a thin cord leaves a deep, narrow depression. The skin under the ligature is usually ecchymosed, abraded, and parchmented.

Position of Ligature.—It is usually low down, at or below the level of the thyroid cartilage, and runs circularly round the neck. The cord may have been wound several times round, and the marks are thus multiple. The mark of the cord may be produced by tying a ligature round the neck of a dead body up to some hours after death, but in such cases the general post-mortem signs of asphyxia would be wanting.

Accidental Strangulation is rare, but may occur from the slipping down of a load carried on the back by means of a cord or strap round the forehead (Newhaven fisherwomen), or held in the hands. A woman's bonnet has been caught on a branch, and the strings under her chin have caused strangulation; an epileptic or drunk man may be strangled by falling asleep with the neck bent over a stiff collar.

Suicidal Strangulation occurs in about one-half of the total cases. If a cord be employed it must be wound tightly several times round the neck, else it would slip and become slack. A rope may be tied round the neck, and twisted tightly by means of a stick. Recently a man put the ends of his scarf into a wringing-machine, and turned the handle until the ligature was tight enough to cause his death. Women have used their long hair as a ligature. Knots or stones may be placed over the trachea to ensure strangulation. The ligature is never bloody in suicide.

Homicidal Strangulation.—As a rule great violence is inflicted on the neck, the thyroid cartilage being fractured, and blood escaping from mouth and nose. If the crime be done quickly and skilfully, the person is unable to call out, and loses consciousness immediately; thus, a man has been strangled on one side of a partition without those in the next room being aware of the deed. The ribs may be fractured, thus indicating "Burking." The person may have been murdered in some other way, and a ligature placed round his neck to simulate suicide; marks of blood are often found on the ligature in such cases. Marks of strangulation, as well as those of hanging, may be present. The ligature may lead to the identification of the murderer. If the deceased has struggled, injuries may be found on other parts of the

body. A single coil of rope round the neck, if tightly knotted, points certainly to homicide.

Imputed or Feigned Strangling.—This may be done by an individual to inculpate some person, or to exculpate himself after he has committed robbery. No great injury to the neck is found in such cases.

Throttling means the compression of the throat by the hands; if fatal, it could only have been done by a homicide. No great force is required, as the vocal cords are easily made to close, or even to overlap, by compressing the thyroid cartilage. A murderer, however, uses great force; nail-marks (three or four) are found on one side of the trachea, and a thumb-mark on the opposite side; the skin is bruised, parchmented, or shows subcutaneous hæmorrhages; fractures may be found in the hyoid bone, or in the thyroid or cricoid cartilages; the skin of the neck may be much scratched and torn, and there may be injuries to other parts of the body if the person assaulted has struggled. Both hands may be used in throttling, and thus nail-marks may be found on either side of the neck, or one hand may be placed behind the neck, and abrasions may be found there. Deceased may have been throttled, and a ligature placed round the neck to make it appear a case of suicide.

Garrotte is the name given by the Spaniards to a form of execution. A steel collar fixed to the back of a chair is placed round the neck of the culprit, who is suffocated by the executioner tightening the collar by means of a screw. In criminology it means partial throttling by seizing the victim's throat from behind, or by a bandage thrown over the head; consciousness is at once lost, and this condition may persist for several hours. The crime was very common in 1862-3.

Thugee.—The Thugs of India were in the habit of making sacrifice to the goddess Kali by strangling victims with a soft loin-cloth, which was thrown over the head, and drawn tight at once.

The Bowstring is employed in Turkey for the execution of criminals.

HANGING.

Hanging really means strangulation induced by the weight of the body.

Causes of Death.—(1) Asphyxia is in most cases the true cause of death. (2) Arrest of the cerebral circulation, inducing coma ("congestive apoplexy"). (3) Shock or syncope. (4) Pressure on the nerves in the neck, especially the pneumogastric. A very frequent form of death is comato-asphyxia—a combination of (1) and (2). A case has occurred of suicidal hanging in a person who wore a tracheotomy tube, and where there could have been no interference with respiration; the arteries at the base of the brain, in the pons and medulla, were engorged with blood.

Symptoms.—The three stages already described may be noted in true asphyxial hanging; the sensations are not unpleasant, and apparent sleep comes on almost at once. Hanging is a painless form of death. Even when the constriction of the throat is slight, sensibility is very rapidly lost owing to compression or complete occlusion of the blood-vessels, so that the person cannot help himself. Respiratory movements persist for one or two minutes, and the heart continues to beat for fifteen to thirty minutes after hanging. Convulsive movements may be seen. Even if the person be cut down at once, death may supervene from secondary causes, *e.g.* injury to the brain and nervous system leading to hemiplegia, convulsions, or heart failure.

Fatal Period.—If the ligature be below the larynx, death is almost instantaneous; if above it, death ensues in from three to five minutes. In the case of a criminal hanged in Boston in 1858, the heart when exposed one and a half hours later was found beating regularly.

Post-mortem Appearances.—*External.*—There may be no distinctive appearances. In suicidal cases the expression is usually placid; in homicidal, judicial hanging, in the plethoric, or in slow death by hanging, the face may be distorted, livid, and swollen. The lower jaw is usually retracted, and saliva runs from the mouth. The tongue is drawn back when the ligature is at the level of the hyoid bone, but when below it the tongue is protruded; the lower limbs and hands show marked lividity; there is turgescence of the male genital organs, but seldom erection or seminal emission, or a bloody discharge in the female; the sphincters are relaxed. The neck is greatly elongated, and punctiform hæmorrhages are found in both neck and face. The hands may be clenched in violent hanging.

Internal appearances are those of asphyxia. The ligature pulls the root of the tongue and the epiglottis against the back wall of the pharynx, and thus assists in producing asphyxia. If the person has allowed his body to fall even a slight distance, the inner coats of the carotid arteries may be ruptured at the site of the ligature.

Mark of the Ligature.—This varies greatly, a soft ligature leaves little mark, while a hard one leaves a definite depression. The furrow is usually pale and parchmented at the bottom, while the margins are swollen and congested, the upper margin being markedly congested or cyanotic. If the deceased has fallen some distance the furrow is abraded and ecchymosed, and if examined some hours later it appears chocolate-brown in colour. On dissection the subcutaneous tissue below the ligature is white, glistening, and depressed.

Position of Ligature.—It is, as a rule, above the thyroid cartilage in front, and slopes up underneath the jaw-bone and ears towards the occiput. Owing to the pulling up of the noose there is seldom a mark behind, but if it has been pulled tight round the neck the mark may be circular, as in strangulation. If the noose be at the side of the neck or under the chin, there will be an absence of mark at these sites, and the head is always inclined away from the knot.

Accidental Hanging occurs rarely. Boys "playing at hanging" have died without giving any evidence of distress, as have also public exhibitors of hanging. Recently a child was hanged by being caught in the cord of the window-blind.

Suicidal Hanging.—This is the most common of all methods for self-murder; it is easily done, and may be resorted to after other forms of suicide have failed, as cutting the throat. The usual evidences of suicide are present, *e.g.*, farewell letters, fastening of door and windows, previous mental condition, obvious design, as overturned chair. Little injury to the neck is usually found, and all the signs of death from asphyxia are present. The deceased may be found in almost any position, kneeling, sitting, or lying on the floor. It has to be remembered that consciousness and power to help oneself is lost at once, and that the ligature may stretch. The hands may even be tied together in cases of suicide. Age is no bar to suicide, the child of nine and the old man of ninety-nine have hanged themselves.

Homicidal Hanging.—This is a rare occurrence, as it could

only be done to the very young, aged, helpless, or when several people combine, as in lynching. Much injury is inflicted on the neck, and there may be obvious signs of a struggle. A body may be hung up so as to cloak more obvious signs of murder. The appearance of the mark in the neck affords little help, as similar appearances may be produced if a body be hung up an hour after death. The trickling of saliva down the clothes is indicative of life at the time of hanging, as this does not occur in the case of a dead body suspended.

Treatment.—The person should be immediately cut down, and the ligature removed; artificial respiration must be continued, it may be, for hours; venesection may be useful, and cardiac stimulants may be introduced hypodermically or by the bowel. After recovery, death may follow in two or three days from convulsions, cerebral hyperæmia, etc., or the person may recover with hemiplegia, amnesia, etc.

Judicial Hanging: "Long Drop Hanging."—In this country criminals are executed by fracturing or dislocating the first three cervical vertebræ, and so injuring the spinal cord. This is done by placing a noose round the neck, and allowing the condemned to fall a distance of 6 to 8 feet before the rope tightens. The knot is placed either behind the ear or under the chin so that the neck may be more readily broken. The odontoid process is almost never broken or dislocated. The skin has a singed appearance where it has been abraded by the knot. Owing to rupture of the spinal cord or to extravasation of blood into it, violent convulsions are usually present. Lacerated wounds may be produced in the neck, and in a few cases the head has even been torn off. The middle and inner coats of the carotid arteries are ruptured, and the hyoid bone is usually fractured.

DROWNING.

When an individual falls into water he sinks at once, but as the body is only very slightly heavier than the water, and through his exertions, he rises to the surface. If he cannot swim, he probably flings up his arms, shouts, or coughs out the water he may have inhaled, and in so doing parts with a large part of the air in his lungs. As his mouth is usually just at the surface, his next attempt at inspiration draws water and air into his lungs. He may make convulsive grasps at anything within reach, and hence the danger of attempts at

rescue by amateurs. The inhaled water sets up coughing, and air and water are again expelled ; more water is inhaled, and as the body weight has increased, it again sinks. It rises more slowly, and now perhaps only the top of the head appears above the surface. The same proceedings are again gone through and the body sinks. This rising and sinking goes on until the lungs are surcharged with fluid, when insensibility is complete, and as no further struggles are made the body sinks to the bottom. A large quantity of water is swallowed during the period of drowning, and may induce vomiting.

Causes of Death.—(1) Asphyxia causes death in the great majority of cases, 94 to 97 per cent. (2) Shock. The individual may die from shock before or at the moment of submersion. Terror or fright may induce shock, or it may be caused by the person falling flat on the water, the blow being transmitted to the solar plexus. The coldness of the water may react on the recurrent laryngeal, trigeminal, or other nerves which reflexly inhibit the action of the heart and lungs. Coldness of the water may also induce shock through the cutaneous nerves. (3) Concussion of the brain and cord, by falls on the head or buttocks from a height on to the surface of the water. (4) Syncope. This may occur in heart disease. (5) Apoplexy. In people with diseased blood-vessels the sudden driving of the blood into the interior may cause the rupture of a cerebral vessel. (6) Exhaustion from long efforts to keep afloat. (7) Injuries received at the time of submersion. If a man dives from a height into shallow water the head may come into violent contact with the bottom of the river, sea, etc., and fracture-dislocation of the cervical vertebræ may result. In falling the head may strike against piers, etc., and be fractured, or fatal injuries may be received from the paddles or screws of steamboats. In the latter conditions it is as if a dead body fell into the water, and the usual evidences of death from drowning will be wanting.

Period when Death Takes Place.—Death takes place more rapidly in submersion than when there is mere deprival of air. In experiments with dogs, they recovered after having been deprived of air for four minutes, but were killed with a submersion of one and a half minutes. The human being is fatally asphyxiated in water within two minutes, and the heart ceases to beat as a rule in from two to five minutes afterwards. After five minutes' submersion there is little hope of

resuscitating the individual. In certain cases water entering the glottis leads to laryngeal spasm, little or no water may enter the lungs, and such cases may be resuscitated even after prolonged immersion—twenty to thirty minutes.

Post-mortem Appearances.—*External.*—The usual appearances of death from asphyxia may be present, though the face is in most cases of ashy paleness. The most characteristic sign is the presence of a white froth at the mouth and nostrils; much can be expelled on compressing the chest; the greater the struggle has been the larger is the amount of this froth. The tongue may be swollen and closely applied to the teeth.

The "goose-skin" appearance (*cutis anserina*) may be present on the extensor aspects of the limbs. It is due to the cold or fright causing the arrectores pilorum to contract, and though not always present, is an important sign as showing that the person was alive when he fell into the water. For the same reason the genital organs in the male are retracted. On turning the body face downwards much water flows from the mouth. Excoriations may be found on the backs and tips of the fingers, and may indicate that the person struggled for his life, and may have grasped at the banks, rocks, or walls. The drowning person may have caught hold of twigs, branches, leaves, sand, gravel, and such like, and these may be found tightly grasped in the hands through cadaveric spasm. Mud or sand may be found beneath the nails. In the act of death, deceased may have caught hold of weeds growing at the bottom of the water, and so the body may remain held down until decomposition is far advanced. Rigidity comes on early after drowning, and the body is often found in a convulsed attitude. Soon after being taken out of the water the face becomes of a brick-red colour. If the body has been lying in the water for several hours the skin of the palms of the hands, soles of the feet, and knees becomes greyish-blue in colour from hypostasis, and this bleached, sodden condition of the skin is known as the "cholera hand" or "washerwoman's hand."

Internal.—The appearances present in ordinary asphyxia are found in death from drowning. Some additional characters allow of a diagnosis of death from submersion, thus, the lungs are very fully distended ("balloon lungs"); on opening the chest the lungs bulge forward, the left covers over the heart

entirely, and both are indented by the ribs, and retain impressions of the finger; they are œdematous and spongy. This is caused by the retention of the air in the alveoli, and their distension by the inhaled water. The lungs are of a pale grey colour with red stains; the punctiform hæmorrhages are not so numerous as in other forms of asphyxia, and are chiefly at the bases. The weight of such lungs is greater than the normal, but they float. On squeezing the lungs an abundant fine white watery froth can be expelled from the air-tubes; it may be tinged with blood. This froth is most characteristic of death by drowning, and persists in the dead body for four to six days; it exudes in large amount on section of the lungs. Occasionally the leaves of water-plants, sand, or vomited matters may be found in the air-passages. The stomach usually contains water which has been swallowed during death; but the presence of mud, sand, water-plants, straws, sewage, and such like in this viscus is very suggestive of death from drowning. Neither water nor foreign bodies can get into the stomach after death. All the internal organs are deeply congested.

The blood in true cases of drowning contains but little oxygen, and is very watery owing to transudation; the more watery the blood the slower has been the asphyxiation. Incisions in the dead body bleed very freely.

In death from injury, apoplexy, heart disease, pathological conditions pointing to these will be found. Wounds inflicted after death show no vital reaction and no coagula.

Determination of the Cause of Death.—Care has to be exercised to determine this, because all bodies found in water are not drowned bodies. A suicide may drink hydrocyanic acid, or cut his throat, and then allow his body to slip into water. A murder may have been committed, and the body may be then thrown into water.

Accidental Drowning is by far the most frequent cause. It may take place in an inch or two of water (as in the water left in a horse-shoe depression) if the individual be helpless from intoxication, epilepsy, or other causes.

Suicidal Drowning.—One-third of all suicides end their lives by drowning; it is the most frequent form of suicide in women. Even when the hands and feet are tied together it may still be a case of determined suicide. Usually the intention is evident, the pockets may be filled with stones, iron

weights may be hung round the neck; other injuries, as cut throat, or gunshot wound, may be present.

Homicidal Drowning is rare except in the case of infants and children. There may be evidences of a struggle on the banks, the dead body may show wounds, bruises, or scratches, and in the hands hair, pieces of clothing, etc., may be found tightly grasped.

It is a frequent occurrence to find people dead in a bath of hot or cold water. Their death may have been due to (1) Syncope induced either by the hot or cold water, or (2) Apoplexy caused by the acceleration of the heart's action, and to the reflex dilatation of the blood-vessels. This may alone cause death, or it may be associated with drowning.

Treatment of the Apparently Drowned.—In rescuing a drowning person approach him from behind, and raising up his face above the water by placing one hand under the occiput, keep him at arm's distance, and draw him slowly to the shore. A drowning man may convulsively grasp hold of the rescuer by the arms, and both may thus be drowned, hence caution is required. Having got the body ashore, rapidly strip off the coat and vest, loosen the neckbands, turn the body on its face so as to allow the water to drain from the lungs, and having cleared the mouth of mud or sand begin *artificial respiration*, and continue it for hours if necessary; not a moment should be lost, every instant of delay is serious.

(1) *The Prone Pressure Method of Professor Schäfer* is the best and easiest to perform. The body is to be placed on its face, with a folded coat under the lower part of the chest. The operator then kneels astride the patient, and placing his hands flat over the lower part of the back on the lowest ribs, he gradually throws the weight of his body forward on to them, and thus firmly compresses the patient's chest. The operator then slowly raises his body while still keeping his hands on the lower ribs. This backward and forward movement (compression and relaxation of the chest) must be repeated every four or five seconds, or twelve to fifteen times per minute, and must be continued until natural respiration is fully established. This method allows of the largest volume of air to enter the lungs, and is little likely to cause rupture of the congested liver.

(2) *Silvester's Method.*—After allowing the water to escape

from the mouth, the body is placed on its back with a folded coat under the lower part of the chest; the tongue must be kept out by a pin or elastic band. The operator kneels at the head, and grasping the arms of the patient at the elbows, he raises them steadily above the head and keeps them so for two seconds. He then depresses the arms, and presses them firmly on each side of the patient's chest. This procedure is to be repeated fifteen times per minute.

(3) *Howard's Method.*—The position of the patient is as in the preceding, but the operator kneels astride the patient's legs, and throws the weight of his body on his hands, which are placed one on either side of the patient's chest. There is danger, however, of rupturing the liver by this procedure.

(4) *Marshall Hall's Method* consists in placing the patient prone with a folded coat under his chest, and turning the body gently on to its side and a little beyond; then it is rolled over on to the face, and the same operation repeated.

(5) *Laborde's Method.*—This consists merely in laying hold of the tongue with a handkerchief, and in drawing it out fully and regularly fifteen times per minute (rhythmical traction). This stimulates the respiratory centre.

While the operator is performing any of the above methods, others should lay hot-water bottles to the limbs, apply alternately affusions of hot and cold water to the face and chest, together with friction and the employment of smelling salts; hypodermic injections of strychnine, atropine or adrenalin may be given. When respiration has been established, the patient should be put to bed, and carefully attended to. After resuscitation death often follows from exhaustion, pneumonia, etc.

CHAPTER X.

DEATH FROM STARVATION, COLD, HEAT, AND LIGHTNING.

DEATH FROM STARVATION.

Death caused by absolute or acute starvation is rarely met with in this country. On the other hand, infants and young children are frequently killed by partial or chronic starvation, cold and neglect. In many cases the partial starvation is unintentional, and is due to the unsuitable character of the food given to the infant. This is particularly true in manufacturing districts where women are largely employed in mills and warehouses, the infants being left to the care of older children. Depraved parents may, however, neglect and starve their offspring with the intention of allowing them to die in order to obtain the burial money. For the same reason interested parties may neglect or even starve their sick, feeble-minded, or aged relatives, so that they may sooner inherit their property. If a master or mistress neglects a servant or apprentice in respect of food, clothing or lodging, he or she is guilty of a misdemeanour and may be punished by three years' penal servitude (24 & 25 Vict. c. 100). The same punishment is awarded under the Cruelty to Children's Act, 1894, and infants are also safeguarded by the Infant Life Protection Act of 1897, against being farmed out.

Cases of acute starvation may occur in miners imprisoned in pits by falls of rock, or in sailors cast adrift in small boats. Prisoners and lunatics sometimes endeavour to starve themselves to death, and have on a few occasions succeeded. In rare instances adults have been starved to death homicidally. In the "Penge Mystery" of 1877, it was alleged that

Harriet Staunton, aged thirty-five, had been starved to death by her husband and his paramour, as well as by 2 other relatives. The report of the medico-legal examination of the body showed that death had been caused by starvation. All 4 accused individuals were condemned to death. Later, it was found that the post-mortem examination had been imperfectly performed; neither the urine, suprarenal glands, nor the œsophagus had been examined, but tubercles were stated to have been present in the lungs and meninges of the brain. The paramour was pardoned, and the capital sentences passed on the others were commuted to penal servitude.

Symptoms.—A painful "sinking" sensation, relieved by pressure or by chewing, is experienced after fasting for some hours. Thirst and hunger become intense, and last for two or three days. After this period the craving for food becomes less and less insistent, but extreme cold is complained of, and progressive weakness. The gait becomes feeble and tottering, the voice sinks to a whisper, and the emotions are easily roused. If starvation lasts four or five days, the body becomes extremely emaciated, the eyes sunken and staring, and the cheeks hollow; the face is pale and ghastly, the mouth is dry, and the lips and tongue are cracked and bleeding. The mucous membrane of the lips, nostrils, eyes, anus, vagina, etc., are inflamed; the skin is pale, dry, parchment-like, and coated with a brown fœtid exudation. The breath is also fœtid. The mind may remain clear to the end, or there may be illusions of sight or hearing. The person may pass into a deep sleep, and often dreams of banquets and feasting. In other cases delirium or convulsions may precede death. The temperature of the body undergoes a steady fall until before death it may reach as low as 70° F. The whole of the tissues in the body undergo a progressive wasting, but the fat undergoes the most rapid and complete absorption. After starvation for a few days, there is practically no fat left. The glandular structures of the body stand next in order of rapid absorption, and the muscular tissues come next.

Post-mortem Appearances.—A fœtid odour arises from the corpse, which undergoes rapid decomposition. The body is shrunken, the skin is dry, shrivelled, and bran-like to the touch. There is an entire absence of subcutaneous fat, and the bones project very visibly; bedsores may be present. The intestines are empty, contracted and translucent from

the absorption of fat and thinning of the muscular coats. Ulceration may be present at the lower end of the intestinal canal. The thinness of the intestinal walls is very characteristic. The gall-bladder is distended with bile. The urine is scanty, dark in colour, and high in specific gravity. Urea is diminished in amount; chlorides disappear; the excretion of potassium is increased; the phosphates remain unaltered in amount; acetone and acetic acid are greatly increased. In making this medico-legal examination, a very careful search must be made for evidences of any diseases which are associated with progressive wasting of the body. The individual may have died from malignant disease of the œsophagus, stomach wall or pylorus. Tuberculosis also leads to progressive emaciation, and disease of the pancreas most markedly so. Certain nervous diseases as progressive muscular atrophy are associated with marked wasting, as is also diabetes mellitus, Addison's disease or chronic intestinal catarrh (especially in infants and children). The urine should be examined for the presence of sugar or albumen.

How Long may a Person Survive Without Food.— If neither water nor food be obtainable, then the average limit of endurance is ten days. If water be obtainable, then life may be prolonged for thirty to forty or even seventy days. There are, however, many exceptions to these averages. The power of endurance varies with the age, condition of the body, and the surroundings of the individual. Children quickly succumb to want of food, whilst old people resist best of all. Females as a rule survive males on account of the greater amount of adipose tissue in their bodies. A girl aged sixteen and an infant were entombed in a cellar in Naples by an earthquake; the child died on the fourth day, but the girl remained alive without food or water until the eleventh day, when she was rescued. When an individual loses $\frac{2}{5}$ or 40 per cent of the body weight, death takes place. The daily loss amounts to $\frac{1}{24}$ of the total weight. The drinking of sea water induces delirium and hastens death; this is due to the fact that the salt water in the stomach and bowels causes an osmotic flow of the watery constituent of the blood into the alimentary tract, and causes a further reduction in the amount of the circulating fluid. Professional fasters (Jacques, Succi, Dr. Tanner) often abstain from food for forty days and upwards.

Treatment.—In the case of persons who have had a prolonged

abstinence from food or drink: they should be placed in bed at once, and gentle warmth applied in the shape of warm bottles. Sips of slightly warm water should be given, and gradually a little milk should be added. Predigested liquid food may then be given in small quantities. Great care should be taken in giving solid food as the digestive processes remain feeble for long and an attack of indigestion may end fatally.

In deciding the question as to whether a child has been starved and ill-used, the body must be carefully examined for the presence of bruises, vermin, and cutaneous diseases. It must then be weighed, and the weight compared with that of a normal child of the same age and sex; if it be only a few pounds lighter than the normal, it may be merely an under-sized child. If, on the contrary, there be a very great disproportion, as only half the weight of a normal child, while at the same time it is of average length, then the probability is that the child has been neglected and starved.

During the first two or three days after birth, an infant loses 4 to 7 ounces in weight. It doubles its weight in six months and trebles it at the end of twelve.

WEIGHT OF INFANT DURING ITS FIRST YEAR.

Age.	Weight at end of Month.	Age.	Weight at end of Month.
Newly born	6 lbs. 8 ozs.	7th month	13 lbs. 4 ozs.
1st month	7 ,, 4 ,,	8th ,,	14 ,, 4 ,,
2nd ,,	8 ,, 4 ,,	9th ,,	15 ,, 8 ,,
3rd ,,	9 ,, 6 ,,	10th ,,	16 ,, 8 ,,
4th ,,	10 ,, 8 ,,	11th ,,	17 ,, 8 ,,
5th ,,	11 ,, 8 ,,	12th ,,	18 ,, 8 ,,
6th ,,	12 ,, 4 ,,		

TABLE OF THE AVERAGE HEIGHTS AND WEIGHTS.

Age last birthday.	Males.		Females.	
	Height.	Weight.	Height.	Weight.
1	2 ft. 5½ ins.	1 st. 4½ lbs.	2 ft. 3½ ins.	1 st. 4 lbs.
2	2 ,, 8½ ,,	2 ,, 4½ ,,	2 ,, 7 ,,	1 ,, 11½ ,,
3	2 ,, 11 ,,	2 ,, 6 ,,	2 ,, 10 ,,	2 ,, 3½ ,,
4	3 ,, 1 ,,	2 ,, 9 ,,	3 ,, 0 ,,	2 ,, 8 ,,
5	3 ,, 4 ,,	2 ,, 12 ,,	3 ,, 3 ,,	2 ,, 11 ,,
6	3 ,, 7 ,,	3 ,, 2½ ,,	3 ,, 6 ,,	2 ,, 13½ ,,
7	3 ,, 10 ,,	3 ,, 7½ ,,	3 ,, 8 ,,	3 ,, 5½ ,,
8	3 ,, 11 ,,	3 ,, 13 ,,	3 ,, 10½ ,,	3 ,, 10 ,,
9	4 ,, 1½ ,,	4 ,, 4½ ,,	4 ,, 0½ ,,	3 ,, 13½ ,,
10	4 ,, 3½ ,,	4 ,, 11½ ,,	4 ,, 3 ,,	4 ,, 6 ,,
12	4 ,, 7 ,,	5 ,, 6½ ,,	4 ,, 7½ ,,	5 ,, 6½ ,,
14	4 ,, 11½ ,,	6 ,, 8 ,,	4 ,, 11½ ,,	6 ,, 12½ ,,
16	5 ,, 4½ ,,	8 ,, 7 ,,	5 ,, 1½ ,,	8 ,, 1 ,,
18	5 ,, 7 ,,	9 ,, 11½ ,,	5 ,, 2½ ,,	8 ,, 9 ,,
20	5 ,, 7½ ,,	10 ,, 3 ,,	5 ,, 3 ,,	8 ,, 11½ ,,
25 } 30 }	5 ,, 7½ ,,	10 ,, 12 ,,	5 ,, 3 ,,	8 ,, 8 ,,
31 } 35 }	5 ,, 7½ ,,	11 ,, 6 ,,	5 ,, 3 ,,	8 ,, 9 ,,

DEATH FROM COLD.

Those who succumb most readily to cold are children or the aged, those suffering from wasting or circulatory diseases, and drunkards. Women withstand low temperatures better than men because of their larger supply of adipose tissue. Cold damp air is more fatal in its effects than cold dry air. The deleterious effects of cold are due to its local and reflex action on the circulatory system, as well as to the production of toxic materials which it induces in the body. About 130 persons fall victims to cold and exhaustion during the winter of each year in England.

Symptoms.—One of the first signs is that of "goose skin." The fingers and toes, or the hands and feet, become more and more painful the longer the person is exposed to the cold;

this painful condition is succeeded by numbness, and a feeling of weight in the extremities; the person complains that he cannot raise his arms or carry anything, and that each step is as if he were dragging legs made of lead. This stiffness spreads over the limbs; great weariness is experienced, drowsiness of an intense nature develops, and unless help is near or the individual makes violent efforts to keep himself awake, he sinks down, and falls at once into a lethargic sleep. This may pass into coma and finally death. There may be disturbances or illusions of hearing or vision, and partial intoxication, convulsions or delirium may result from congestion of the brain, or from the circulation of toxins. Some years ago a party of Newfoundland fishermen were cast adrift on an ice floe, and were exposed to great privation and cold; several of them had the illusion that a vessel was waiting for them at one side of the ice. In spite of the entreaties of their friends and attempts to restrain them, they ran to the imaginary vessel, and perished in the sea. On examination it is seen that the extremities first become pale, then purplish and cyanotic, and finally pale again, owing to paralysis of the internal vessels of the body, and the driving in of the blood from the surface.

Post-mortem Examinations.—The skin generally is very white, but the tips of the fingers, toes, and ears are livid. There is marked congestion of the internal organs, and much blood is found in the paralysed large vessels of the thorax and abdomen. The brain is congested, and effusion into the ventricles may be found. Small extravasations of blood are present in the lungs, brain and kidneys. The blood remains very fluid, and is bright red in colour resembling arterial blood; this red colour is especially well seen in the heart, and is due to the fact that extreme cold prevents the normal dissociation of oxygen from the hæmoglobin; oxyhæmoglobin being reduced with difficulty at low temperatures. The skin is very pale, but on exposed situations there are cherry-red spots (frost-erythems) resembling those seen in poisoning by carbon monoxide. These red spots are not present on depending parts as occurs in ordinary hypostasis. If the body be warmed, these red patches become changed in colour into the usual cadaveric lividities. In cases of recovery, certain parts of the body, as the ears, nose, fingers, etc., remain livid, and may became intensely inflamed and even gangrenous owing to

the thrombosed condition of the vessels, and the devitalised state of the parts. Even after the person is rescued and warmed, death may supervene from failure of the circulation induced by exhaustion and toxæmia. In badly conducted asylums, death has followed the employment of a cold bath as a punishment to refractory patients; the fatal result may be immediate, or may be deferred for some hours, the reaction never having taken place. A woman compelled her daughter to stand in a pail of ice cold water on the 28th December: the girl soon complained of being tired, and of being unable to see; a pail of cold water was then thrown over her, and she died shortly afterwards.

Treatment.—This consists in conserving the warmth of the body, and in stimulating the circulation; the individual should be placed between blankets in bed, and warmth gradually and carefully applied. Care must be exercised not to apply heat too rapidly lest the blood be brought back too quickly to the devitalised tissue, and intense congestion or inflammation be set up. Friction should be applied to the limbs by the hand or warm flannel, and a weak warm stimulant administered (a teaspoonful of brandy in a wine-glassful of warm water). Injections of warm saline fluid into the rectum are very useful. As the person recovers weak warm soup or coffee should be given. Nephritis or bronchitis may ensue, and will require appropriate treatment.

DEATH FROM HEAT.

Any external source of heat may suffice to cause death, thus, the heat from a furnace or oven may cause heat apoplexy. It is usual, however, to apply the term "sun-stroke" to a condition induced by exposure to the direct rays of the sun. Heat-stroke is often associated with deficient circulation of air, thus, those working in the open air in a confined enclosure are very liable to sun-stroke, and more especially if the air be humid, thus retarding evaporation of sweat from the body. Those most liable to the slighter forms of heat-stroke are the young, the old, and those suffering from disease, wounds, or from severe fatigue. Improper clothing, as tightly-fitting tunics which hamper respiratory movements and prevent normal transpiration, render the wearer more liable to sun-stroke. Adult males, owing to their

occupation, are more subject to sun-stroke than females. Intemperance predisposes to an attack. The dark-skinned races are less easily affected by heat than the fair ones, hence the common practice of employing lascars as stokers. Those unaccustomed to direct exposure to the sun's rays are more prone to be attacked. Thus, town dwellers labouring in open meadows and exposed to temperatures of from 80 to 85° F. are liable to sun-stroke. This has also happened to parties of picnickers engaged in arduous games. The effects of exposure to heat may be grouped into three divisions :—

(1) **Mild Thermic or Simple Continued Fever.**—The patient complains of malaise; there is intolerance of bright lights or sounds. The temperature may rise to 103° or 104° F. and the skin over the body is reddened. There is pain in the muscles, severe headache, prostration, and, it may be, slight delirium; the condition may last from three to ten days. In very warm climates as in India, the patient may pass into a comatose condition, and death take place in from three to four days.

(2) **Heat Collapse—Syncopal Form.**—(*a*) In the *mild form* the symptoms are those of exhaustion, and come on gradually with throbbing pain in the temples, epigastric sinking, vomiting and purging, giddiness, dimness of vision, dilatation of pupils, sighing respiration, pallor of the skin, and collapse.

(*b*) In the *grave form* the individual falls down and immediately becomes unconscious; the surface is cold, pale, and covered with perspiration; the pulse is feeble and irregular, and death usually supervenes rapidly from heart failure. This grave form may develop spontaneously or it may be a further stage of the mild form (*a*).

Heat syncope is liable to attack those working hard in a very warm atmosphere either in the open air or in a factory (stokers, glass-blowers, dancers, wrestlers). Soldiers on parade, or on the march in close order, encumbered with tight clothing, often fall out from cardiac failure, and may succumb. The human body can stand enormously high temperatures for short periods if the air be very dry and the work be not arduous. Thus, the workmen in potteries often enter furnaces where the temperature may be 300° F. Chabert in his exhibitions as the "fire-king" was in the habit of entering an oven heated to temperatures varying from 400° to 600° F.

(3) **True Sun-stroke, Insolation; Coup de Soleil; True Thermic Fever; Siriasis.**—The onset may be absolutely sudden, but there may be premonitory symptoms (as complaints of heat, headache, and giddiness), which are usually first noticed during the night; consciousness is suddenly lost, and the individual may fall down; the pulse is full and bounding; the surface of the body hot and red; the face congested; the respirations stertorous; the pupils contracted; and a peculiar pungent odour is given off from the skin and the breath. There is marked hyperpyrexia, the temperature rising to 112° or 115° F. The patient may remain quiet in this comatose condition, or there may be subsultus or convulsions and occasionally delirium. Death may take place almost instantly, but more usually in from half an hour to one hour, and is due to heart failure or asphyxia.

Post-mortem Appearances.—Petechiæ may be present in the skin. Cadaveric rigidity comes on soon, and rapidly passes off. The blood remains dark and fluid; the red corpuscles are crenated, and numerous blood-plates are present. The internal organs are greatly congested, the lungs and the meninges of the brain especially so. The right side of the heart and the large veins of the thorax and abdomen are distended with blood. Putrefaction takes place early. The mortality in this variety is very high (40 per cent) as it is also in the grave form of heat collapse. If recovery takes place it is slow and often retarded by relapse. Intolerance to the sun's heat or to light persists for long, and nervous affections such as headache, irritability, forgetfulness, or even epilepsy or insanity, may persist permanently.

Treatment.—(*a*) In the condition of collapse, stimulation is required; if the surface of the body is cold, heat must be applied, as also mustard blisters over the heart or to the soles of the feet; ammonia to the nostrils; enemata of saline solution or hypodermic injections of ether or strychnine are very useful.

(*b*) In true sun-stroke, the temperature of the body must be lowered by placing the patient in a warm bath, and adding cold water gradually until the temperature of the water falls to 70° or 80° F. He should be kept in such a bath until his temperature falls to 101° F. If the temperature should again rise the cold bath may be repeated; an ice bag should be applied to the head, and a mustard blister behind the neck.

DEATH FROM LIGHTNING.

From 18 to 20 persons are killed each year in England from lightning-stroke; usually the shock causes instant death. The body may exhibit no markings whatever, especially in death by "return shock." On the other hand, severe contusions or lacerations of skin and muscles may be present at situations corresponding to the entrance or exit of the current, and may even simulate homicidal wounds.

Varieties of Effects.

(1) In very slight shocks, the person merely complains of confusion of ideas, giddiness, ringing in the ears, headache, hysteria, etc. Recovery soon takes place.

(2) If the shock has been more severe, loss of memory is often observed, or peripheral paralysis of various groups of muscles, delirium, and even insanity. The effects of lightning on the eyes are numerous, some are transient, but others may lead to permanent blindness. Clouding of the cornea and opacity of the lens are the most frequent. Retinal hæmorrhage, detachment of the retina or optic atrophy may follow. The individual may remain "queer" subsequently to the shock, or may become actually insane.

(3) In intense cases, the person falls insensible at once; the respirations are slow and deep; the jaws are rigidly fixed; tetanic spasms may be present.

(4) Death may take place instantly from the severity of the electric discharge, or fatal results may follow in days or even weeks from the burns or lacerations. Metallic substances in the pockets, such as watches, coins, chains, etc., are rendered magnetic or fused, and they may leave their impression on the skin. The clothing is almost invariably torn at the entrance or exit of the current; it may be entirely stripped off, and thrown to a distance, and yet the person may remain unharmed; if he were unconscious, it might be thought that the person had been murderously attacked. A servant girl crossing a meadow during a thunderstorm was struck by lightning, and though every shred of clothing was torn from her body, she herself merely experienced slight giddiness. Again the clothing may be unharmed whilst the boots or shoes

are torn to shreds; this is due to the non-conducting character of the leather, and to the presence of the metallic nails or heel-plates causing the current to be split up.

Post-mortem Appearances.—The body may be rendered rigid by the passage of the electric current, and it may thus retain the attitude which it had at the moment of being struck. The hair may be burnt off the head or face either in part or entirely. The skin at the point of entrance or exit of the current may exhibit erythema, contusions, or lacerations; the latter may be superficial, or so severe as to lay bare and split the bones or expose the viscera. The muscles and skin may be torn into shreds, and the bones fractured. In some cases the wound resembles closely a stab or incised wound. In other cases actual burns are produced; these may be superficial, giving rise merely to vesication; if more severe, the skin and underlying tissues are charred. In the passage of the current through the brain the scalp may remain uninjured, whilst there may be extensive hæmorrhage on the brain.

Markings on the Skin.—Occasionally "tree-leaf" markings are produced on the skin. These are reddish brown in colour, and consist of a branching arrangement which gave origin to the idea that they were photographic imprints of adjoining trees or shrubs produced on the skin by the electric current. They are really due to the subdivision of a somewhat feeble current by the resistance of the tissues, and to the rupture of superficial capillaries in consequence. Rigor mortis comes on very quickly, and is very transient.

Fig. 7 illustrates the appearances seen in some cases of lightning-stroke. The electricity entered through the man's cap, and passed out through the right foot, causing burns of the second and third degree throughout its course. The clothing was also stripped almost entirely off and left in the condition shown in Fig. 8. The case occurred in the practice of Mr. J. Lynn Thomas, C.B., F.R.C.S., Cardiff, to whom I am indebted for the photographs.

Mechanism of the Discharge.—When there exists a great difference of electric potential between a cloud and the underlying earth, a condition of electric tension exists; this increases until the resistance of the dielectric (the air in this case) is overcome, when the discharge takes place. If on a level surface any objects project for some distance (*e.g.*

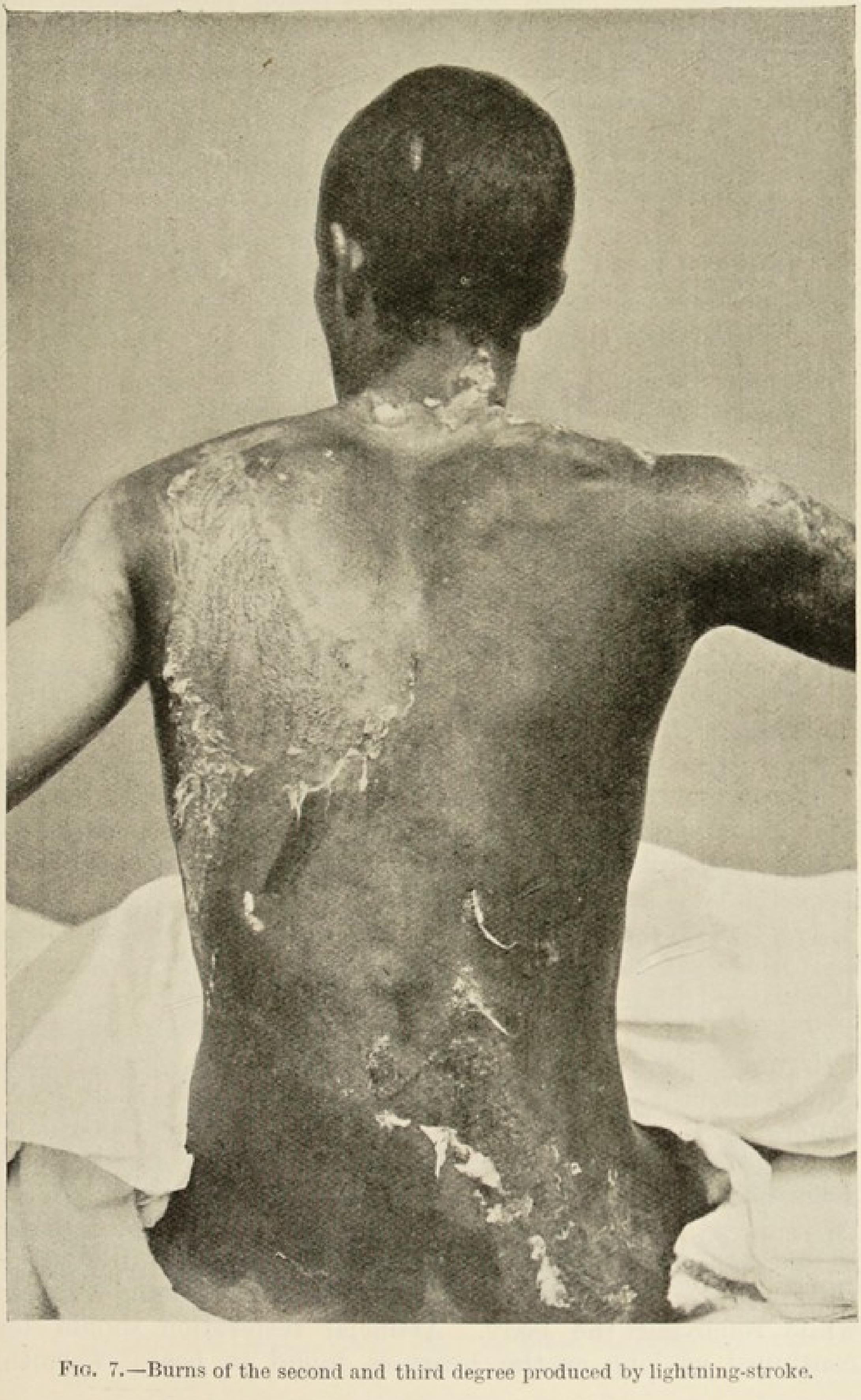


FIG. 7.—Burns of the second and third degree produced by lightning-stroke.

a tower, tree, or human body), these lessen the resistance by the exact height to which they rise. When the discharge takes place, it is most likely to do so by way of one of these projecting bodies, thus, the tower might be demolished, the tree-trunk rent asunder, or the man killed. The most destructive effects are found close to the centre of the electric discharge; the whole area around this centre is likewise influenced. When a discharge takes place through the trunk of a tree, the latter is shattered, and animals or persons are killed not only when close to the tree, but even when at some considerable distance from it.

Deaths from Electric Discharges.

Owing to the almost universal use of electric energy, accidents due to the passage of the current through the human body are not infrequent. Accidents happen to workmen from touching dynamos, or the live-wires of electric railways or tramways; leaky or broken electric mains are also the frequent cause of accidents. When the dynamo sends a current of high potential (above 500 volts) through the mains either directly or in alternating currents, then the shock produced by such is exactly comparable to lightning-stroke. The alternating is much more dangerous than the continuous current.

(1) In minor cases the parts of the skin where the wires have touched are burnt, the surface of the body is cold and moist, the breathing is stertorous, the pupils are dilated, and insensibility is usually present.

(2) In severe cases, the person immediately becomes insensible, makes a few gasps and dies. Death is due to paralysis of the heart and respiratory centre.

Post-mortem Examination reveals numerous subserous ecchymoses, and capillary hæmorrhages in the brain. The cytoplasm of the nerve cells in the brain and spinal cord undergoes marked change.

Treatment.—The current in the electric main must be cut off at once if the station is at hand; if not, the person must be removed from contact with the electric cable; the rescuer should encase his hands in indiarubber gloves or in several thicknesses of flannel to prevent the risk of his getting a shock while removing the body. Artificial respiration should be continued as long as the heart is found to beat; warmth

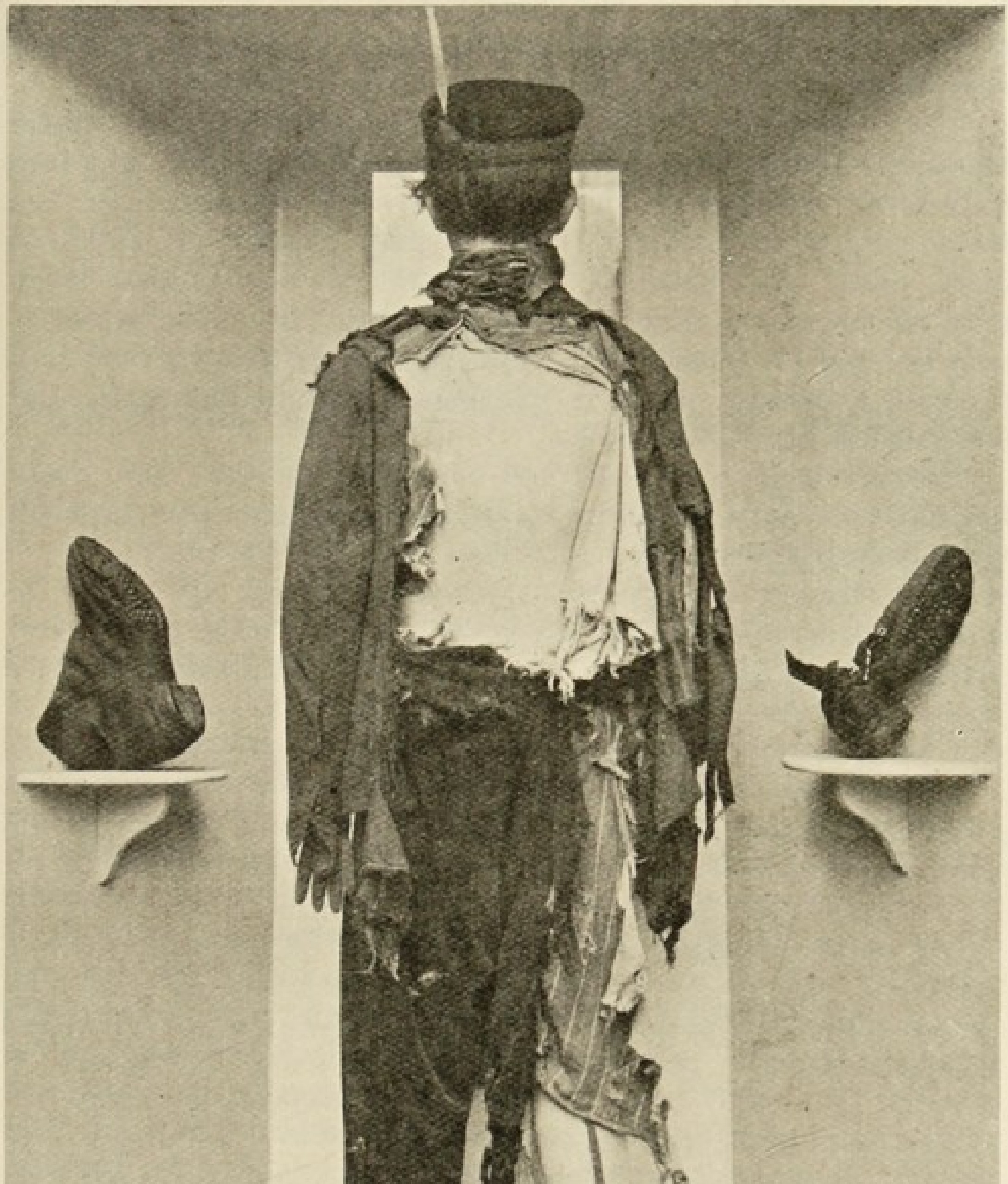


FIG. 8.—Clothing of the same individual which was almost completely torn off his body by the same lightning-stroke.

should be applied to the extremities, and the circulation promoted by gentle friction of the skin. Extensive gangrene may supervene on recovery, and may cause death later.

There is little danger from shocks produced by electric fittings in the house. Before it is allowed to be brought into a dwelling the voltage has to be greatly reduced. In the street mains the ordinary current may amount to 2000 or 3000 volts; the Board of Trade, however, insists that it be reduced by means of a "transformer" to 250 volts before it may be used for house-lighting purposes. Such a current may produce faintness, dimness of vision, pain in the eyes, and nervousness for a day or two.

Electrocution is the method employed in New York State for the execution of criminals, an alternating current of 1500 volts being required.

CHAPTER XI.

PREGNANCY IN RELATION TO LEGAL MEDICINE.

During the earlier weeks of utero-gestation it is very difficult to determine with certainty whether pregnancy exists or not. The greater the experience of the practitioner the more likely is he to give a correct diagnosis. Cautious medical men will, however, seldom give a positive answer before the sixth or eighth week of pregnancy. In *diagnosing pregnancy*, a careful examination must be made into the history, and this must be followed up by a thorough physical examination of the woman. If one or more of the certain signs be absent, no matter how strong the presumption may be, then no definite opinion should be expressed. If an erroneous diagnosis be made, and it is stated that a woman is pregnant when she is not so, the medical examiner has, it may be, slandered the woman, and may have rendered himself liable to an action for damages through false accusation. In any case such a mistake in diagnosis renders him an object of ridicule, and loss of professional reputation is sure to follow. Medical men may be called upon to determine whether pregnancy exists in a woman who affirms that she has been seduced, or who desires to enforce marriage on her seducer. Pregnancy may be alleged in order to obtain blackmail from the reputed father. A divorced woman may state that she is pregnant in order to obtain a larger amount of aliment. Women sentenced to death may state that they are pregnant in order to delay their execution, or to obtain mitigation of the sentence. It may be alleged in order to secure greater compensation for the death of a husband, or a widow may feign pregnancy so as to defraud the rightful heir by producing a supposititious child.

SIGNS OF PREGNANCY.

The Subjective signs of pregnancy are of little value in determining the condition with accuracy. The patient may purposely make false statements so as to mislead the examiner. Amenorrhœa may be due to anæmia, phthisis, cancer, nervous excitement, as well as to pregnancy, and unmarried women may, through fear, miss one or two menstrual periods after illicit intercourse. On the other hand, menstruation may persist for two or three months during pregnancy, and may be due to the non-union of the decidua vera and reflexa until the third month. Hæmorrhage may also result from partial separation of the membranes from the uterine wall. In rare instances menstruation has persisted during the whole term of pregnancy, this could only result from the uterus being double or bicornuate. The other subjective symptoms of pregnancy (morning sickness, nervous phenomena, quickening, etc.) do not call for comment.

Objective Signs.

(1) **Changes in the Mammæ.**—General enlargement of the mammæ takes place as early as the second month. The nipple increases in size and becomes more erectile, while the pink areola surrounding it becomes dark in colour. In fair women this areola becomes pale brown, while in dark-complexioned women it becomes dark brown or almost black. The sebaceous follicles in the areola increase in size, and at the end of the second month project as twenty or thirty distinct tubercles on the skin surface ("Montgomery's tubercles"). The darkening of the areola usually persists throughout life, but in very fair women a single pregnancy may not cause a permanent pigmentation. Milk is secreted at an early period, pressure on the breast from the third month onwards usually causing a flow of "colostrum." Apart from pregnancy, repeated sexual intercourse or irritation of the breasts or genital organs may cause enlargement of the breasts and secretion of milk. A little girl aged nine years was in the habit of suckling her baby brother; this soon induced the secretion, and she was enabled to rear the infant on her own milk. Ovarian or uterine disease may also lead to enlargement of the breasts. When once the glands have been stimulated to activity, the

flow of milk may remain permanent, or if in abeyance, each menstrual period may bring back the flow. In cases of suspected pregnancy, an examination of the breasts may afford information, and this without rousing suspicion in the mind of the patient.

(2) **Pigmentation of the Skin.**—This is seen chiefly in the perineum and vulva, and may extend as the *linea nigra* up to and beyond the umbilicus.

(3) **Changes in the Vagina.**—As early as the fourth week the colour of the vaginal and vulvar mucous membrane undergoes a marked darkening. The normal pale pink colour changes to pale violet, and later to a deep purplish blue as pregnancy advances; this is known as *Jacquemier's test*, and is very characteristic of pregnancy. A vaginal pulsation can also be detected by the finger at an early period. A copious leucorrhœal discharge is usually present during pregnancy.

(4) **Cervix Uteri.**—In the non-pregnant condition the feeling which the tip of the cervix uteri gives to the examining finger is comparable to that felt on touching the tip of the nose. As pregnancy advances the vaginal part of the cervix undergoes a progressive softening and enlargement. After the third month the feeling given to the examining finger is like that experienced on touching the closed lips of the mouth. This softening of the cervix has a high value in diagnosing pregnancy, and is sometimes known as *Goodell's sign*.

(5) **Softening and Compressibility of the Lower Uterine Segment** (*Hegar's Sign of Pregnancy*).—This is determined by bimanual examination, when the softening and broadening out of the lower uterine segment is easily made out. A spot of peculiar softness and elasticity of the uterus just at the junction of the body and cervix makes its appearance at the fifth or sixth week, and its presence is asserted to be a positive proof of pregnancy.

(6) **Intermittent Uterine Contractions** (*Braxton Hicks's Sign*).—Each contraction lasts from one to five minutes, and the interval between varies from five to twenty minutes. Such contractions may be felt as early as the third month of pregnancy on bimanual examination.

(7) **Uterine Souffle.**—Auscultation low down on either side of the uterus from the fifth month will reveal a soft blowing murmur synchronous with the maternal pulse. This is due to

the flow of blood through the dilated and tortuous uterine vessels. A similar souffle is present with many fibroid or ovarian tumours, and hence its value as a test of pregnancy is only corroborative.

(8) **Enlargement of the Abdomen.**—After the third month a gradual enlargement of the abdomen takes place. In the later months the skin becomes stretched, and bluish red lines, or *striæ gravidarum*, are formed. But any condition which leads to rapid distension of the abdomen (ascites, ovarian tumour) may also cause striæ. The umbilical depression becomes level with the skin surface at the sixth or seventh month, and later it becomes everted.

(9) **Uterine Tumour.**—At the end of the *third* month the fundus is a finger's breadth above the pubis. At the end of the *fourth* month this distance has increased to 2 inches; at the fifth month, 4 inches; at the sixth month, at the level or slightly above the umbilicus; at the seventh month, 2 inches above the umbilicus; at the eight and ninth months it reaches the ensiform cartilage.

(10) **Fœtal Heart Sounds** are absolutely indicative of pregnancy, and are heard on auscultation after the *mid term* of pregnancy.

(11) **Fœtal Movements.**—After the sixth month these can be both seen and felt through the abdominal wall. They have to be distinguished from peristaltic movements. The fœtal parts may also be palpated through the abdominal walls.

(12) **Ballottement.**—This is the sensation observed by moving the fœtus about in the liquor amnii. If the investigation be made per vaginam, ballottement can be made out by the fifth month, and a month later it is readily felt on manipulating the abdomen.

Positive Signs of pregnancy are (1) palpation of the fœtal parts; (2) fœtal movements; (3) fœtal heart beats.

DURATION OF PREGNANCY.

The duration of pregnancy varies from 270 to 280 days counting from the onset of the last menstrual period. It is impossible to fix an absolute period, for (1) the duration of utero-gestation varies in different women, and (2) the exact period when fertilisation of the ovum takes place cannot be determined.

Even the exact date of a single intercourse does not furnish data for calculating the duration of pregnancy. Spermatozoa are able to live for many days in the female genital canal, and the duration of pregnancy depends not only on the period when ovulation takes place, but on the period of fertilisation as well. Ovulation does not necessarily correspond to menstruation, and hence there may be an interval of from one to fourteen days between insemination and fertilisation. The first week following menstruation is the most favourable for fecundation of the ovum. In France 270 days is reckoned the normal period. This average duration is, however, subject to great variation. There are many authentic cases where pregnancy has been prolonged for 300 days; several are recorded of 11 months' duration, and one undoubted case went on for 348 days, or $11\frac{1}{2}$ months. In cases of shortened pregnancy, it must always be borne in mind that the child may have been born prematurely. The characters which belong to the fully developed infant must be looked for in such cases.

Legal Limitations.—No fixed period is assigned in English or American law to the duration of pregnancy, though it is allowed that utero-gestation may be much prolonged. By the laws of Scotland, France, and Italy, if the duration of pregnancy be longer than 300 days the infant may be declared illegitimate, and in Germany if the period be longer than 302 days. The statutes of Scotland, France, and Germany declare 180 days to be the shortest period of utero-gestation. It may, therefore, be stated that in general the law allows the maximum duration of pregnancy to be 300 days, and the minimum 180 days.

Feigned Pregnancy.—A woman may assert that she is pregnant to obtain blackmail from a man who has had intercourse with her, to enforce marriage, to obtain a larger amount of compensation in actions for breach of promise of marriage and seduction, to delay or mitigate punishment, as when a woman is sentenced to death or to penal servitude. A woman who feigns pregnancy will as a rule object to a medical examination, as her real state would then be discovered. This refusal will in itself excite suspicion.

Pseudocyesis or Phantom Tumour Pregnancy.—This may occur in newly married women; after illicit intercourse, or in women at or about the climacteric period who intensely desire

offspring. The administration of an anæsthetic causes these spurious evidences of pregnancy to disappear.

Examination of a Woman Who Alleges She is Pregnant.—Before doing so the willing consent of the woman must be obtained, otherwise she may bring an action for simple or indecent assault against any one who tries to, or who has examined her. The woman must also be informed that if her condition furnishes any evidence, then such information may be used against her. No one is expected to furnish evidence against himself or herself, and, therefore, if the woman thinks or knows that an examination of her body will furnish incriminating evidence she will most probably refuse to be examined. The Court may order one or two medical practitioners to make an external examination of a woman under certain circumstances, as where an heir-at-law requests such examination of a woman who alleges that she is about to give birth to a posthumous child, or where a woman condemned to death asserts that she is pregnant. In the latter case if the woman is pregnant the sentence is as a rule commuted to penal servitude, and in extreme cases the woman is respited until the birth of her child. By ancient law the judge may empanel a *jury of matrons* from those present in the court-room, to determine whether the woman is "big with a quick child or not." These matrons have frequently arrived at totally erroneous conclusions. Such a jury was empanelled by a judge in the south of England in 1907. A vaginal examination must not be made either by medical men or by matrons. *De ventre inspiciendo* is the legal phrase employed for this examination in civil cases.

Child-bearing Age.—As a rule this corresponds to the menstrual life of the woman, and in this country extends from the fourteenth to the forty-fifth year. Many cases are recorded, however, of menstruation commencing at very early ages, as the second to the fourth year. Such precocious development may have been due to unnatural offences committed against the child.

Precocious Pregnancy.—One girl aged eight years was delivered of a healthy living infant. Another girl commenced to menstruate when one year old, and when nine years of age she gave birth to a child weighing 7¾ lbs. In warm climates it is common for girls of thirteen or fourteen to give birth to twins.

Prolonged Child-bearing Age.—There are many authentic cases of women who at the age of fifty or even sixty have given birth to healthy children. The onset of menstruation has generally been greatly delayed in such cases. A woman first commenced to menstruate when at the age of forty-three, and two years later she was delivered of a healthy child after a short labour of thirteen hours. Cases are reported as true, where women at the age of sixty-three and even seventy have been delivered of healthy children. One woman aged sixty-four gave birth to twins.

Unconscious Connection.—It may be safely affirmed that no woman under normal circumstances, as in sleep, could be the subject of intercourse without being aware of the fact. If, however, the woman has been accustomed to intercourse (married women or prostitutes), then during deep sleep produced by alcohol or narcotics she might be unconscious of connection having taken place, as no local injuries would result. If, however, the woman were a virgin, or unaccustomed to sexual intercourse, then although she might be taken advantage of during deep post-epileptic sleep, during a syncopal attack, hysterical seizure, or while in a sleep produced by narcotics, the local injuries would soon reveal to her the fact that she had been outraged.

Unconscious Pregnancy.—Many women are quite unconscious of the fact of being pregnant until their condition is far advanced. This ignorance may arise in cases where means have been taken to prevent conception, and these having proved inadequate, conception has occurred. It may also happen in rare cases where unconscious intercourse had taken place. About the climacteric period the increase in size of the breasts and abdomen may be ascribed to the cessation of menstruation, and so the woman may not be aware of her pregnancy. Pregnancy may also occur in young girls before menstruation has commenced, and thus the physiological amenorrhœa may be mistaken for mere delay in the onset of the function. In rare cases menstruation, or at least a bloody discharge, takes place at intervals throughout the period of utero-gestation, and even married women may be misled by the continuance of the discharge into believing that they are not pregnant. In by far the majority of cases, however, where a woman asserts that she has been ignorant of her condition, it may be taken for granted that she is telling a

falsehood. She will probably deny ever having had connection, and the alternative lies between her condition being miraculous, or else she is making an untrue statement; the latter will receive more general acceptance.

Unconscious Delivery.—In rare cases a woman may be delivered of a child without having been awakened from deep sleep. The question may arise in cases of infanticide, where the child may have been drowned in a privy, and the mother may assert that she was only conscious of an evacuation of the bowels. In other cases the woman may state that she only experienced a bearing down, and the child was then expelled while she was standing, and thus she may explain the occurrence of fatal fractures of the child's head. Delivery may be quite painless: a primipara aged eighteen gave birth to a male infant weighing 8 lbs., without the slightest pain; many cases are recorded where, in repeated labours, the women have only complained of feeling "queer," and one woman laughed at each strong uterine contraction, saying it was such a funny sensation. The husband of a woman had to waken his wife because he felt something moving in the bed, and this was her first intimation that she had been delivered. If the woman is under the influence of alcohol, narcotics, or during coma, apoplexy, or asphyxia, she may be quite unconscious of her delivery.

Concealment of Pregnancy.—By the Law of Scotland it is a penal offence for a woman to conceal the fact of her pregnancy if the child be missing, or if its dead body be found. It is expected of every pregnant woman that she should have made some preparations for the birth of her child. The punishment consists in imprisonment for any term not exceeding two years. If the woman, however, has intimated the fact of her pregnancy to any person, even in an indirect way, or if she has prepared clothes for the infant, then she cannot be charged with the crime of concealment. From 1690 until 1803 in Scotland this crime was considered as presumptive of child murder, and the penalty was death; Scott's *Heart of Midlothian* has made this well known by the punishment awarded to Effie Deans.

False Accusations of concealment of birth or pregnancy are frequently brought against women by evil-disposed persons, for the mere purpose of annoying them or destroying their character. In two charges brought against widows the

medical examination showed that they had never been pregnant.

Concealment of Birth.—By the law of England concealment of birth is a misdemeanour punishable by imprisonment, with or without hard labour, for a period not exceeding two years. It matters not whether the child was born alive or dead. To bring this accusation against a woman, however, it must be proved that there has been a *secret disposition of the dead body* of the infant, no matter whether it died before, at, or after its birth, as well as the endeavour to conceal its birth, (Criminal Law Consolidation Act, 1861). This charge is frequently made as an alternative to infanticide, when it might be difficult to obtain a clear legal issue in the latter case. Many cases are really infanticide through exposure of the infant.

Signs of Recent Delivery at Full Term.

During the first few days after parturition the woman is exhausted, the face looks haggard, the eyes sunken, the skin sweating; the breasts enlarge two or three days after delivery, and the secretion of milk becomes profuse. The abdominal walls are lax, and the overlying skin is wrinkled, and shows pink-coloured lineæ gravidarum. On palpation, the uterus is felt about the size of a cricket ball just after labour; it soon relaxes, however, and may be felt as a flabby mass extending up to the umbilicus a few hours after delivery. The labia are swollen and tender; the vaginal orifice is patulous, the hymen gone, and the canal lax; the fourchette is usually torn, and the perineum may be lacerated. The os uteri is soft, patulous, and its edges torn. The lochial discharge during the first four days is bloody; it becomes serous and lighter in colour during the next four days, and gradually turns to a thick greenish yellow purulent discharge during the third period of four days. A fortnight after delivery it would be impossible to state when the woman had been confined. The more premature the delivery the less marked will be the signs; thus, after abortions there may be few or no signs, but a mere bloody discharge. Careful examination of this discharge may reveal the presence of pieces of membrane or placenta.

Signs of Delivery at a Remote Period.—After a labour at full term the following characters are left more or less

permanently: the lineæ albicantæ are white and like cicatrices; the mammæ are lax and soft, the areolæ dark, and tubercles present; the abdominal walls are loose; the posterior commissure is torn, and the cervix uteri split; the vaginal rugæ are absent, and the hymen is replaced by carunculæ myrtiformes. In the case of primiparæ many of the above signs

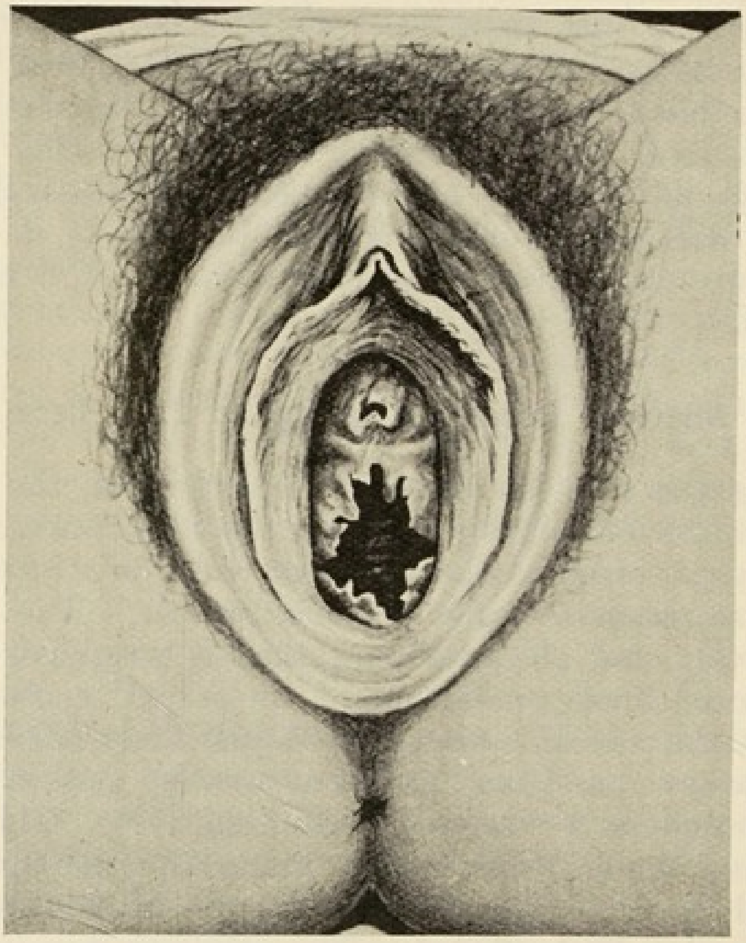


FIG. 9.—Condition of hymen after parturition.

may be wanting, and if children be born prematurely all the signs of former pregnancy may disappear.

Signs of Recent Delivery in the Dead Body.—In cases when a woman has died very soon after abortion has been induced criminally, the following appearances may be found if the pregnancy has advanced some months:—The uterus is large and relaxed; the interior is raw and covered either with adherent membrane or by clots. If the placenta has been present its insertion will be indicated by a raw surface with the large dark openings of the placental vessels. The os uteri is dilated, and

the vagina may be relaxed. The Fallopian tubes and ovaries are congested. The uterus will be found more and more contracted and firmer the longer the woman has lived after delivery. A careful examination must be made for signs of criminal abortion, as injuries in the form of punctured wounds of the upper part of the vagina, cervix, or lower uterine segment; and the entire genital organs should be removed *en masse* for this purpose. In cases of criminal abortion induced at very early periods (second or third month), a careful examination must be made to distinguish the condition from ordinary menstruation, or from endometritis with an enlarged uterus. During ordinary menstruation there is a general congestion of all the pelvic viscera; the endometrium is swollen and œdematous, and the uterine walls are softened. After pregnancy has taken place, the uterus permanently remains less triangular than in the virgin condition; the os internum is less marked; the cervix is much shorter than the body of the uterus, and the arbor vitæ disappear from it. The corpus luteum of pregnancy is said to be much larger than that of menstruation, and to persist for a much longer period. In medico-legal autopsies, however, little reliance can be placed on their relative size in establishing the fact of antecedent pregnancy.

Development of Embryo.

1*st Month.*—Ovum size of pigeon's egg. Embryo $\frac{1}{3}$ of an inch long, with tail and traces of extremities; branchial arches; amnion closed.

2*nd Month.*—Ovum size of hen's egg. Embryo 1 to 2 inches long; eyes as black spots; extremities forming; digits appearing; internal and generative organs appearing; placenta and umbilical cord forming; ossific centres in clavicle and lower maxilla.

3*rd Month.*—Ovum size of goose egg. Embryo 3 to 5 inches long; nails on fingers and toes; placenta formed; chorionic villi almost gone; heart divided into two chambers; external genitals beginning to differentiate. It is now called a *fœtus*.

4*th Month.*—Embryo 5 to 6 inches long; sex distinct; mouth large and open; pupillary membrane present; umbilicus inserted near pubis; meconium present.

5th Month.—Embryo 6 to 10 inches long; light hair on head and lanugo on body; heart and kidneys large; germs of permanent teeth.

6th Month.—8 to 13 inches long; fat under skin; pupils closed; head very large; sutures and fontanelles wide. If born, makes inspiratory efforts and moves limbs.

7th Month.—11 to 16 inches long; skin red and covered by vernix; nails not quite to finger tips; eyelids separated; face free from lanugo; pupillary membrane disappearing; testes descending.

8th Month.—14 to 18 inches long; pupillary membrane gone; nails at ends of fingers; fissures appear in brain.

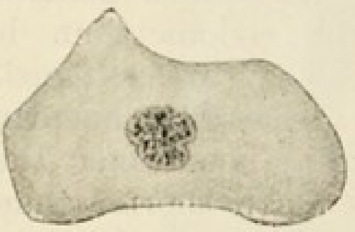


Fig. 10.—Horizontal section through lower epiphysis of femur of mature child showing appearance and size of ossific centre.

9th Month.—17 inches long; face has lost wrinkles.

10th Month.—Characters of Mature Fœtus:—Length 20 inches; weight 6 to 7 lbs.; nails well developed; skin white, plump, and covered by vernix; head large and covered with dark hair; lanugo gone except on shoulders; cranial bones hard; cartilages in nose and ears; testicles in scrotum; ossific centre in lower end of femur $\frac{1}{3}$ of an inch in diameter.

Products of Conception Expelled.—It is sometimes necessary to examine carefully substances expelled from the vagina to determine whether they are the results of conception or disease. Such examinations may arise in questions of disputed chastity. In cases of incomplete abortion, the membranes and villi may remain *in situ* in the uterus, and becoming thick and vascular, are expelled later as a *fleshy mole*. In other cases it may be a hydatid mole, which can only result from the degeneration of the villi, and hence both conditions indicate a previous pregnancy. Apart from the expulsion of such, curetting may reveal the presence of decidual cells or chorionic villi in the scrapings, so proving abortion. On the other hand, in membranous dysmenorrhœa shreds from, or casts of, the uterine cavity are expelled, and cervical polypi or submucous fibroids may become separated, and require identification.

CRIMINAL ABORTION OR FŒTICIDE.

In law this means the bringing about of the expulsion of the contents of the gravid uterus at any period before full term for an improper purpose. Any pregnant woman who endeavours to procure miscarriage by unlawfully taking poison or other noxious thing, or who unlawfully uses any instrument or other means with the same object, and any person who endeavours to procure the miscarriage of any woman (whether she be pregnant or not) by such means, is guilty of a felony (Vict. 24 & 25, cap. 100). The intention constitutes the crime quite as much as the actual production of abortion. The woman may have received no material injury, yet the offence is the same, and the crime may even be committed on a non-pregnant woman under the idea that she is pregnant. The patient as well as the criminal abortionist are equally guilty. The crime is a felony, and is punishable by penal servitude for life or any period not less than three years. If the woman dies, then the abortionist or accomplice is charged with her murder. Any person who sells drugs or instruments for the purpose of inducing abortion commits a misdemeanour, and may be sent to penal servitude for any period up to three years, or to imprisonment for any term not exceeding two years. The crime is very common in certain countries; thus, in the State of Maine (U.S.) it is affirmed that 63·5 per cent of all abortions are criminally induced. It has to be borne in mind that spontaneous abortion is very common in married women, but is seldom associated with septic infection.

Abortifacients, or means to induce abortion, may be :—

(1) *Mechanical or Local.*—Pressure on the uterus (tight bandage, kneeling, squeezing), if successful, is likely to kill the patient. Venesection of the limbs or pudenda is thought to induce abortion, but does not really do so. Endeavours to pierce the membranes by knitting kneedles, bougies, sharp-pointed sticks, etc. are made, but as the abortionist is generally ignorant of anatomy, lacerations or perforations are often made in the upper part of the vaginal walls, in the cervix, or in the walls of the uterus, and the woman only too frequently dies from septic pelvic peritonitis. Women may perform such operations on themselves, but they are usually the work of an abortionist. A woman recently confessed to having induced abortion thirty-

five times on herself. Her method was to squat down, and feeling the os uteri, she passed a bone knitting needle into the uterus. The proceeding was followed by severe hæmorrhage on several occasions. Caustics (caustic potash, nitrate of silver, mineral acids) have been applied to the cervix for the purpose of inducing abortion. In some instances such a degree of stenosis has resulted that Cæsarean section has been required in order to deliver the woman. Injections of water, or of solutions, such as acetate of lead, corrosive sublimate, may be made into the uterine cavity, and often with fatal results.

(2) *Medicinal Agents.*—There are practically no drugs which exert any ecbolic action on the non-parturient uterus. On the other hand many agents cause a marked increase in the power of the already contracting uterus (*e.g.* quinine or ergot of rye). Drastic purgatives may induce abortion, but only through the reflex action of the already greatly irritated intestinal or genito-urinary tracts. In the endeavour to produce abortion the woman may die from exhaustion caused by this intense gastro-intestinal irritation, or from peritonitis which results. Good preparations of ergot of rye or diachylon pills (lead plaster) are the most successful of the so-called abortifacients, and are most largely employed. Vegetable irritants, such as aloes, aloes and canella bark (*Hierapicra*), colocynth, gamboge, croton oil, etc. are commonly used, as are also infusions of pennyroyal, tansy, savin, yew, rue, as well as such drugs as cantharides, arsenic, corrosive sublimate, steel drops (Tr. Ferri Perch.). Drugs advertised for the purpose of "regulating female disorders," "for relief of female obstruction," etc. contain these agents.

Indecent or Obscene Advertisements.—It is a criminal offence to affix to any wall, or to put into circulation, advertisements of an obscène or indecent character (including those relating to venereal diseases). The penalty is a fine not exceeding 40s., or imprisonment not exceeding one month with or without hard labour.

Abortion is Usually Attempted by the administration of drugs about the third month, or when the woman suspects her condition. If these fail then mechanical means are employed, and usually between the fourth or fifth month. In many cases debased medical men have been found guilty of the crime.

Signs of Abortion.—If the woman be alive the signs will vary according to the period of pregnancy; in the discharge

decidual cells will usually be found. Septic metritis, peritonitis, etc. may lead to a matting of the ovaries, tubes, and uterus, and a chronic condition of ill health may supervene.

In the Dead Body a careful examination of the pelvic organs

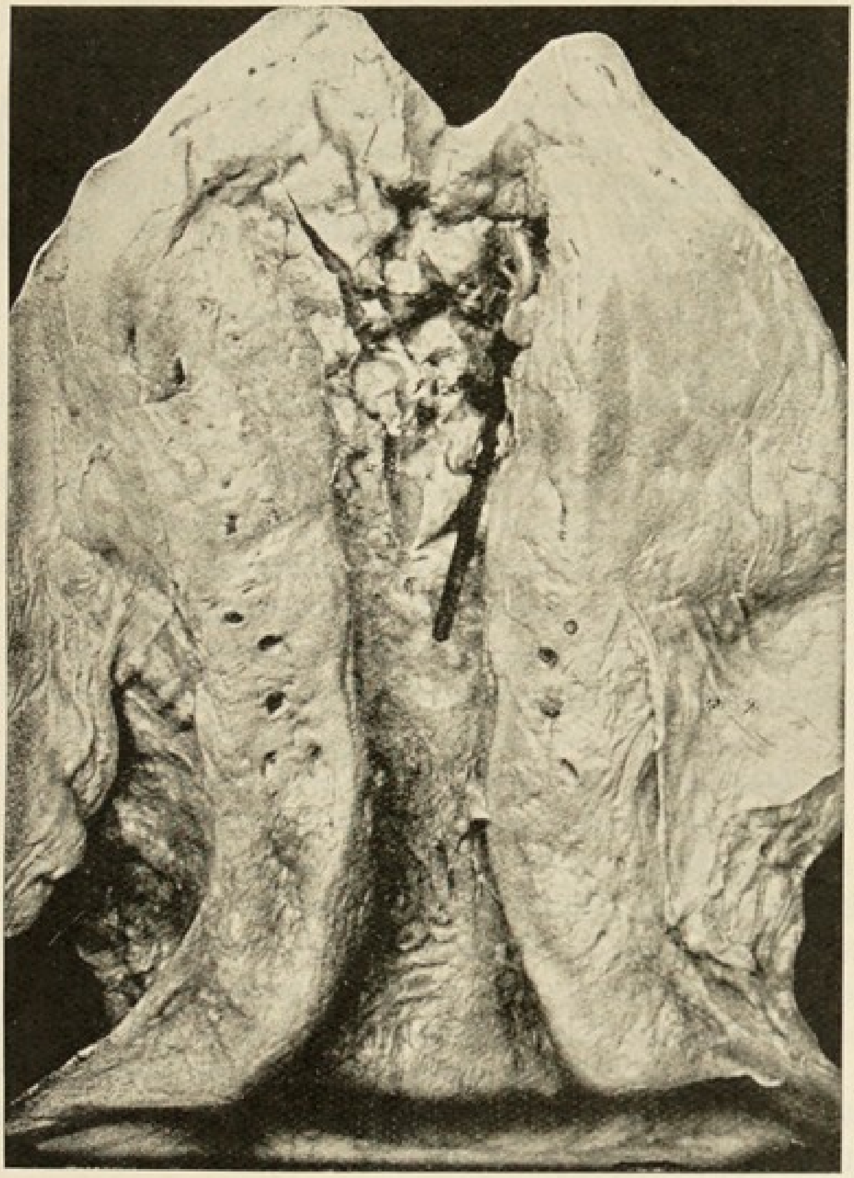


Fig. 11.—Uterus from a case of criminal abortion, death having resulted from septic peritonitis and endometritis. The probe has been introduced into a wound which leads into the abdominal cavity. Abortion had been induced by the passage of a probe-like instrument.

must be made. Lacerations or punctures may be present in these; acute inflammation of the intestines, ureters, bladder, and often a necrotic condition of the uterine mucosa, may be present. Broken pieces of stick, needles, catheters, etc. may be found in the pelvic organs or free in the abdominal cavity.

Occasionally large rents have been made in the uterine walls through which coils of intestine have escaped. A careful examination of the stomach and intestines must be made for the presence of irritant poisons such as cantharides. Death may have resulted from shock, hæmorrhage, air embolism, septic absorption, or septic inflammation. Wounds in the fœtus may indicate that criminal abortion has been practised.

Mortality from criminal abortion is always very high; in cases mechanically induced it may amount to 50 or 60 per cent. If the patient recovers there is usually long-continued ill-health from the chronic inflammatory or suppurative conditions which remain.

Conduct of the Practitioner when Called to a Case.—If the abortion has been self-induced then it will be wise to call in a brother practitioner to share the responsibility, and to obviate the risk of a charge being brought against a single attendant of having induced abortion. Unless the woman be seriously ill, it is hardly necessary to inform the criminal authorities. If, however, there is no doubt but that the woman has been operated on by a professional abortionist, then the police authorities should be immediately apprised so that means may be taken to apprehend the criminal. The case should be treated as an ordinary abortion; any fragments left in utero must be removed; antiseptic douches given; and if any evidences of peritonitis ensue, probably laparotomy, abdominal lavage and drainage, or hysterectomy may be required.

Induction of Abortion or of Premature Labour in General Practice.—This should never be done unless the necessity be extreme, and if possible the operation should be delayed until the infant is viable. The patient and her immediate relatives should be informed of the risks, and consent should be given in writing. One or more medical men should be consulted before the operation is undertaken.

CHAPTER XII.

INFANTICIDE.

INFANTICIDE means the murder of a newly-born infant. The crime is usually committed immediately or very shortly after the birth of the infant. A child is considered in law "newly-born" up to fifteen days after its birth. Newly-born children may be destroyed (1) Negatively by omission; thus, neglecting to tie the cord, or to provide warmth, food, or clothing, may lead to their death; or by (2) Commission or positive acts of wounding, strangling, ill-treating, etc. In either case the crime is that of murder or manslaughter according to circumstances. The unlawful abandoning or exposure of any child under two years of age, whereby its life and health are endangered, is a misdemeanour punishable with three years penal servitude. As so many children are still-born or dead-born, in the interests of humanity it is held in law that every child is dead-born unless the contrary can be proved by medical or other evidence. To obtain a conviction the prosecutor must prove that the infant was legally a living child when it received the injuries from which it died, or in other words, that its birth was complete, *i.e.* that its whole body was delivered in a living state outside that of the mother. The production of the child's body is not in law held to be essential, but the medical evidence is usually concerned with its production and examination. In most cases it is very difficult to arrive at a clear issue as to infanticide, and thus the charge is frequently altered to concealment of birth.

Live-birth.—In law, the whole of the infant's body must have been expelled outside of the body of the mother, and it must have had an independent circulation or life, before it can be asserted that the child has been born alive. The umbilical cord need not, however, have been divided. In

English civil law it is not necessary to prove that the child has breathed or cried; the slightest voluntary movement which it has made, or any pulsation of the heart or arteries which has been observed by a witness, is sufficient to prove its live-birth. The question of live-birth has nothing to do with the viability of the child. The fœtus may be born alive at the fourth or fifth month, and though it is not viable it may inherit property, and transmit such to its heirs.

Viability is the ability of the infant to continue its existence apart from the mother. In practice it is seldom found that a child born before the seventh month is viable; in law, however, it is considered viable if born at the sixth month. The less mature the infant the less chance there is of its being viable. It may be born at full term, and yet may not be viable on account of some deformity, as anencephaly, exomphalos, acardia. It matters not whether the child be non-viable from prematurity or malformation, to kill it after it has been fully born constitutes infanticide, though it is rare to charge any one with the crime unless the infant was viable. The infant may be killed by violence inflicted on it while in the act of being born, and before it is entirely free from the mother's body, and yet the crime is not infanticide, for it had not a separate existence. Thus, the child's head might be smashed immediately after its extrusion from the vulva, and the mother might affirm that she did this unknowingly, and while delirious from the pain. On the other hand, if the fœtus while *in utero* receive such injuries that it dies in consequence after its birth, the law of murder applies.

PROOFS OF LIVE-BIRTH.

As there are usually no witnesses of the infant's murder, the crime being done by the mother in secret, the onus of proving that the infant was born alive lies with the medical witness. The most important proof of life is the evidence of respiration, though this by no means proves that the child was legally born alive. It may be possible to prove that the child lived without any reference to its having breathed. In law, breathing is only looked upon as one proof of life after birth. In one case a woman cut off her child's head immediately on its expulsion from the vulva and before respiration had commenced. She was discharged, as the crime

was committed on the child before it had a separate existence. Again, the infant may breathe before it is completely born, and may die before birth is complete.

I. **Evidences of Breathing.**—(a) *Arching of the Chest.*—Before respiration is established the chest is flat, and in cases where breathing is very feeble the chest may remain flat. As soon as the child breathes fully, however, the chest wall expands and becomes arched.

(b) *Fall in the Level of the Diaphragm.*—If the abdomen be opened, and a finger be passed up to the vault of the diaphragm, it will be found to reach the level of the fourth or fifth rib before respiration has commenced, but after its full establishment the finger will only reach the level of the sixth or seventh rib.

(c) *Expansion of the Lungs.*—Full expansion of the lungs is the best test of life at the time of birth. It does not, however, prove legal live-birth, as the infant might have breathed though not entirely free from the maternal structures. In determining this the thorax must be opened in the usual way by removing the anterior chest wall.

(1) In the fœtal condition the upper central part of the thorax is occupied by the pale *thymus gland.* At the lower half the *heart* enclosed in its pericardial sac is seen situated in the middle but extending towards the left side. The lungs are hardly seen, and, if so, only the edges project on either side of the thymus or heart. They are small structures situated on either side of the vertebral column, and are of a uniform pale red-brown colour resembling the liver in colour and consistence. On the surface the lobules are seen to be marked out by shallow furrows, but *no mottling* is present. On section little blood exudes. Microscopically they are solid organs.

(2) If the child has *breathed fully*, on opening the chest the lungs appear to fill the whole cavity, and by their anterior edges they cover over the thymus gland and heart. They have increased enormously in volume. One may meet with every variation in size of these organs between the extremes of non-expansion and full expansion. This depends entirely on the degree of vigour of the child's inspiratory efforts. Unexpanded areas of lung tissue may retain their fœtal characters (most usually about the apices), and are surrounded by fully-inflated tissue. These are known as *atelectatic* areas,

and in the case of children who have breathed very feebly these areas may be numerous and large. The colour of expanded lungs is light vermilion, and (what is very characteristic of breathing) the surface *is mottled*, bright red patches alternating with bluish red patches. The arrangement and form of the air cells on the surface of the expanded organ are very characteristic, being angular, not elevated, and four being usually grouped together. These spots are almost invariably present on the lungs of infants no matter how feebly they have breathed. The consistence of the tissue has entirely changed, being spongy and crepitant. The edges and concave surface of the upper lobe of the right lung are the parts which first undergo expansion, and become vermilion-red in colour. In infants who have feebly breathed these may be the only parts inflated. On section blood-stained froth can be squeezed from the cut surface.

(d) **Absolute Weight of the Lungs (Static Test).**—Because of the increased flow of blood into the lungs their absolute weight is increased after respiration. The average weight of the two fœtal lungs varies from 450 to 650 grains; while after respiration it is 900 to 1000 grains. In comparing the weights, the degree of maturity or immaturity of the child has to be noted; the heavier the child the greater is the weight of the organs *cæteris paribus*; the more thoroughly the child has respired the heavier will the lungs be. This test is very unreliable, however.

(e) **Specific Gravity of the Lungs (Hydrostatic Test. Docimasia Pulmonum Hydrostatica).**— Unexpanded lungs sink when placed in water, while lungs after respiration float, the former having a higher specific gravity than the latter. The method of performing the experiment is to remove the entire thoracic organs *en bloc* without separating them from each other. They are then placed in a large vessel of water at a temperature not higher than 60° F. If the whole mass floats easily, the lungs have been well expanded. If they tend to sink, it should be noted whether they sink rapidly or slowly. The lungs should then be separated from the heart and thymus gland, and each immersed in water, and their buoyancy noted. If either tends to sink, it should be cut into its lobes and note made of which lobes sink or float. Each lobe may be further subdivided and experimented with. Formerly this test was considered of great value in cases of

infanticide. At best it is only a proof of respiration, but not of legal live-birth. If the lungs sink rapidly there can be little or no air in them, and this would point to their not having been expanded by respiration. Even in cases where an infant has lived for some hours or days, and has cried, every part of the lungs may sink in water when this test is applied. In such cases the child has breathed very feebly, and its blood has been oxygenated through the mucous lining of the bronchi and bronchioles. In other cases the pulmonary tissue may have been expanded to a slight extent, but as the breathing became more and more feeble, the natural elasticity had caused them to contract to their fœtal size, and resume their fœtal colour. Generally, however, certain parts of such organs will float. Infants have survived several weeks, and after death the lungs have been found in the fœtal condition. In cases of fœtal suffocation where the infant has inspired during birth, and where the lungs have not been expanded, numerous petechial hæmorrhages are usually found beneath the pulmonary pleura, and in the trabeculæ of the pulmonary tissue.

Fallacies Connected with the Hydrostatic Test.

(1) **Consolidation of the Lungs from Disease.**—The lungs may sink as the result of disease (croupous or broncho-pneumonia). This condition would be easily recognised, because of the large size of the expanded lungs, and by the presence of consolidation. The stomach and intestines would also reveal the presence of food. Even in cases of congenital tuberculosis or syphilis of the lung (if indeed they exist) parts of these organs would float if the infant had been born alive.

(2) **Floating of the Lungs Due to Decomposition.**—The lungs may float as a result of the development of the gases of decomposition. In such cases they are more or less decomposed, being soft and green in colour, and the gases usually accumulate in bubbles beneath the serous covering, and chiefly towards their free borders and bases. The bubbles are minute at first, but increase in size later, and can be squeezed from place to place under the pleural membrane ; if an incision be made into the lung, the gas can be entirely expelled, and the organ will sink when placed in a vessel of water.

Such decomposing lungs never float very buoyantly, and gaseous decomposition is also present in other organs. If decomposition be far advanced no opinion as to expansion of the lungs can be given ; though if they sink, it is presumptive of non-expansion.

(3) **Artificial Inflation of the Lungs.**—It is said that the lungs might be inflated by air being driven down the trachea. This might be done by passing a catheter or elastic tube into the trachea, by applying the mouth of the operator to that of the child and blowing air down, or it might happen with Schultze's method of resuscitation. In such cases the lungs become expanded and may cover the heart. They float well when immersed in water. Their colour is, however, paler, as no blood is drawn into them, mottling of the surface is seldom present, and on section the organ is dry. If such lungs are squeezed firmly, a large part of this air artificially introduced is expelled, whilst it is impossible to drive the air out of those normally inflated. The lungs would also not have increased in weight. In several cases, however, those inflated artificially have very closely resembled lungs after normal respiration. Such an artificial inflation may take place either in part or extensively during artificial respiration as performed by Schultze's method, and though the above appearances might guide one, there is no absolute test which would allow of a distinction between normally and artificially inflated lungs. The methods of artificial respiration would hardly be carried out by an unskilled person, and mouth to mouth inflation of the lungs usually causes distension of the stomach with gases. If it could be shown that the mother did this operation, then the charge of infanticide could not be brought against her.

Conclusions as to the Value of the Hydrostatic Test.

(1) If the whole of the lungs float, either when entire or divided, or after compression, it is likely that the child has breathed well, and this is almost presumptive of live-birth in the legal sense. (2) If they sink either when whole or cut up, there is great probability that the child has not breathed, though it is not a proof that the child has breathed feebly. (3) When putrefaction has set in it is unsafe to draw any conclusions.

Vagitus Uterinus (Uterine crying).—In rare cases an infant has been heard to cry while still *in utero*. In a case of locked twins, one child was heard to cry during a period of more than three hours, and during delivery. The membranes would require to have been ruptured, the head low down, and the vagina dilated so as to allow of the entrance of air. Respiration under such conditions would be stimulated if there were any interference with the fœtal circulation, as compression of the cord. The lungs would, in such cases, be imperfectly expanded.

Vagitus Vaginalis (Vaginal crying).—This has been observed in certain breech births when the cord has been compressed, or cold air acting on the skin of the lower limbs and trunk has caused the infant to respire, and to cry. If the vagina be held open, and air be allowed access to the child's mouth and nose, the lungs may undergo expansion, and yet the child would not be legally born. The child may breathe when only its head has been born, the rest of its body being still within the maternal passages. It may be presumed that the child has breathed, if in a mature body it be found that the lungs are fully expanded, that they float easily, that on section a bloody froth can be expressed, and that their surface is distinctly marbled or mottled.

II. **Condition of Stomach and Intestines.**—When the stomach and intestines are ligatured and removed, they sink when placed in water if the child has not breathed. If, however, the infant has lived and breathed, the stomach and duodenum float when placed in water, owing to air having been swallowed. This is known as *Breslau's Second Life Test.* It is not absolutely trustworthy, but it is confirmatory of the hydrostatic lung test. If the child has lived only a few minutes, air may be present only in the stomach. The longer the infant lives the farther does the air penetrate into the intestines, therefore, it may be found in the stomach and duodenum alone, or also in the small intestine. On opening the stomach mucus only is found if the child has been stillborn. If it has respired, then mucus, with air bubbles and saliva, will be present. Blood and meconium may be found in the stomach owing to the child having swallowed these as it lay face downwards on the bed. If milk or starchy food be present, the infant must have lived some time, and must have been fed.

In the stomach of dead-born infants a glairy mucus closely resembling milk is sometimes found, and must be identified by microscopic examination. The absence of meconium from the bowels, or of urine from the bladder, is of little importance as a test of life.

III. **Condition of the Middle Ear.**—The middle ear of the child before birth is filled with gelatinous embryonic connective tissue. After breathing has been established this disappears, so that twenty-four hours after birth the middle ear may be almost empty. In other cases the embryonic tissue may not undergo absorption until twenty days after birth.

IV. **Condition of the Skin.**—The skin of the newly-born child is bright red in colour, and gradually becomes lighter. On the second or third day after birth it again undergoes a marked darkening. The whole surface may become brick-red in colour; this changes gradually to a deep saffron yellow, giving the infant a jaundiced appearance. In about a week after birth the skin assumes its normal appearance. The superficial epidermic layer of the skin covering the abdomen is usually shed in fine scales during the first three days of life.

V. **Umbilical Cord.**—That part of the cord left attached to the umbilicus soon dries, and forms a semi-translucent, tough, horny-looking, or mummified appendage. Surrounding the base there is a red ring of inflammatory reaction. The dried stump of the cord is cast off by a process of ulceration in four or five days, and leaves a healing ulcer with purulent discharge. This raw surface is completely cicatrised in from ten to twelve days. The inflammatory reaction round the base indicates that the child has lived for some time.

VI. **Marks of Violence.**—Wounds on the body of the infant may show some degree of vital reaction in the shape of swelling, serous or purulent discharge, etc. Such would indicate that life had been maintained for some time.

VII. **Changes in the Heart and Fœtal Vessels.**—Those parts of the circulatory apparatus special to the fœtus are the umbilical arteries and vein, the ductus venosus, the ductus arteriosus, and the foramen ovale. After birth the blood ceases to flow through these structures, but their obliteration is somewhat slow, and it is impossible to determine how long the child had lived from the condition of these vestiges.

Umbilical Arteries.—These close earlier than the vein; the walls, and especially the inner coats, commence to thicken at their distal extremities within twenty-four hours after birth. This obliteration extends along the course of the vessels, and reaches their proximal end at the third day after birth. The *Umbilical Vein* and the *Ductus Venosus* are somewhat later in closing, and obliteration may not occur throughout until the fifth day.

Ductus Arteriosus undergoes contraction first at its aortic extremity, and complete closure may not be found until the tenth day post-partum. It is ultimately converted into a fibrous cord, the ligamentum arteriosum.

Foramen Ovale is usually completely closed by the eighth or tenth day after birth. It may, however, remain open to a slight extent for long, and even in adult conditions it may be possible to pass a probe through a small patent foramen. In a few cases it remains permanently open, and gives rise to the condition known as Morbus Cæruleus.

Is the Case One of Infanticide?

It is impossible to base a diagnosis on any one single test. A most careful medico-legal examination of the body must be made, and all circumstances must be carefully inquired into. The number of accidents which may lead to the natural death of the newly-born infant is so great, that unless it can be absolutely proved that criminal means have been employed, the accused will be discharged. The question to be solved is whether the marks or injuries on the infant's body were produced by the mother while attempting self-delivery. The relation of the size of the child's head to the mother's pelvis must be measured. If the inlet of the pelvis be found narrow, then the probability is that the labour has been tedious, and that the child may have died in consequence of the compression of the head. The caput succedaneum is well marked in such cases. The condition of the cord must be noted, as to whether it has been torn across, or from its insertion into the placenta, or whether it has been cleanly cut by a knife or scissors. The child may have been accidentally suffocated by lying face downwards in the maternal discharges; in such cases the mouth, nose, throat, œsophagus, and stomach would be filled with blood, meconium, or amniotic fluid. In criminal suffocation, on the

other hand, it may be found that the nose and lips have been tightly compressed, or that foreign bodies (wool, handkerchief, etc.) have been forced into the throat. The brain may show the presence of hæmorrhages, either on the surface or in the substance; when these have been due to compression-fractures during labour, they are, as a rule, on the surface and not large. When extreme violence has been used there is generally extensive hæmorrhage, both on the surface and in the brain substance, accompanied by depressed fractures of the cranial bones. The condition of the mother may throw much light on the case; she may feign madness or exhibit various nervous affections, either real or simulated. It is rare that infanticide is committed by a married woman, whereas it is a crime commonly committed by the unmarried to hide their disgrace. The better the social position of the unmarried mother the more likely is this crime to be committed; this is easily understood, as the disgrace is greater amongst those placed higher in the social scale. The crime is frequently committed by domestic servants, and usually presupposes concealment of pregnancy or birth, which often form alternatives to the charge of child murder. Before coming to a conclusion as to whether the case is one of infanticide, a careful consideration must be given to the causes of natural death before, during, or immediately after birth.

Causes of Death of the Fœtus Before and During Birth.—These may be (1) Premature cessation of the placental circulation, as from too early separation, fatty or syphilitic degeneration of the placenta, etc. (2) Pressure on or prolapse of, knots or twists of the umbilical cord during parturition may prevent the circulation of blood. As soon as the fœtal circulation ceases, attempts at respiration ensue; this leads to asphyxia, and thus in the air passages of the lungs, blood, meconium, liquor amnii, and particles of vernix caseosa may be found. (Cover glass films of the latter stain in gentian violet.) The other common signs of death by asphyxia are present, Tardieu's spots being very well developed. (3) Excessive or prolonged pressure on the fœtal head, leading to fracture of the cranial bones with extravasation of blood on to or in the brain. (4) Accidents to the mother may cause fracture of the fœtal bones.

Characters of Intra-uterine Maceration.—When the fœtus dies *in utero*, and before the rupture of the membranes, the

following changes take place: it becomes exceedingly soft; the skin takes on a red or purple colour (never green); it peels off in parts, and large bullæ filled with red fluid are formed; the umbilical cord becomes red and softened; the bones of the skull become freely movable, and the abdomen resembles a loose bag. If the fœtus be retained for several days the whole of the internal organs become reddened, a serous exudation is found in the cavities, and the epiphyses become entirely separated from the diaphyses. There is no odour of putrefaction. If the membranes have been ruptured the ordinary phenomena of putrefaction are present, and their progress is very rapid.

Causes of Death in Newly-born Infants.—The child may be so *immature* or badly nourished as not to be capable of extra-uterine life, or it may be born *asphyxiated* from interference with the fœtal circulation (pressure on or twists of the cord, separation of the placenta, etc.) during birth. The funis may be twisted round the neck, and as the child is expelled these coils are drawn tight, so stopping the circulation, and preventing respiration. The child may be smothered by the membranes coming down along with the head, and covering over the nose and mouth ("the caul"), or suffocated by its face being closely pressed on the bedclothes, or immersed in blood, meconium, or liquor amnii in the bed. The child may die from imperfect expansion of the lungs, or because of the excessive size of the thymus gland, causing laryngeal spasm. Hæmorrhage from the cut or torn funis, or cerebral hæmorrhage caused by undue pressure on the head during delivery, may be fatal. Certain malformations, as imperforate gullet or glottis, or monstrosities, may be inconsistent with life. Congenital diseases (variola, scarlatina, syphilis, etc.) may lead to death of the infant soon after its birth.

DEATH OF INFANTS DUE TO VIOLENCE.

1. **Suffocation.**—This is the means usually adopted in cases of infanticide. The hand may be tightly held over the nose and mouth, and after death the lips and nose may be found compressed and pale. Handkerchiefs, towels, pillows, etc., may be used to smother it, or rags, feathers, wool, paper, dough, etc., may be forced into the mouth and pharynx. Newly-born children are very easily and rapidly suffocated; the mere

weight of the bedclothes may be sufficient. The post-mortem signs are not very characteristic if the child has been suffocated before respiration has been established. Usually, however, excessive violence is employed, and lips, nose, mouth, or throat bear evidences of injury. If respiration has been established before the child has been suffocated the ordinary appearances of asphyxia are present. Accidental suffocation may arise from the lodgment of food (*e.g.* curdled milk) on the vocal cords while the infant is vomiting.

2. **Strangulation** is a common form of infanticide. It may be accidental from the funis being twisted round the infant's neck. In this case, at most, only a broad continuous groove livid or red in colour is left on the neck, and no excoriations are present. Death is usually due to stoppage of the fœtal circulation, and the lungs are found unexpanded. Such cases of accidental strangulation probably only occur to the infant before respiration has been established. In infanticidal strangulation excessive violence is employed; hence severe marks and abrasions are usually found on the neck. The groove left by the ligature is white at the bottom, with blue and livid margins. Cord, garters, tape, the funis, etc., have been employed as ligatures, and may leave their impress on the skin of the neck.

Throttling is often employed, and great violence is inflicted on the neck, the muscles being ruptured and the cartilages broken.

3. **Fractures of the Skull.**—These may occur *accidentally* from severe compression of the head during delivery, as happens in a flat or rachitic pelvis. The bones most usually fractured are the parietals, and the fissures are situated round the edges or run from above downwards, or there may be a spoon-shaped depression-fracture. The scalp is almost never injured, but blood may be effused under it, or on the surface of the brain. The mother may assert that the fractures were produced by the infant falling on the ground as a result of precipitate labour, and while she was standing. Women likely to have such rapid deliveries would exhibit a roomy pelvis, with a recent or remote rupture of the perineum. In actual cases the cord has drawn the placenta with it, or it has been torn at the usual site of laceration near the umbilicus. The fractures are usually on the vertex, and are severe; they run antero-posteriorly, and sand, mud, or gravel may be found

in the abraded scalp. In the great majority of precipitate births the child is expelled while the woman is standing, and though fatal injury to the child is rare, a fall of 18 inches may cause fracture of both parietal bones. *Fractures from criminal violence* usually show that great violence has been inflicted in the shape of lacerations of the scalp, and depressed and extensive fractures of the skull.

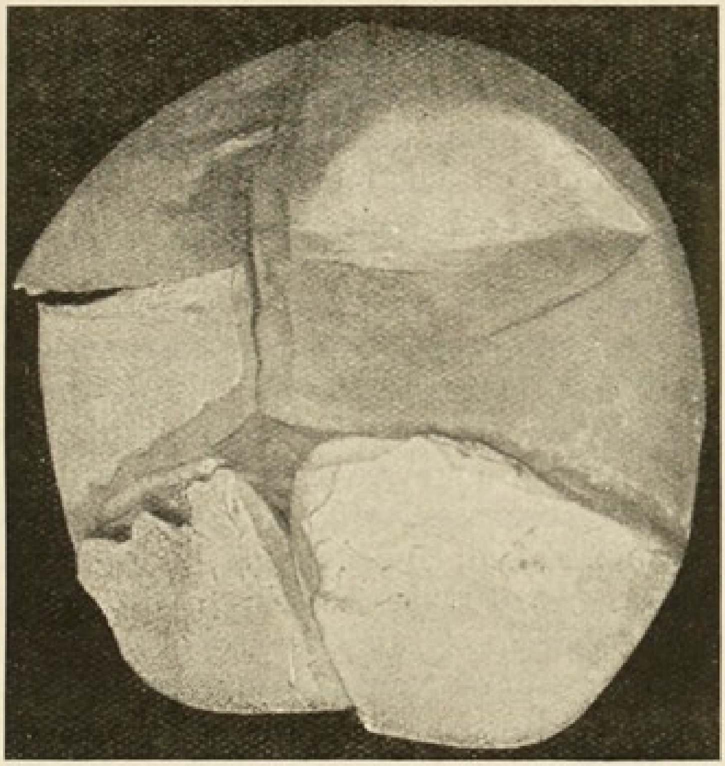


Fig. 12.—Skull of infant showing spoon-shaped fracture of left parietal bone caused by pushing it through a water-closet basin, and a gaping fracture of the right parietal bone caused by a fall from a distance of two storeys. The mother alleged that the injuries were the result of a precipitate birth.

4. **Drowning** is a rare form of child-murder. Few post-mortem signs are present if the child has been drowned before breathing has been established—engorgement of the great veins, and petechial hæmorrhages, being most characteristic. If drowned after the lungs have been expanded the usual signs are present.

The child's body may be found in a *water-closet or privy.* The woman may assert that, not having been aware that she was in labour, and thinking that she required a movement of the bowels, the child was born precipitately into the receptacle; that she either fainted, lost consciousness, or became maniacal,

and so was unable to rescue the infant. If this statement were true, one would expect to find the cord still attached to the child and to the placenta, or *torn* across, but not sharply cut. The usual site of tear in accidental rupture is most usually close to the umbilicus, but it may also be close to the placenta; the torn ends are ragged. If the infant had been born alive then the lungs would be unexpanded, but urine, fæces, etc., would be inspired into the air passages, and could be squeezed out, but with no froth, owing to the absence of air. This accident may happen to infants born legitimately. A married lady expecting her confinement, rose to make water, and while doing so, the infant and placenta were expelled precipitately into the chamber. The mother fainted at this moment, and the child would have been drowned had not the nurse come into the room. If the lungs are more or less expanded, and the body be found in a privy or water-closet, suspicion points strongly to infanticide, and the post-mortem examination will reveal fæcal matter in the bronchi of the lungs when they are squeezed. If the cord be mummified, then the child must have lived several hours before being drowned.

5. **Cold and Exposure.**—Newly-born infants readily die if unattended or left naked, and exposed in the cold. Starvation may be associated with exposure. In such cases the post-mortem examination reveals no cause of death. To expose a child under two years of age so as to endanger its life, or to inflict permanent injury on it, is a misdemeanour, and the accused may be sentenced to penal servitude for five years as a maximum.

6. **Wounding.**—Infants may be killed by inflicting penetrating wounds on them; needles or pins may be thrust into the heart or brain.

Hæmorrhage from the cord or from wounds may be fatal. A case is recorded of a woman who was seized with labour in a railway carriage. The child's arm prolapsed; she tried to tear it off, but only broke it, and then she cut it off with a knife. Later she was delivered of a dead-born ex-sanguine child.

Dislocation of the Cervical Vertebræ may occur accidentally in the endeavours of the woman to extract the child after the head has been born; it may also be criminal. A contusion on the head must be distinguished from the caput succedaneum.

Poison is rarely administered to newly-born infants, but opium, belladonna, or strychnine has been given.

7. **Omission to Attend to the Child** may lead to its death. Thus, the cord may be cut or torn, and not being ligatured, the infant may bleed to death; it may be allowed to lie in the maternal discharges, and may be suffocated; the whole of the uterine contents may be expelled *en masse* without the membranes being ruptured, and unless the child is removed it will be asphyxiated. A woman was delivered of such a mass in a railway carriage in the presence of 2 young girls, none of them knowing what to do. The child died, and the mother was charged with infanticide, but was exonerated.

Post-mortem Examination of Infants.

1. Record the length and weight; maturity; nutrition; degree of putrefaction; presence or absence of vernix (indicating washing of child); length and condition of funis (tied, cut, torn). Keep everything likely to lead to identification (ligatures, wrappings, clothing, etc.).
2. Examine surface for scratches, abrasions, marks of ligatures on neck.
3. Condition of lips, nose, tongue, pharynx, etc.
4. Examine the orifices for the presence of foreign bodies.
5. Open abdomen and determine height of diaphragm.
6. Expose chest; note position of lungs; apply various tests to lungs.
7. Examine stomach and intestines, and apply tests.
8. If it has lived, how long has it survived its birth?

Ability of Woman after Delivery.—The mother, especially after an illegitimate birth, may continue to do her ordinary work as a domestic servant, farm labourer, or mill-worker. Cases have occurred where a woman has walked 6 or 8 miles immediately after parturition. In the case of a woman who was found dead from post-partum hæmorrhage, she had been able to strangle her child with a cord and to hide the body in a cupboard before she herself succumbed. Juries often return a verdict of *Transient mania* in cases of infanticide. Clinically this condition is seldom observed during or after parturition, and puerperal insanity does not come on until from five to fifteen days after delivery. The intense agony

experienced as the head is being born may, however, momentarily deprive the woman of her power of inhibition, and she may kill her infant during this period.

Examination of the Woman.—A medical man may be asked to examine a suspected woman in order to determine whether she has lately given birth to a child, and if so, whether her present condition corresponds to the period when it is alleged that she was confined. There is no law, however, which compels a woman to submit herself to such examination. The woman may refuse to be examined. This may be a suspicious circumstance, but not necessarily, as many modest and innocent women may refuse. One lady committed suicide rather than be examined. If the woman consents to be examined, she must first be told that any evidence which such an examination may furnish will be used against her when the case comes to trial. No undue pressure should be brought to bear on the suspected woman, for if she is really guilty, she is being compelled to furnish proof of her own guilt. In spite of obvious evidences of criminality in most trials for infanticide, the mother is acquitted, because the medical witness finds it impossible to make a positive statement as to whether the injuries were inflicted before or after the infant was wholly born. The jury take a lenient view of the case, knowing that if they return a verdict of guilty the woman will be condemned to death.

Baby Farming.—By the *Infants' Life Protection Act*, 1897, any one who boards and lodges more than one infant under the age of five years must give notice to the Local Authority, and must state the names, ages, sex of the infants, together with the address where the infants are to be kept, as well as the names of the persons from whom the infants have been received. The penalty for a breach of these regulations is £5, or imprisonment not exceeding six months. It is illegal to receive an infant under two years, for any single lump sum under £20, without informing the Local Authority.

This Act is intended to get rid of baby farmers. The practice of the latter is to adopt children on the payment of a single sum. They then get the infants adopted by other persons on paying them a much smaller sum than that which they have received, or else they keep the infants, and neglect them so that they soon die.

CHAPTER XIII.

BIRTH IN RELATION TO THE CIVIL LAW—IMPOTENCY, STERILITY.

BIRTH IN RELATION TO THE CIVIL LAW.

In Civil Law it is most important in many cases to be able to prove that the infant was born alive. No matter how transient its life may be, a child which has had an independent existence apart from its mother may inherit and transmit property to its heirs. The child need not have been viable, but if it has survived even a few seconds, and has been heard by one or more witnesses to cry, seen to move its limbs, or even if pulsations of the heart or arteries have been observed, these are proofs of its having been born alive. According to Scotch law respiration and crying must also have been noted, and in French law the child must be viable and have breathed, to prove live birth. When in attendance at a birth, carefully note the exact time of delivery of the child. This is important when the birth happens close to midnight, and especially so on the last night of the year. The exact time is also important in disputed questions of succession. The child may be heir to some one who died about the same time as the birth took place. If the death took place before the birth, then the child could have no claim as heir, unless a will made special provision for such an event.

Tenancy by Courtesy.—If a married woman who owns estates dies, and has given birth to a living child during her marriage, her husband will hold the lands for life as tenant by the courtesy of England. If she has had no child, then at her death her estates pass to her next heir-at-law. In such cases medical advice and help may be required to obtain a

living child, as by inducing premature labour. The child must be born during the lifetime of the mother (not by Cæsarean section), and must be capable of inheriting property (*e.g.* not a monster).

Minority.—By English law a minor corresponds to an infant, and the term is applied to any one under the age of twenty-one. In Scotland a minor is a lad between the ages of fourteen and twenty-one, or a girl between twelve and twenty-one, both being called pupils before that age. A child under the age of seven is irresponsible for his or her acts. He is legally incapable of crime, as he is not supposed to know what is right or wrong. Between the ages of seven and fourteen, though still presumed to be irresponsible, if it can be shown that he knew he was doing wrong, he may be punished by receiving stripes, or by being detained, if under twelve years, in an industrial school until he attain the age of eighteen, or longer if his consent be obtained in writing. At the age of fourteen he becomes responsible for his acts. He may then make a will disposing of movable property, and in Scotland he may contract a lawful marriage. A girl at the age of twelve has arrived at a legal marriageable age. In England the consent of the father is required to the marriage of an infant under the age of twenty-one. Young offenders between the ages of twelve and sixteen may be sent to a reformatory school for not less than three nor more than five years. Such cases are usually disposed of at the Police Court or at a special Juvenile Offenders Court. At the age of twenty-one a man attains his majority. He may then will away his lands and goods (heritable and movable property), and may be called upon to serve on juries. In former times the law punished children very severely. Thus, a case is recorded of a child aged eight and a half years who was executed for arson; a child of nine was burned at the stake for killing another child, and a girl of thirteen was executed for murdering her mistress. All contracts for money lent, etc. made by minors (except for necessaries) are void in law.

Monsters.—In disputed cases evidence is led in the Court to prove the monstrosity. Such cannot be heir to or inherit lands. It is a crime to kill monsters even though they are not viable and usually die a short time after birth.

Legitimacy.—Any child born in wedlock is presumed to be legitimate, or if born nine months after the death or absence

of the husband. In Scotland a child born before marriage may be rendered legitimate by the subsequent marriage of the parents. This is not so in English law, but the offspring of voidable or invalid marriages are usually made legitimate by law. Medical evidence as to legitimacy may arise in cases of disputed chastity of the wife; duration of pregnancy; viability of the child; physical incapacity of husband or wife; superfœtation, etc.

Illegitimacy.—Children are illegitimate or bastard if born out of lawful marriage, or where it is impossible that one could have been born in marriage. Thus, absence of the husband, his state of health, advanced age, extreme youth, impotence, etc. may make it impossible that he could have been the father. In order to substantiate a plea of illegitimacy the proofs must be made very clear to the Court. The father of an illegitimate child is liable to pay aliment in a sum not exceeding 5s. per week until the child reaches the age of sixteen years.

Superfœtation means the conception of a second embryo while the uterus is already gravid. The condition must be very rare, as ovulation almost always ceases during pregnancy. Cases have occurred where a woman has given birth to 2 mature infants at an interval of from one to three months. In some cases these infants have been of different colour, so indicating a double paternity. It may be that the case was one of twins, one being born prematurely, or, on the other hand and more probably, the uterus has been double, and one cornu has become gravid at a later period than the other.

Paternity. Affiliation.—In law the husband of a woman who gives birth to a child is presumed to be the father, unless he can prove the contrary. A settlement of the question of paternity may arise in cases of alleged adultery, where a mature child is born before the term of utero-gestation, or at a period longer than nine months after the death of the woman's husband. The question may require solution where an unmarried woman sues a man for the aliment of her child. It may be that she has had intercourse with more than 1 man. In deciding this the jury look to resemblance between the child and the alleged father in feature, gesture, form, deformities, etc. The period of utero-gestation has also to be thought of. The man who had intercourse with the woman at the period most closely corresponding to the calculated time

is most likely to be the father. In cases which cannot be clearly decided, both of 2 defendants may be ordered to contribute to the aliment of the child.

Supposititious Children.—A woman may be actually delivered of a dead or of a female child, and may replace such by a living or male child, or she may have feigned pregnancy and delivery, and may produce a living child. Such cases are extremely rare, as they presuppose the connivance of other parties, and if carried out, such large sums have to be paid as hush money, that in time information is given to the authorities, because the criminal refuses to or cannot pay more. In investigating such cases the woman may have to be examined to determine if she has recently been confined, and whether the state of the child corresponds to the alleged time of its birth and the mother's condition. If called to a case where the child is already born, and dressed, ask to see the placenta and cord; examine the funis of the child, and investigate the state of the mother. Cases occur amongst the rich in order that an heir may be obtained, and amongst the poor when a woman blackmails a man for alleged seduction.

Hermaphroditism means the union of both sexes in one individual. A few real cases have been described. In general, however, the condition is spurious.

Distinction of Sex.—It is often not easy to determine the sex in such cases, and yet the determination may be very necessary in questions of succession to estates by a male heir. It may be impossible to affirm the sex during childhood. If so, a positive answer must be delayed until the child reaches puberty, when characters particular to each sex usually arise. Thus, the male develops a deep voice, hair appears over the extensor surfaces, erection of the penis may be observed, and he develops a fondness for, or shyness at the opposite sex. In the female the breasts and body generally become plump, menstruation commences, and habits peculiar to the female develop.

False Hermaphroditism.—The male generative organs may simulate those of the female; thus, the penis may be very small and hypospadic, the scrotum may be divided, and the testicles may be undescended. Bimanual examination may show that neither uterus, ovaries, nor tubes exist. The female organs may resemble male organs (androgyna). Thus, the clitoris may be hypertrophied, and the labia majora may be

united. A bimanual examination may reveal the presence of an atrophied uterus and non-developed ovaries.

True Hermaphroditism.—A few cases have been described where the external genitals have resembled the male, and the internal those of the female, or *vice versa*. Such individuals have both menstruated and have had seminal emissions. In determining sex, consider the anatomical condition, and apportion to whichever predominate; look to the habit of the body, pursuits, and functions, if any exist (emission or menstruation).

FIG. 13.—Case of unusual development of the clitoris.

In certain cases the individuals are entirely neuter. Mistakes in apportioning sex have arisen in many instances. Men have been brought up as women, have married, and have submitted to intercourse through a dilated urethra, and yet have kept mistresses. Of nine hundred and thirty cases of hermaphroditism investigated, sixty-eight were cases of marriage of persons of the same sex; in fifty-nine of these the wife was in reality a male. In twenty-eight cases public prostitutes were found to be males. Two soldiers were really women, one menstruated regularly, and the other gave birth to a child. The medico-

legal aspect may lie in deciding sex in cases of succession where the estate may be entailed on male heirs. Hermaphrodites are usually impotent or sterile, and hence actions for divorce may be raised against them. The question may also arise in cases of alleged illegitimacy.

IMPOTENCY.

Impotency.—Incapacity for sexual intercourse constitutes impotency. Discussion as to the condition may arise in regard to the validity of the marriage contract, in cases of separation, divorce, or annulment, in disputed paternity, or in alleged rape or unnatural offences. The conditions may affect either sex, but are most commonly met with in the male, he being the active partner.

Causes.—(1) Anatomical Peculiarities.—Certain of the generative organs may be absent or deformed. Thus, the penis may be absent, infantile, or enormous; it may be cleft (epi- or hypo-spadias), or buried in an enormous hernial protrusion. In the female the hymen may be so tough as not to be penetrable; fissures at the introitus vaginæ may be so painful, or the vagina may be so narrow, as to prevent intercourse. Some of these conditions are remediable, and the Court would expect the individual to submit to reasonable and safe means of cure before pronouncing decree of divorce.

(2) Impotence from Age.—Impotence is usually present at the extremes of age. Boys under the age of fourteen are supposed to be impotent, but a precocious development of the sexual function may be stimulated by association with vicious companions, or by hearing of, or seeing acts of intercourse, or by too early excitation of the organs. Many precociously developed boys or girls appear quite childlike. A boy of thirteen impregnated his sister aged fourteen, and she became a mother; and another of similar age was father to the child of a young woman. In old age the spermatozoa usually disappear, and even though intercourse is possible to old men, it is generally unfruitful. In cases of prostatic enlargement sexual desires often persist to old age. Men of eighty years and upwards have procreated children, and one seemingly authentic case is that of a man over one hundred years of age.

(3) General diseases may lead to impotence. Thus, mere muscular weakness resulting from acute diseases may lead to

inability to perform the act, as may also neurasthenia, diabetes mellitus, mumps, various nervous diseases (locomotor ataxia, general paralysis); masturbation, or excessive indulgence in intercourse, as well as over-indulgence in tobacco or the morphine habit.

(4) Psychical Causes.—There may be an absence of desire for intercourse. This may be natural ("frigidity of constitution"), or may result from hypochondria, general paralysis, hysteria, fear, aversion; attempts at coitus may invariably bring on an epileptic fit, and so produce impotence. Refusal of intercourse from the time of marriage is of itself considered evidence of impotence. If the party refuse reasonable means of cure, then the presumption is considered conclusive of impotence. Nullity of marriage is only declared by the Courts if the defect existed at the time of marriage, and is of a permanent and incurable nature.

STERILITY.

Sterility is inability to procreate. Either party may be able to have intercourse, and yet the act may be fruitless.

Causes.—In the male, absence of the testicles or their non-development (cryptorchids are usually sterile); atrophy of the testicles after mumps; excessive venereal indulgence or masturbation; gonorrhœal orchitis, epididymitis, vesiculitis, or prostatitis may produce occlusion of the ducts, may inhibit erection, or may lead to premature expulsion of the spermatic fluid, and hence sterility. Nearly all cases of sterility, however, are due to disease in the female organs of generation. There may be congenital defects (conical cervix, occlusion of vagina, absence of uterus, tubes, or ovaries), or disease of the pelvic viscera may prevent conception (gonorrhœal salpingitis, ovaritis, displacements and adhesions of the ovaries, displacements of the uterus, endocervicitis, endometritis, tumours of the ovary or uterus, etc.). Some are capable of cure, while others are incurable. If the conditions are such as to render either of the contracting parties manifestly sterile, then the Courts may give an order for divorce, or if they were married while ignorant of the condition, the marriage may be annulled. If, however, the cause of sterility develops after marriage there are no grounds for divorce. If the reasons for sterility be not obvious, then after a three years' cohabitation without pregnancy resulting, a suit for divorce can be instituted.

CHAPTER XIV.

RAPE AND UNNATURAL OFFENCES.

RAPE.

Definition.—"The carnal knowledge of a woman's person by force and against her will." The perpetrator must be above the age of fourteen years. "Carnal knowledge" means the penetration of the penis within the vulva, and it is unnecessary to prove the completion of the act to prove that rape has been committed, the slightest penetration being sufficient—the hymen need not even have been ruptured. The crime is a felony, and the punishment may vary from two years' imprisonment up to penal servitude for life. To bring forward a charge of rape it is essential to prove that force had been employed, that the woman resisted, and that she had not consented. The punishment is the same if the crime be committed on girls under the age of thirteen years, but in such it is unnecessary to prove the employment of force, for the girl may have consented. It is justifiable homicide if a woman kills a man who attempts to rape her. The following offences are misdemeanours in law, and are punishable by imprisonment for any period up to two years, with or without hard labour :—

(*a*) An attempt at carnal knowledge, or the rape of girls between the ages of thirteen and sixteen years, even though consent be given ; (*b*) an attempt at carnal knowledge with a child ; (*c*) attempts at, or rape itself of imbeciles or idiots ; (*d*) indecent assaults on females. The force employed in rape need not necessarily be physical : the woman may not resist through fear ; thus, a woman submitted under the threat that the ravisher would murder her child. The woman may also be ravished while in an unconscious condition from alcohol, narcotics, or in the post-epileptic lethargic sleep. If a woman

consent while under the influence of intoxicants the charge of rape cannot be brought. If a man has intercourse with a woman while personating her husband, he is liable to be charged with rape.

Examination of Woman.—First allow the woman to give her own account of the outrage without putting questions to her. Find whether she had lodged a complaint soon after the crime was committed; it is a suspicious circumstance if she has delayed doing so for some time. Note whether she appears to have difficulty in walking. Get the woman to undress and examine her clothing for tears, and the underclothing for blood or spermatic stains. Examine the whole surface of the woman for bruises, scratches, etc., then placing her in the lithotomy position make a careful examination of the pudenda.

Signs of Virginity.—The woman may have been an unmarried virgin. The labia majora and minora are closely applied to each other, and are firm in character, except in advanced age. The fourchette is present, and the vagina is narrow with rugose walls. The hymen is present as a thin membranous fold of mucous membrane filling up the ostium vaginæ. It may be attached all round and (1) *annular* in form with a central round or elongated opening; (2) it most frequently is deficient above and anteriorly, and has then a *crescentic* appearance; (3) it may have a more or less fringed edge (*fimbriated*), or (4) there may be two openings divided by a bridge of tissue (*septate hymen*). If the hymen is intact it is presumptive that rape has not been committed, or at least that penetration was incomplete. On the other hand, the hymen may be very tough, and its edges may contract after coitus; even in prostitutes the hymen may retain its virgin condition. The hymen may have disappeared as the result of vaginitis, diphtheria, injuries, or from the introduction of foreign bodies.

Signs of Rape on Unmarried Women.—These are chiefly evidenced in the genital organs. Having got the consent of the woman to make an examination, make her lie in the lithotomy position in front of a good light. If the outrage has been very recent, the hymen will show either a single or several radiating ruptures; the edges are covered with blood, and are red and swollen. The labia may be more or less bruised, and the fourchette torn. If severe bruising

of the parts be found, or if the orifice of the vagina or the perineum be ruptured, then excessive violence has been used, either by the large size of the male organ, or more probably by the use of the fingers. The hymen lies deeply in children, and so may escape laceration. The spermatic fluid may be found as a glutinous, sticky substance, matting the pudendal hairs, or it may have dried into crusts. Pain is

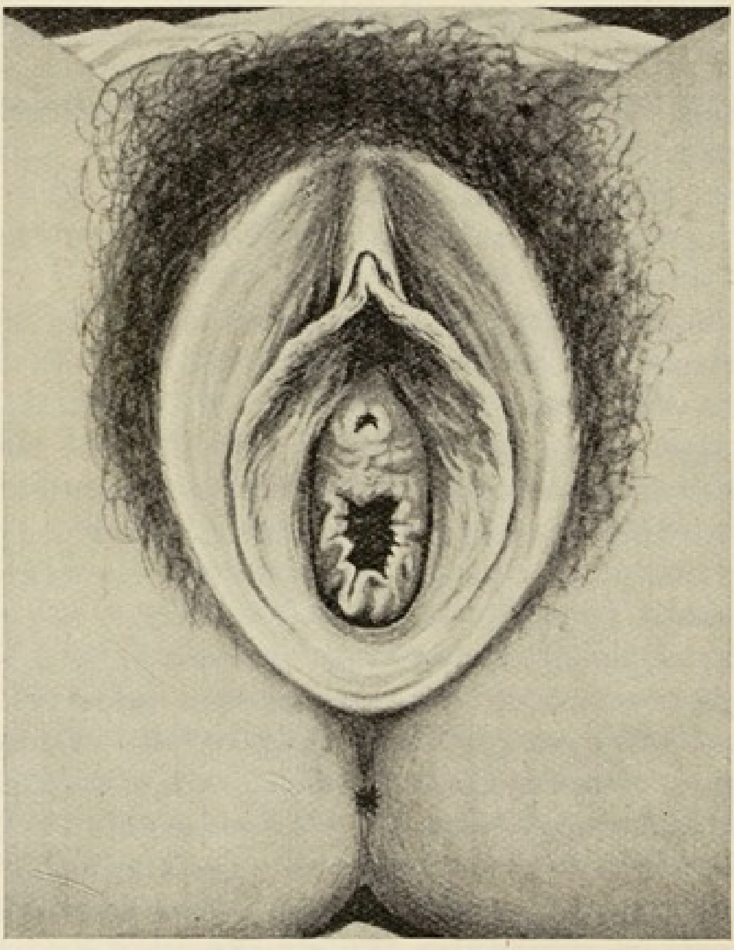


Fig. 14.—Hymen ruptured into fringes after intercourse.

complained of in walking, or during the act of micturition or defæcation. After the lapse of a few hours the parts become still more painful, and are covered with a sticky, mucopurulent secretion. Slight lacerations of the hymen heal up in two or three days, leaving the shrunken edges as carunculæ myrtiformes. If the above signs are present, the case is probably one of rape, but where there has been mere vulvar penetration no evidences may be found on the genital organs. The medical examiner would also expect to find marks on the woman's body

indicating that she had resisted. Careful notes should be made of any scratches, bruises, nailmarks, etc. on the throat, arms, thighs, legs, etc., as regards their size, position, and character. It should be determined whether these are perfectly recent, or whether they show inflammatory reaction, so pointing to more remote injury. The underclothing must be examined for the presence of stains. Blood-stains are frequently present, but may be due to menstruation. In the act of rape seminal emission usually takes place. The underclothing is only too frequently very dirty, and stained with urine, blood, or fæces, hence the detection of seminal stains may not be easy.

Rape on Married Women.—The local injuries to the genital organs are much less marked, though bruising of the labia is often present. Numerous bruises are found over the body, and especially on the thighs.

Seminal Stains.—The seminal fluid may be found on the legs, pubic hair, or underclothing of the woman, either in the recent state as a sticky substance or dried. The stains stiffen the cloth, and are of a greyish yellow or slightly red colour on white material. When moistened they give off a characteristic odour, and when heated the colour becomes deeper yellow, and small white spots appear in the stain. The edges are more or less translucent. Seminal stains on the clothing of children or young girls are strongly suggestive of rape.

Microscopic Examination for Spermatozoa.—Cut out a small piece of the stain, and separate one or two threads; place these on a glass slide with a drop of normal saline solution, or in water rendered faintly acid with hydrochloric acid, and tease very gently with needles so as not to break up the spermatozoa. Allow to soak for one to two hours, then make cover-glass preparations. If stained with eosin and methyl-green, the basal part of the head appears green, while the pointed extremity of the head and the long tail are red. Human spermatozoa alone take on these staining reactions. The head of the spermatozoon is about the size of a red blood corpuscle. An examination of the vaginal mucus may reveal the presence of motile spermatozoa up to six or seven days after intercourse.

Micro-chemical Tests.—(1) Florence's Test.—If a drop of the fluid obtained from a spermatic stain be mixed with a drop of a solution of iodine and iodide of potassium in a watchglass (1·65 parts KI, 2·54 parts pure iodine, 30 parts distilled water), brownish red pointed crystals resembling hæmin crystals

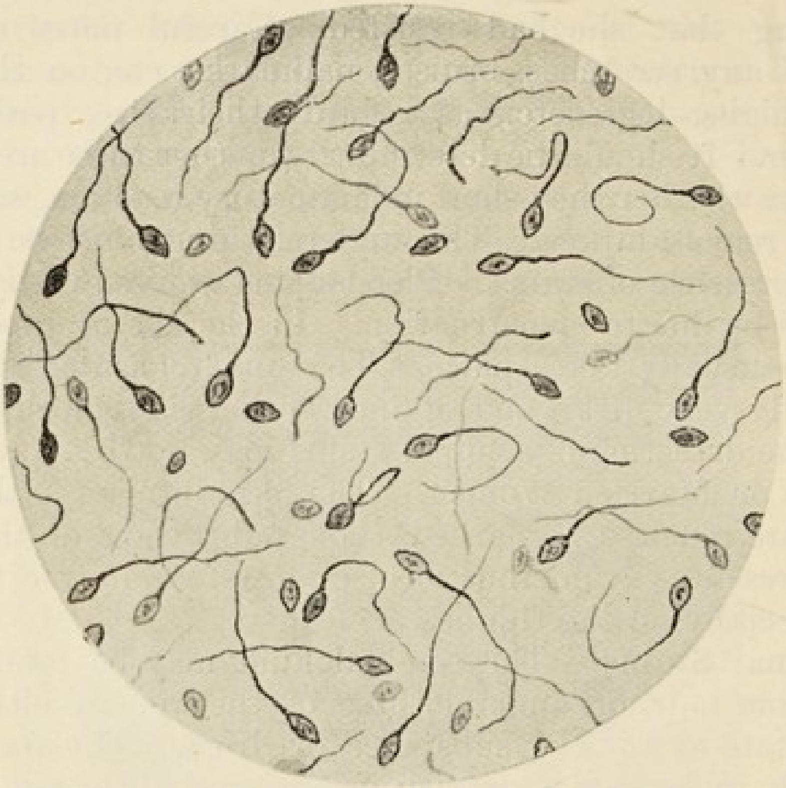


FIG. 15.—Human spermatozoa from unstained film. × 350.

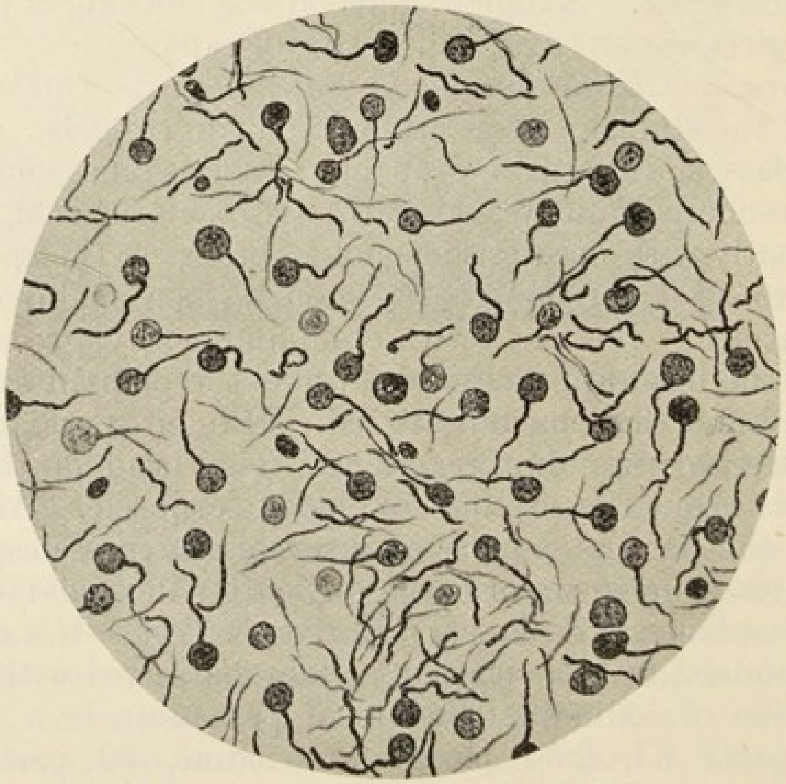


FIG. 16.—Spermatozoa of bird. × 350.

appear. These crystals may be seen clinging to a single fibre of cloth.

(2) Barberio's Reaction.—When a drop of a concentrated solution of spermatic fluid is added to a saturated alcoholic solution of picric acid, yellow needle-shaped rhombic crystals (like Charcot's crystals) appear. This is a specific test for human sperma.

Biologic Test (Farnum's).—This resembles the precipitin test for blood. From five to eight injections of human spermatic fluid are made into the peritoneal cavity of a rabbit at intervals of two days. The serum of this rabbit's blood gives a specific reaction only with human sperma.

Stains Due to Gonorrhœal Pus.—Cover slip preparations made in the usual way, and stained with alkaline methylene blue reveal the characteristic cocci. Gonorrhœa may be present in the woman, and not in the accused; this would prove that her allegation was false. If the man has suffered from gonorrhœa, then the woman whom he has outraged will probably develop the disease in from three to five days subsequently.

Examination of the Accused.—He can only be examined if he consent, and he must be warned that any evidence found on him will be used to secure his conviction. Bites, scratches, bruises, and abrasions may be found on his face, hands, and especially on his genital organs; a man who was endeavouring to rape a strong young woman had his penis torn completely off in the struggle.

Examination of the Locality.—Evidences of the outrage may be found in pieces of torn clothing, blood stains, trampled or crushed condition of the grass or ground, indicating that bodies had lain there.

Conclusions.—Discharges from the vagina are common in young women or girls, and may be due to such diseases as measles, scarlatina, struma, to the presence of oxyurides, or to mere neglect and dirt. The medical man must be careful in expressing an opinion under such circumstances. A practitioner who was called to see a child on whose clothing red and yellow stains were present, expressed the opinion that the child had been raped, while in reality these stains were due to a pastry and fruit tart. The previous character of the accuser, as well as that of the accused, must be taken into account; whether any motive for the allegation is present; the locality, and whether the woman could have called for

assistance, and the time which had elapsed since the outrage had been committed have all to be considered.

A strong active woman cannot be raped by a single man. It is alleged in certain cases that the clothes being thrown up over the woman's face and arms she was rendered helpless, and partially asphyxiated. Rape may be perpetrated, however, by a man under any of the following conditions in the woman: weakness, age, intoxication, narcosis from drugs, fear, threat, syncope, hypnotic sleep, etc. Medical men and dentists are often falsely accused of committing rape on women after having administered chloroform for some minor operation. Anæsthetics frequently arouse erotic feelings, and hence there should always be a reliable witness present when such drugs are administered to women. That a woman can be raped while sleeping is possible, though very improbable. It has to be remembered that the completion of the act of coitus is unnecessary to prove rape, the slightest penetration being sufficient. This might, therefore, be the condition in women who were accustomed to intercourse, and while in deep sleep. Though it has happened that a virgin has been raped during profound sleep induced by drugs, yet she would be at once aware of the fact when awake by reason of the pain and discomfort. Recently a man was found guilty of having committed rape on a girl during post-epileptic unconsciousness. Women have committed rape on boys or male children, and have conveyed syphilis and gonorrhœa to them by such means.

False Charges of rape are often made, the motive being to extort blackmail, or in revenge. In other cases it is a mere delusion on the woman's part; lunatics often prefer such charges against male attendants or medical men. In feigned cases bruises are seldom found, and if scratches exist they are on the anterior part of the body. In the case of children, the mothers make them repeat a concocted story, and only too often inflict the local injuries themselves. In other instances a vaginal discharge, the result of disease, leads them to suspect that the child had been outraged.

Rape on Infants and Children.—The local injuries are very great as a rule, owing to the disproportion between the male and the female organs. The parts are more or less torn, and much blood is effused. The hymen may escape laceration, as it is deeply placed during childhood. The child experiences

pain in walking, or in evacuating the bladder or bowels. The inflammatory reaction is severe, and a copious mucopurulent discharge follows. In certain cases great laceration has taken place, tears in the vagina may extend into the peritoneal cavity, or the perineum may be torn into the rectum. The child may die from the inflammation, or from gangrene which supervenes. *Noma pudendi* has to be distinguished from such gangrene. In cases of repeated attempts at coitus in children, the orifice of the vagina, and the vagina itself becomes widely dilated. Amongst the lower classes it is a popular idea that gonorrhœa can be cured by having intercourse with a virgin, hence the frequency of rape on children.

UNNATURAL OFFENCES.

Indecent Exposure of the private parts in public so as to shock natural modesty is a criminal offence. The exposure must have been made to more than 1 person. An intoxicated person may lose all natural modesty, and so may urinate or defæcate in public thoroughfares. On the other hand, mental disease, or disease of the genito-urinary apparatus, may lead to exposure of the private parts. Hypertrophy of the prostate gland in men may cause such irritation that a desire to exhibit their genital organs may be stimulated. It may, however, be due to sheer pruriency; thus, a man aged thirty-five was in the habit of lingering about a school for girls, and when he had attracted their attention he exhibited his private parts. The individual may be summarily punished with imprisonment for three months.

Incest, or intercourse between a man and a woman who are closely related (as between a father and his daughter), is a statutory crime or felony in law.

Sodomy, or "carnal knowledge against the common order of nature," as intercourse between man and man, or between either sex and a lower animal, is a heinous crime and punishable with long terms of imprisonment, as from ten years' penal servitude to a life sentence. The hairs of animals on the private parts or clothes of the accused may help in formulating a charge.

In Pederasty (*immisio penis in anum*) both parties are equally guilty, though one (usually a boy) may be irresponsible for his acts. The evidence of an accomplice alone is insufficient

to prove guilt. The investigation of such cases is similar to that in rape. *The Signs* of the crime may be evident in the passive agent by the anus being abraded, torn, or inflamed; the sphincter ani may be relaxed, and the entrance funnel shaped. In other cases, however, no obvious change is present.

Tribadism (Lesbian Love) is necessarily a rare condition (*immisio clitoridis in vaginam*). A minor form is kissing of the genital organs (*cunnilingus*).

CHAPTER XV.

INSANITY.

Lunacy, unsoundness of mind, mental derangement, etc. are names given to a defective working of the supreme regions of the brain which actuate conduct. The object in considering insanity here concerns mainly its legal aspects, viz. questions of correct diagnosis, the validity of wills, the repudiation of contracts, competency to manage one's own affairs, as to whether an alleged criminal is responsible for his actions, etc. Legally, the presumption is in favour of a man's sanity, even though the individual has been born deaf, dumb, or blind. If he be proved insane, however, it is presumed in law that he remains so during his lifetime.

The law recognises two classes of insanity :—(1) Congenital Idiocy or Imbecility (*Dementia naturalis*); (2) Acquired Insanity (*Dementia adventitia*). Certain other conditions are also recognised, *e.g.* "*non compos mentis,*" a term given to individuals who cannot be included in either of the above groups. "Feeble-minded children" are also legislated for by the Elementary Education (Defective and Epileptic Children) Act of 1899.

A Delusion means a perversion of the judgment. Thus, a man may believe himself to be eternally lost, or to be the angel Gabriel. Delusions may be of (*a*) Exaltation, as is common in general paralysis; of (*b*) Depression, leading, for example, to the murder of wife and family, and suicide; of (*c*) Persecution, where in order to draw attention to the injustice under which he imagines he is suffering, he may assault or murder some influential person.

Hallucinations are perceptions without external impulses. These are common in delirium tremens, *e.g.* the individual

imagining that some person is talking to him or watching him through a window.

An Illusion is a visual impression incorrectly interpreted, as a certain light is thought to be a ghost. As a rule the intellect soon corrects the wrong impression.

Legal Proofs of Insanity.—Lawyers usually lay great stress on the presence of *delusions* as proving insanity. These delusions, however, must be such as to materially influence the individual's conduct. Thus, a man may have the delusion that he is made of glass, and may yet be quite capable of doing his business. The ability to manage his own affairs is usually taken in law to mean that the person is sane.

Symptoms of Insanity are manifested by (1) Disorders of conduct; (2) Disorders of bodily function; (3) Disorders of mind.

Clinical Varieties.

Idiocy.—The condition is congenital, and leads as a rule, to early death. Many cases are the result of defective development of the brain or of myxœdematous cretinism. All degrees of this condition exist, from helpless living creatures to those comparable in mental development to young children. There is usually physical deformity also, *e.g.* microcephaly, high palatal arch, cleft palate, etc. Idiots are usually quiet and gentle, but are easily irritated and passionate; atrocious acts of cruelty may be perpetrated by them, as the wanton torture of animals.

Imbecility.—Mental development proceeds for a time after birth, but then becomes arrested. All degrees of intelligence are found in these persons of weak intellect. They are able to speak, but seldom able to reason, and cannot distinguish between right and wrong. They are easily roused to passion, and may thus be dangerous. A girl fourteen years old, of weak intellect, recently confessed to having killed six infants by thrusting hair-pins into their brain. When they grow up they may give trouble owing to associating with prostitutes, thieves, etc. If rich they waste their money, or may contract improper marriages.

Mania.—(1) *Acute Delirious Mania* (Delirium grave) usually affects young people. It may be a result of mental shock or acute disease, and commences suddenly. There is violent excitement, shouting, and singing; sleep is totally absent; the

patient may tear his clothes off, and is without modesty; homicidal attacks may be made. Recovery may be complete, or it may pass into general paralysis. Death may result from exhaustion.

(2) *Acute Mania* may be a result of acute fevers, inflammation of the internal organs, after operations or accidents, or poisoning (belladonna). The onset is often gradual; later, delusions, illusions, and hallucinations are usually present. The patient is indecent and may commit rape. Lucid intervals are frequent. Ideas of persecution or of being poisoned are often present, and murders may be committed under this belief. Recovery is the rule, though it may be one of the phases of *folie circulaire*. Chronic mania may be a consequence.

(3) *Transitory Frenzy* is a violent mental disturbance which comes on without warning, lasts a few hours, and is terminated by deep sleep. During the paroxysm crimes may be committed of which the patient has no recollection. As a rule no recurrence takes place. It often results from anxiety or physical exhaustion. It is a condition which ought to be kept in mind by the medical jurist.

Dementia.—(1) *Acute Dementia* may affect the youth of both sexes or adults after overwork, anxiety, shock, sexual over-indulgence, etc. It may produce a condition similar to idiocy or imbecility, or may lead to mere apathy.

(2) *Secondary or Chronic Dementia* may follow melancholia, mania, general paralysis, alcoholism, epilepsy, hemiplegia, cerebral tumours, etc.

(3) *Senile Dementia* or the fatuity of age (not necessarily old age).—This is seen in loss of memory; inability to give attention; non-recognition of friends; dirty habits; greediness; suspiciousness; erotic tendencies; and latterly stolidity and confinement to bed. In the early stage the patient may remain quiescent for hours, or may be in constant movement. Misers often belong to this class.

(4) *Paretic Dementia or General Paralysis of the Insane.*—In this affection there are both physical and psychical symptoms. The disease usually affects individuals between the thirtieth and fiftieth years. The patient may become loquacious, over friendly, restless, forgetful, neglectful of his family; has ideas of grandeur; moral perversions; is often indecent, and may have maniacal attacks. The physical symptoms are well marked (tremors), and the pupils are unequal; apoplectic or epileptic-

like fits develop; the gait becomes unsteady, and paralysis or dementia may finally supervene. The *causes* are overwork, worry, alcoholism, but almost always syphilis.

Melancholia.—The name is descriptive of the condition; the individual is apparently in deep sorrow; he may sit wringing his hands for hours together (stupor); insomnia is persistent; the general health is bad; delusions as to the cause of his disease are often present, *e.g.* that the bowels are rotting away or that a reptile is eating his vital organs. Delusions of a sexual character are common. Suicide is frequent, as is also the murder of wife and children to save them from ruin, or the murder of the person who they think is causing their trouble. It may alternate with mania (*folie circulaire*), or be associated with paretic dementia. The *cause* may be grief, overwork, or over-excitement. "Religious melancholia" is common after revivals, and is a very incurable form of the disease.

Moral Insanity.—Individuals may be perfectly sane in every respect, except as regards their moral nature over which they have lost control. Some may steal without occasion (*kleptomania*); others are unable to resist the temptation to tell falsehoods, or they show baseless hatred; decent men suddenly become most immoral; an insatiable craving for alcohol may be present (*dipsomania*), etc. Delusions are absent. It is difficult in many cases to distinguish such cases from the ordinary moral depravity of the criminal classes, and "moral insanity" is frequently alleged in favour of a prisoner on trial for homicidal assault.

Causes.—It may be associated with general paralysis of the insane, mania, apoplexy, injury to the brain, epilepsy. In children or youths it may be the result of want of development of the moral faculties.

Monomania (Delusional Insanity; Paranoia) means a mental unsoundness on one subject or class of subjects, the other mental attributes remaining more or less normal. There may be a single fixed delusion, as that he is the King of kings; that he is compelled to keep silent, etc. During the early stages of the disease those affected will not speak of their monomania, but later they constantly speak about it. The patient often becomes demented or maniacal. Delusions of persecution may lead the unhappy individual to seek police protection, or may impel him to suicide or to murder. In other cases

there is a mere suicidal or homicidal impulse. *Homicidal mania* may lead the maniac to kill several innocent people. He may appear quiet and docile, but yet on the first opportunity may commit murder. Murders often follow on the discharge of a quondam homicidal maniac from an asylum. *Suicide* is by no means always due to an insane impulse. The loss of money or reputation may drive a sane person to self-murder. The suicidal tendency often runs in families, and is three times more frequent in males than females. Suicides have increased enormously within the last thirty years. In law, suicide is a felony, and any one who aids or abets another to commit suicide is guilty of murder. This charge is sometimes brought against the survivor of 2 persons who have agreed to commit suicide together. An attempt at suicide is a misdemeanour.

Impulsive Insanity.—The individual feels impelled to commit some act or crime. He is obsessed by the idea, and may struggle against committing it; thus, a woman may ask that her children may be removed from her care as she feels compelled to kill them. The impulse to suicide is also often present. There are no delusions, and such cases are difficult to decide in Courts of Law.

Epileptic Insanity.—Either in childhood or in adult life epilepsy tends to cause a slow degeneration of the intellect which often ends in chronic dementia (*Epileptic insanity*) with periods of mania. Those cases where the fits partake both of the petit and grand mal type tend more frequently and more rapidly to this deterioration. *Before* an epileptic fit the individual may be restless, quarrelsome, morose, or have delusions. *After* a fit many acts may be performed of which the patient has no recollection (*Post-epileptic automatism*). Even after petit mal attacks such automatic acts may be done, as urinating in public, undressing on the street (this has given rise to charges of indecent exposure). A woman who was cutting bread while holding a child in her arms had a petit mal attack; on recovering she cut off the child's arm so that it bled to death. She was tried for murder, but acquitted on the ground of insanity. Even after the epileptic sleep, violent gesticulation or mania may develop; the latter may lead to brutal violence. A German epileptic recently confessed to murdering 3 little girls with fiendish cruelty. The epileptic fit may in certain cases be entirely replaced by a maniacal

seizure (Masked Epilepsy; Psychic form of Epilepsy; Epilepsie larvée). Such individuals are exceedingly dangerous to themselves or to others. Epileptics sometimes suffer from temporary entire lapses of memory, forgetting their own name and where they live.

Toxic Insanity may result from the long-continued use of alcohol, opium, cocaine, etc.

Alcoholic Poisoning.—(1) *Acute Delirium* may result from a large dose of alcohol. Delusions are present, and the individual requires constant care until recovery takes place.

(2) *Delirium Tremens* is the result of a drinking bout continued for several days. Accident or shock may precipitate an attack in a chronic alcoholic individual. The patient is restless, suspicious, sleeps little, and has horrible dreams; illusions of sight and disturbances of hearing are present. Homicidal attacks may be made by the patient, or he may attempt to commit suicide.

(3) *Dipsomania.*—This means an uncontrollable craving for alcohol, which comes on at intervals in an otherwise (perhaps) abstemious individual. It is a variety of periodic insanity.

(4) *Chronic Alcoholic Insanity* results from long-continued over-indulgence in alcohol; the person becomes slovenly in his person and habits; untruthful; delusions as to his being poisoned or watched, or as to the infidelity of his wife, are often present. The face becomes expressionless, and the lips tremulous. Peripheral neuritis may lead to paralysis of the legs. The mind becomes weaker until dementia results. The delusions may lead to brutal murders.

Insanity of Pregnancy.—During normal pregnancy there are various mental alterations, *e.g.* perversions of taste, irritability, etc. These may be aggravated until actual insanity may supervene, usually after the third month. The patient is suspicious, sleepless, has a horror of her husband, with hallucinations. Suicidal tendencies are present.

Puerperal Mania almost always develops within a fortnight of delivery, and takes the form of mania or melancholia. The mother may kill herself or her infant.

Insanity of Lactation is caused by the long-continued exhaustion of nursing, and occurs either in the form of mania or melancholia. It comes on from three to eight months after delivery. Suicide and infanticide are common.

Lucid Intervals.—In law, this is taken to mean that the

lunatic regains for a longer or shorter period his capacity to understand what he is doing. In practice an absolute condition of sanity is seldom seen, still the individual may have periods of remission during which he understands perfectly what he is about, and is quite responsible for his acts. In mania these quiescent periods are perhaps most often observed (recurrent mania).

Feigned Insanity.—No person feigns insanity without a motive; *e.g.* the murderer to escape punishment. Such insanity always comes on *after* the crime; its onset is very sudden; it is usually over-acted, and very obvious to the onlooker. Real insanity, on the other hand, precedes the crime; its onset is gradual, or there is an obvious cause, and the patient denies his lunacy. *Mania* is the condition usually simulated, but it is difficult to keep up the condition for long, and sleep overpowers the impostor. The real maniac is sleepless, has a high temperature, and is as violent when alone as when observed. *Dementia* is more often feigned by women, and can be kept up for a longer period. *Melancholia* is not often simulated, and when so, the digestive troubles are not present as they are in the real condition. If *delusional insanity* be feigned the delusions vary from day to day, while in the real variety the delusion is fixed.

LEGAL ASPECTS OF INSANITY, ETC.

(Lunacy Acts, 1890 and 1891).

Responsibility for Criminal Acts.—To establish a defence on the ground of insanity, formerly it had to be clearly proved that the accused was "labouring under such a defect of reason from disease of the mind as not to know the nature and quality of the act he was doing, or if he did know it, that he did not know what was wrong." This was known as the *legal test.* Unless it could be proved that the accused was insane according to this definition, he might be punished. The law has gradually altered, however, and at present the *power of controlling his actions* is usually made the test. A lunatic may even be punished for committing a crime if it be proved that he knew that he was doing wrong. In other words, a person is liable to be punished if (1) he can distinguish between right and wrong, and if (2) he has sufficient will-power to control his

impulses. The plea of insanity is seldom urged in criminal cases unless the charge is one of murder, when it is brought forward so that the prisoner may escape capital punishment. If proved insane, the prisoner may be found "guilty, but insane," and is then sentenced to be kept in a Criminal Lunatic Asylum for the rest of his life ("during His Majesty's pleasure"). It may be that the jury find before the trial commences that he is incapable of pleading, or when apprehended he may be so obviously insane that the charge is not brought against him, and the Home Secretary may order his removal to an asylum at once. If in cases where a prisoner has been sentenced to death the question of his sanity has been raised by the defence, the Home Secretary orders 2 mental experts to examine his mental condition. If they report that the prisoner is insane, he is sent to an asylum for criminals for the rest of his life.

The plea of *drunkenness* (intoxication) as regards criminal responsibility affords no mitigation of the sentence. Chronic intoxication may, however, lead to insanity, and this would afford a valid excuse. Very often in cases of homicide by a drunken person the charge is that of manslaughter, as premeditation and malice are not present. Individuals are not responsible for acts done during *somnambulism or nightmare.*

Civil Responsibility.

1. **Management of Property.**—By the law of England, if a person is squandering his estate by reason of his mental derangement, his nearest relative may apply to the Master in Lunacy to hold a *Commission of Inquiry or an Inquisition.* This resembles a trial, and medical evidence is called ("*de lunatico inquirendo*"). If the Commission find him insane, an official (*the Committee of the Person*) is appointed to look after him, and another official, a *Committee of the Estate*, looks after his property, the control of which is taken out of the lunatic's hands. Where the lunacy is not disputed, a summons may be made to the Master in Lunacy, who appoints a receiver, and gives directions as to the property. Such are known as *Chancery lunatics*, because they are under the care of the Lord Chancellor.

In Scotland 2 medical men give certificates "on soul and conscience," "that the person is insane, and incapable of managing his own affairs, or of giving directions for their

management," and these, along with a petition from the nearest relative stating the extent of his property, are submitted to one of the judges. If he is found insane, the Court of Session interdicts him or prohibits him from managing his affairs, and appoints a *Judicial Factor or Curator bonis* (generally a lawyer or accountant) to take charge of the estate. The process is known as *Interdiction*. In many cases it is not necessary to place such lunatics under restraint in asylums. Lawyers rely greatly on a person's ability to count in judging of his capacity to manage his affairs. Badly educated persons, however, often find great difficulty in solving arithmetical questions in public.

2. **Civil Contracts**: (*a*) *Necessaries*.—The insane are liable in all contracts for necessaries (food, clothing, lodging, etc.), unless the person who sells takes advantage of them, knowing their insane condition. Unless the order has been grossly extravagant the lunatic is usually held responsible for its payment, it being immaterial whether his condition was known or not to the vendor. The necessaries for the support of the lunatic's wife and family must also be paid for out of the estate. Intoxication does not render void implied contracts, *e.g.* sale of goods; necessaries bought; money borrowed or lent.

(*b*) *Marriage Relations: Nullity of Marriage*.—If it can be proved that one of the contracting parties was insane at the time of marriage the contract is null and void. Wealthy imbeciles are often induced to marry persons far beneath them in the social scale, and such marriages are often repealed by the Court. Marriages made during lucid intervals are usually upheld, however.

(*c*) *Partnerships* may also be dissolved by order of the Court if one of the parties is proved insane.

3. **Testamentary Capacity,** or competency for will-making, consists in the ability of the individual to recall (*a*) the nature and extent of his property, and (*b*) the persons who have claims on him, and their relative degree. Unless a will is outrageous in its dispositions it is usually upheld by the Courts. If he is of "a disposing mind" a lunatic may make a perfectly valid will. Perfectly good wills are often made during periods of remission (lucid intervals).

Wills made by *eccentric* individuals are often contested by the relatives on account of the peculiar distribution of the

estate. The disposition is, however, seldom interfered with by the Courts.

Wills made during *senile dementia* may be disputed on the ground that the testator had been unduly influenced. In many cases the deceased has been more or less isolated, and having been of a facile disposition, may have been influenced by the nurse, medical attendant, or relative to dispose of his estate in their favour. In many cases the Courts have decided against legacies left to the medical attendant.

An Imbecile may make a will if he understands what it means, and what he is distributing.

Monomaniacs may make good wills, provided the delusion is not such as to materially affect the disposition. If a medical man is called to witness a testamentary disposition, it is well that he should carefully inquire into the mental condition of the testator to see if he is in a fit condition to make such; he should make the testator state the amount of property he has, and repeat the chief provisions of the will, etc.; if the latter were disputed, his evidence would then be of great value.

Wills made *in extremis*, and especially if peculiar, are considered suspicious, as it is well known that the mental condition of a person in this condition is seldom normal. Undue influence may be easily brought to bear on individuals exhausted by pain, or apathetic from approaching death.

Wills made during *motor aphasia and agraphia* may be perfectly valid. The names of the legatees being written on slips of paper, and the amounts of money or property on other slips, the testator may assort these, and so construct a good will. Unless the individual is so *drunk* as not to know what he was doing, contracts signed by him, or wills drawn up, are valid, and unless immediately repudiated when sober are binding. Chronic alcoholics are easily influenced, and hence the plea of "undue influence" is often brought forward in attempts to reduce their dispositions.

4. **Giving of Evidence.**—If a lunatic understands the nature of an oath, and the character of the proceedings, he is a competent witness, and may give reliable evidence.

Board of Lunacy.

The Lord Chancellor of England, as judge in lunacy, has supreme authority in all questions relating to the insane.

Two Masters in Lunacy (barristers) are appointed to hold inquisitions, and to appoint Committees of the Person or of the Estate ; there is a **Registrar** and 3 extra Chancery **Visitors**, 1 being a barrister, and 2 being medical experts.

The Commissioners in Lunacy form a board consisting of 11 persons, of whom 3 barristers and 3 physicians are paid members. These commissioners visit lunatic asylums (public, private, or criminal) to see that they are well conducted. No person may keep more than 1 insane person in his house without applying to this board for license, and the premises are inspected before such is granted. In England if a lunatic is kept by a private person, he must have been ordered there by a Judicial Authority, and must have been duly certified. On every occasion in which mechanical restraint has to be put on a patient in a public or private asylum, an entry must be made in a book kept for this purpose; it is a misdemeanour if this is omitted. There is also a General Board of Commissioners in Lunacy for Scotland.

Lunacy Certificates.—Before certifying that an individual is insane, one must be perfectly assured of the fact. In many cases the determination of this condition is by no means easy. It may be necessary perhaps to interview the person on several occasions, and for prolonged periods before the medical examiner can satisfy himself as to the sanity or insanity of the individual. Letters written by insane persons often betray their mental condition much better than conversation. If the examiner is not quite certain, then the patient ought to have the benefit of the doubt, and he should refuse to fill up the certificate. Wrongous certification may result from carelessness or from actual design, and in numerous cases the medical examiner has had to pay heavy damages for certifying as insane a person who was sane By the Lunacy Act of 1890, any wilful mistatement made by the medical examiner is a misdemeanour in law, and punishable as such. If the individual is incapable of looking after himself, or dangerous to himself or to others, however, no time should be lost in placing him under proper care. Many dreadful crimes have been committed during the time in which the medical examiners have been debating the condition. On the other hand, many acute cases recover in a short time, and it is inadvisable in such cases to resort to certification.

Placing of the Insane under Restraint or in a Lunatic Asylum.

Idiots and Imbeciles (Act 1886) can be placed in institutions for their care under (1) one medical certificate, and (2) a statement from the parent or guardian.

Of the seven different processes by which the insane may be certified, the most important are the *Reception Order on Petition* and the *Urgency Order*. In many cases, and especially amongst the well-to-do, it is not necessary to place the insane person in an asylum. He may be kept at home under the care of attendants. Monomaniacs seldom require asylum treatment.

I. **Reception Order on Petition.**—This is the usual method of dealing with private patients. The form of petition can be obtained from any law stationer, or from a magistrate's or justice's clerk, and contains five sections: (1) the petition which is made by the nearest relative; (2) a statement of particulars made by a relative; (3, 4) two medical certificates; and (5) the reception order, which is signed by the Judicial Authority if he is satisfied as to the alleged insanity.

Medical Examination.—Each medical man must examine the patient separately, privately, and at different times, not more than seven days previous to the presentation of the petition. The medical examiner must be in no way related to the alleged lunatic, nor must he have any financial interest in the asylum in which it is proposed to detain the patient. The medical men should not be related to each other or be in practice together. In the certificate the examiner has to state:—
(*a*) Facts indicating Insanity Observed by Himself.—He should describe the most telling indication of insanity he has observed, especially any delusion; the manner of the patient (incoherence, want of reasoning power, etc.), expression, apathy, etc. must also be described.

(*b*) Facts indicating Insanity Communicated by Others.—A brief summary of facts which the medical man thinks conclusively prove insanity, and which have been communicated to him by near relatives of the patient or by persons who have had ample opportunity of observing him, and on whose testimony the medical examiner can rely, must be appended.

The fee is usually £2 : 2s. If a medical man has signed one of the certificates, he may not attend the patient

medically while the latter is in an asylum. In the examination of a prisoner as to alleged insanity, the exact words of his conversation should be written down; also his condition as to speech, pupils, gait, etc. On no account should questions be put to him as to the alleged crime; if he volunteer a statement, however, notes of it should be taken.

Reception Order.—The Judicial Authority in England may be any judge of a County Court, a Stipendiary Magistrate, Justice of the Peace, or the Chairman of the Board of Guardians appointed under the Lunacy Act. In Scotland it is the Sheriff. If any of the above is not satisfied with the statement and certificates, he may himself examine the alleged lunatic, or may summon witnesses. If he refuse the petition he must give his reasons. A reception order remains in force for seven days only from the date of its being signed. It requires renewal at the end of the first, second, fourth, seventh, and every subsequent five years.

II. **Urgency Order or Emergency Certificate.**—In urgent cases, as in suicidal or homicidal mania, the lunatic may be received into a registered house on one medical certificate alone, the examination having been made within two days. A near relative signs the Emergency Order also, and makes a statement of particulars. It is not necessary to have Judicial Authority for the removal of the patient. The lunatic can only be detained seven days under this order in England, and in Scotland three days. If he is to be detained longer, the routine method of certification must be proceeded with during this emergency detention.

III. **Summary Reception Order.**—Any constable or relieving officer who knows of a lunatic uncared for must acquaint the Judicial Authority, who then proceeds in the usual way.

IV. **Order for Lunatics Wandering at Large.**—Such are detained in the workhouse asylum on one medical certificate.

V. **Pauper Lunatics** are also detained on one medical certificate. In Scotland, however, the same formality as for private patients is adhered to.

VI. **Reception Orders may be Granted by Two Commissioners** on the strength of one medical certificate.

VII. **Order for Detention may be given after an Inquisition.**—This is usually only carried out in cases where a wealthy person is wasting his estate.

In Scotland insane persons whose disease is not confirmed

may be placed in private care for a period not exceeding six months without formality, but with a special certificate from 1 medical man.

In Ireland the procedure is very similar to that of England.

Discharge of Lunatics.—As great care should be taken in discharging lunatics as in receiving them into asylums. Lucid intervals may be so long as to suggest complete recovery. Suicidal or homicidal maniacs should seldom be discharged. Patients in asylums frequently appeal to the Commissioners to hold an inquiry into their condition. Certificates of sanity may then be given, and such not only liberate the individual, but restore to him his civil rights. If a lunatic escape from an asylum, he may be taken back without any fresh certification or reception order if within fourteen days. If he evade capture longer than this, the whole process must be gone through anew.

Copy of the Reception Order on Petition.

[FORM **A**.]

25 & 26 *Vict.*, *Cap.* 54, *Sect.* 14.

PETITION TO THE SHERIFF TO GRANT ORDER FOR THE RECEPTION OF A PATIENT INTO AN ASYLUM.

(1) Sheriff or Steward.
(2) Shire or Stewartry.

Unto the Honourable the (1) *of the* (2) *of* *and his Substitutes,—*

The Petition of

humbly sheweth that it appears from the subjoined Statement and accompanying Medical Certificates that

(3) State degree of Relationship or other capacity in which Petitioner stands to Lunatic.

your Petitioner's (3) is at present in a state of Mental Derangement, and a proper person for treatment in an Asylum for the Insane. May it therefore please your Lordship to authorise the transmission of the said to the and to sanction admission into the said Asylum.

(*To be signed by the Party applying*)

(4) The date of the Petition must be within fourteen clear days following the dates of the Medical Certificates.

DATED this (4) day of One thousand nine hundred and

STATEMENT.

If any of the Particulars in this Statement be not known, the fact to be so stated.

1. Christian name and Surname of Patient at length, . . .

2. Sex and Age,
3. Married, Single, or Widowed,
4. Condition of Life, and previous Occupation (if any),
5. Religious Persuasion, so far as known,
6. Previous Place of Abode,
7. Place where Found and Examined,
8. Length of time Insane,
9. Whether First Attack,
10. Age (if known) on First Attack,
11. When and where previously under Examination and Treatment, (5)
12. Duration of Existing Attack,
13. Supposed Cause,
14. Whether subject to Epilepsy,
15. Whether Suicidal,
16. Whether Dangerous to others,
17. Parish or Union to which the Lunatic (if a Pauper) is chargeable,
18. Christian Name and Surname, and Place of Abode of nearest known Relative of the Patient, and degree of Relationship (if known), and whether any Member of Family known to be or to have been Insane,
19. Special circumstances (if any) preventing the insertion of any of the above particulars,

(5) If patient has been previously in an Establishment, state fact, and date of latest admission or approximation thereto. If never previously under examination or treatment, state fact.

I certify, that, to the best of my knowledge, the above particulars are correctly stated.

DATED this day of one thousand nine hundred and

(*To be signed by the party applying*)________________

MEDICAL CERTIFICATE, No I.

I, the undersigned,
being a (1)

and being in actual practice as a (2)
do hereby certify, on soul and conscience, that I have this day, at (3) in the County of separately from any other Medical Practitioner, visited and personally examined (4) and that

(1) *Set forth the qualification entitling the person certifying to grant the certificate; e.g.* Member of the Royal College of Physicians in Edinburgh.

(2) Physician or Surgeon, *or otherwise, as the case may be.*
(3) *Insert the street and number of the house (if any), or other like particulars.*
(4) *Insert Designation and Residence, and if a Pauper state so.*
(5) Lunatic, *or* an insane person, *or* an idiot, *or* a person of unsound mind.
(6) *State the facts.*
(7) *State the information, and from whom derived.*

the said is a (5) and a proper person to be detained under Care and Treatment, and that I have formed this opinion upon the following grounds, viz.:—

1. Facts indicating Insanity observed by myself: (6)

2. Other facts (if any) indicating Insanity communicated to me by others: (7)

Name and Medical Designation, ________________

Place of Abode, ________________

DATED this day of One thousand nine hundred and

MEDICAL CERTIFICATE, No. II.

(1) *Set forth the qualification entitling the person certifying to grant the certificate; e.g.,* Member of the Royal College of Physicians in Edinburgh.
(2) Physician or Surgeon, *or otherwise, as the case may be.*
(3) *Insert the street, and number of the house (if any), or other like particulars.*
(4) *Insert Designation and Residence, and if a pauper state so.*
(5) Lunatic, *or* an insane person, *or* an idiot, *or* a person of unsound mind.
(6) *State the facts.*

I, the undersigned,
being a (1)
and being in actual practice as a (2)
do hereby certify, on soul and conscience, that I have this day, at (3) in the County of separately from any other Medical Practitioner, visited and personally examined (4) and that the said is a (5) and a proper person to be detained under Care and Treatment, and that I have formed this opinion upon the following grounds, viz.:—

1. Facts indicating Insanity observed by myself: (6)

2. Other facts (if any) indicating Insanity communicated to me by others: (7)

Name and Medical Designation, ________________ ([7]) *State the information and from whom derived.*

Place of Abode, ________________

Dated this day of One thousand nine hundred and

CERTIFICATE OF EMERGENCY.

(*This Certificate authorises the detention of a Patient in an Asylum for a period not exceeding three days without any Order by the Sheriff.*)

I, the undersigned,
being ([1]) ([1]) State medical qualification.
hereby certify, on soul and conscience, that I have this day, at ([2]) ([2]) State place of examination.
in the County of , seen and personally examined , and that the said person is of unsound mind, is a proper Patient to be placed in an Asylum, and is in a sufficiently good state of bodily health at this date to be removed to the Asylum at ([3]) ([3]) State place at which Asylum is situated.

And I further certify that the case of the said person is one of Emergency.

____

Dated this day of One thousand nine hundred and

(*The following should be filled up in every case in which a Certificate of Emergency is acted on.*)

I hereby request the Superintendent of the

Asylum to receive therein
to whom the foregoing Certificate of Emergency refers.

Relationship or other capacity in which Applicant stands to Patient, ________________

Signature and Address ________________

Date ________________

ORDER TO BE GRANTED BY THE SHERIFF FOR THE TRANSMISSION AND RECEPTION OF THE LUNATIC.

(1) State whether Sheriff, Sheriff-Substitute, Steward, or Steward-Substitute.
(2) State whether a County or Stewartry.
(3) Insert name and Designation.
(4) Describe him, and if a Pauper state so.
(5) Lunatic, *or* an Insane Person, *or* an Idiot, *or* a Person of unsound mind.
(6) Public District, Parochial, *or* Private.
(7) His, *or* her.
(8) Public District, Parochial, *or* Private.

I, (1) of the (2) of having had produced to me, with a Petition at the instance of (3) Certificates under the hands of and being two Medical Persons duly qualified in terms of an Act, intituled "An Act for the Regulation of the Care and Treatment of Lunatics, and for the Provision, Maintenance, and Regulation of Lunatic Asylums in Scotland," setting forth that they had separately visited and examined (4) and that the said is a (5) and a proper Person to be detained and taken care of, DO HEREBY AUTHORISE you to receive the said as a patient into the (6) Asylum of and I authorise (7) Transmission to the said Asylum accordingly; and I transmit you herewith the said Medical Certificates, and a Statement regarding the said which accompanied the said Petition.

DATED [at] this day of
One thousand nine hundred and

To the Superintendent of the (8)
Asylum of

[*Signature*]________________________

Stigmata or Evidences of Degeneration.

By Degeneration is understood any morbid deviation from the normal type. Degenerates are very often the offspring of drunken, insane, epileptic, or criminal parents, and may themselves be feeble-minded or imbecile.

Evidences of Degeneration may be seen as :—

(1) *Anatomical Deviations*; *e.g.* microcephalus, prognathism, abnormal depth or irregular shape of the palate (very often present); cleft palate; hare lip; irregularity of the teeth; deformity of the tongue; defective vision; strabismus; deformity in the shape of the ear (often present); supernumerary digits; dwarfism; giantism; nondevelopment of the sexual organs, etc.

(2) *Physiological Deviations*: delay in walking; deaf mutism; defective speech; incontinence of urine; gluttony (merycism); depraved appetite; precocity of mental development, etc.

(3) *Psychic Deviations*: night terrors; migraine; epilepsy; idiocy; imbecility; insanity; sexual perversions.

Marriage in its Legal Aspects.

The following conditions render the contract of marriage void: bigamous marriages; where the girl is under twelve or the boy under fourteen years of age; when the marriage has not been consummated or followed by cohabitation; where one of the parties was incapable of contracting marriage or consummating it (impotency, malformation), and when such was not known to the other at the time of marriage; concealment of pregnancy at the time of marriage; if one of the parties was drunk at the time of marriage, the contract may be annulled; if, however, it is consummated when sober, the marriage is valid.

Habitual Drunkards.

Inebriates' Retreats.—Habitual drunkards who are dangerous to themselves or to others, or incapable of managing themselves or their affairs, may on their own application be admitted to licensed retreats, and are not allowed to leave until the expiry of the time fixed in the application (but such must not exceed two years).

Inebriates Act (1898).—If a habitual drunkard be sentenced to imprisonment or penal servitude for an offence committed during drunkenness, or if he has been convicted four times in one year, the Court may order him to be detained for a term not exceeding three years in an Inebriate Reformatory.

CHAPTER XVI.

LIFE ASSURANCE.

(Life Assurance Companies Acts 1870-1872).

Life Assurance or Insurance means that an individual pays to a company a small sum annually, so as to obtain these added sums together with interest at some future period of life or at death. The principle depends on the accumulation of money at compound interest, and on the remarkable uniformity of mortality at different ages amongst large masses of people.

Numerous Life or Mortality Tables have been constructed (Dr. Farr, Dr. Ogle, the Northampton Tables, the Carlisle Tables); the Institute of Actuaries' Mortality Table $H^{M.}$ (healthy males) is now almost universally used, however. These show the number of individuals, out of 1,000,000 born, who are alive at the end of each succeeding year, and from these the "expectation of life" at any age can be computed, or, in other words, the number of years which a person at any given age may be expected to live. With this knowledge the companies are enabled to make a certain annual charge or premium proportioned to the age, health, and occupation of the proposer, knowing that on an average they will not lose on paying the sum assured for. For example, a man aged twenty-five may have to pay each year £2 : 5s. so as to secure £100 at death, because his expectation of life is thirty-eight years; while a man aged forty-five has to pay £3 : 15s. for the same sum assured, his expectation being only twenty-four years. One man may die after having paid only one premium, and his heirs will receive from the company the sum for which his life was insured, the company losing heavily on this transaction; other individuals, however, live far beyond their expected period, and each year that they survive means added profit

to the company. As each company charges a little more than is absolutely necessary to meet the claims, they are enabled to build up a reserve capital which can be drawn upon in times of exceptional mortality. The larger this reserve is, the stronger is the company financially. A certain proportion of this is distributed every five years amongst the policy holders as a bonus.

The Policy is the document or contract by which the company promises to pay at death or after a definite time a fixed sum in return for a certain amount paid by the insured each year. The *premium* is this annual charge.

Whole Term or Life Policies mean that the premiums have to be paid each year until death. A person may, however, pay one lump sum in lieu of annual payments.

Terminable Policies mean that the individual pays only a certain number of premiums, or only for a certain number of years. The policy may thus become payable at the age of fifty-five or sixty, or at death if it takes place before these ages. A man aged twenty-five pays about £4 : 4s. each year, so as to secure the payment of £100 on reaching the age of fifty-five, or he may make twenty annual payments of £3 : 4s. One person may insure another person's life, if the former can show that he has an "insurable interest" in the latter's life, as, for example, after advancing him money; a creditor has this interest in the life of his debtor, etc.

A Short Term Assurance may cover only one or two years. The policy may be effected as security on money borrowed.

Joint Life Assurances.—This means that the sum assured becomes payable on the death of the first of two or more persons.

Besides these there are many other forms of life assurance. In order to prevent fraud by diseased or unhealthy persons insuring their lives, it is usual for companies to insist on a medical examination of the proposer. Each insurance company engages the services of (1) one or two chief medical advisers or referees to the Board of Directors, and (2) medical examiners. The latter may be appointed in each large town, or the proposer may desire any medical man to examine him, as his family medical attendant.

Medical Examination for Life Assurance.—The endeavour of the examiner should be that of absolute fairness, both to the company and to the proposer. As the examiner receives his

fee from the company, he is really acting as an agent for that company, but ought not to show any partisanship. His duty is a difficult one, because many proposers deny that they have any disease or trouble, or at least minimise these; they take up a position exactly the reverse of that of the ordinary patient who comes for medical advice.

The object of the examination is to determine whether the applicant has an average healthy life, and an average expectation of life at his age, or the reverse. A form of questions is supplied to each medical examiner, and these must be filled up to the best of his ability. If he is the ordinary medical attendant of the proposer, and knows that the latter suffers from some disease which is likely to shorten his life, it is advisable for him to decline to examine him. If he does, the proposal will either be refused, or an addition or "load" will be made to each annual premium, and the medical attendant will assuredly be blamed for this.

Let the examination be entirely private, even the wife should be excluded; questions have to be asked as to his past history, the answers to which it is wise, perhaps, that she should not know. Inquiries should be made under the following heads:—(1) the family history of the applicant; (2) his past history; (3) his present state of health; (4) his habits and occupation; (5) his place of residence; (6) his age.

Let the examination be very thorough; mistakes made, may cause heavy loss to the company. Three months after insuring his life heavily, a man died from cancer of the tongue, the medical examiner being satisfied with the statement that a sharp tooth had scratched the organ.

Examine for signs of intemperance. Note the build of the body, excessive stoutness or thinness, deformities, etc. The complexion of the face and nose may indicate intemperance; examine the eyes, feel the tongue; look into the throat (syphilitic ulceration); note any clubbing of the fingers; colour of the hair (gouty). Pay special attention to the various systems; examine most carefully the lungs and heart, as well as the vascular system generally (aneurism, arterio-sclerosis). Inquire as to hæmoptysis, and determine its cause. The abdomen should be carefully palpated, and the urine examined for albumen, sugar, etc. The nervous system demands careful investigation (general paralysis, locomotor ataxia, etc.). The medical form after completion is sent to

the head office, together with a statement made by the proposer.

Duties of the Chief Medical Officer or Adviser.—He examines candidates for life assurance at the head office; he criticises the reports sent in by the medical examiners, and advises the Board to accept proposed lives, or to refuse them; or, after consultation with the actuary, he may advise certain lives to be accepted on certain terms, *e.g.* additions made to the average premium, increased premiums after a certain number of years, etc. He may ask further information from the medical examiners if he thinks fit.

Classification of Lives.—(1) First Class lives—the person being perfectly healthy, the family history good, no business worries, etc.; (2) Second Class or under average lives, as for example, an attack of hæmoptysis three years ago in a person aged thirty-five; if accepted, an addition is made to the ordinary premium ("loading"): (3) lives unassurable either from age or disease.

In the case of second class lives, it is usual for the medical adviser to state approximately by how many years the individual's life may be lessened, and the actuary then adjudges the additional premium to be paid; thus, a man at the age of thirty may be asked to pay the premium usually charged to a man of forty. By "*diminishing risks*" it is understood that the liability to certain diseases (*e.g.* phthisis) becomes less with advancing years; thus, the premium charged may be lessened after a certain period. "*Increasing risks*," on the other hand, usually appear after middle life (gout, arteriosclerosis, etc.), and to meet these risks the premium may be increased after a certain age is reached.

Extra Charges.—There are additions made to the annual premium on account of some tendency to disease, it may be hereditary, as gout, rheumatism, phthisis; or acquired, as obesity, or exposure to unhealthy trades or dangerous occupations.

Forfeiture of Policy.—If it be found that the proposer has wilfully made false statements, or has concealed the fact of disease present at the time of examination, his policy may be declared void, and the premiums paid may be forfeited.

Occupation as it Affects Life Assurance.—The lives with the highest expectation are found in those who enjoy a fair annual income with moderate amount of work, *e.g.* clergy,

judges, medical men, or professional men generally. The worst lives belong to those liable to alcoholic indulgence, *e.g.* publicans, innkeepers, butchers, brewers, young men with no occupation and plenty of money ("West-end lives"), etc. Those exposed to dusty occupations (millers, stone-masons, china-scourers, etc.) have bad lives, as have also compositors, reporters, or those exposed to lead poisoning risks (plumbers, painters). Married men, owing to their more temperate lives, have a better expectation than unmarried men.

Heredity and Life Assurance.—Careful inquiries must be made into the family history to determine the influence of heredity on the proposed life. Longevity is often a family characteristic. It is said that the mother is apt to transmit her disease to sons, and the father to daughters.

Insanity of the parent may appear in the children as hysteria, epilepsy, or insanity itself. If one parent alone is insane, and the proposer is healthy and above thirty years of age, his life should be accepted.

Nervous Diseases are also markedly hereditary. Different members of a family may suffer from different nervous affections or from insanity.

Cancer is hereditary in about one-fifth of the cases.

Phthisis.—The tendency to this disease appears at an earlier age, and is intensified with each tubercular generation. After the age of forty-five the disease is rare.

Gout is markedly hereditary, and appears at an early age in gouty families (eighteen to twenty years).

Diabetes has a marked relation to family; several members of a family may suffer from this disease. It is often associated with gout in other members of the same family.

Glycosuria may be transient, and due to digestive troubles or gout. If present on examination, test the urine at intervals before completing the examination form. If constantly present, the proposal must be rejected.

Acute Rheumatism.—The tendency to this disease is often transmitted, and hence heart disease is said to be hereditary owing to its causal relationship.

Asthma.—In about one-half the cases one of the parents has suffered from this affection. It usually comes on in early life, and if the proposer is healthy, and above thirty-five years of age the life may be accepted at ordinary rates.

Intemperance is very liable to run in families. The

children of alcoholic parents often suffer from nervous diseases or from insanity. The tendency to suicide is frequently transmitted. The life of the individual who is always taking small amounts of alcohol (*tippling*) is very precarious, and far more so than that of the man who has occasional bouts of drinking.

Albuminuria of renal origin almost necessarily implies rejection of the proposal. The merest trace of albumin may cause the proposal to be deferred, or if accepted, an addition to the premium will be demanded. Cases of functional albuminuria must be carefully investigated.

Syphilis may be congenital. If the symptoms have entirely disappeared the life may be insured. If acquired, and visceral lesions have resulted, the proposal should be rejected.

Hernia.—The presence of a rupture necessarily places the insurer in a dangerous condition; this is minimised if a well-fitting truss be worn.

Suppurative Disease of the middle ear, if acute, bars insurance; if slight and chronic, the proposal may be accepted.

Sickness and Accident Insurance.—The premium is paid annually to indemnify the insured against disease or accident. A certain sum is paid to the insured weekly (£2 : 2s. to £6 : 6s.) during his total or partial disablement, and a lump sum if his death results from accident. The policy usually covers all accidents, and either all diseases or a selected number of these. This is a form of insurance specially applicable to medical men, whose income depends almost entirely on the personal management of their profession.

Infant and Funeral Expenses Insurance is commonly practised by the lower classes. It is undoubtedly true that the sums of money paid for funeral expenses is often an incentive to the murder of infants.

Employers' Liability Assurance.—By this assurance companies guarantee to refund to employers damages which they may have to pay to workmen, domestic servants, or others injured while in their service. These damages are awarded by juries under the Workmen's Compensation Acts (1897, 1900, 1906). Medical evidence is often required in contested cases.

SECTION II.

TOXICOLOGY.

CHAPTER I.

DEFINITION ; LAWS RELATING TO POISONS, ETC.

Toxicology is the science which treats of poisons, their origin, properties, physiological action, detection, and treatment.

Definition.—A poison is a substance which when introduced into or applied to the body is capable of injuring health or destroying life, irrespective of temperature or mechanical action. A poison may, therefore, be swallowed, applied to the skin, injected into the tissues, or introduced into any orifice of the body.

Legal Interpretation.—In law there is no attempt at the definition of a poison, but stress is laid on the malicious intention in giving a drug or other substance. It is a *felony* to administer or cause to be administered any poison *or other destructive thing* with intent to murder, or with the intention of stupefying or overpowering the individual, so that any indictable offence may be committed. It is a *misdemeanour* to administer any poison or destructive or noxious thing merely with the object of injuring, aggrieving, or annoying an individual. The latter may be brought as an indictment against a prisoner when it might not be easy to prove the former charge.

Sale of Poisons.—Legally qualified druggists are alone permitted to dispense or sell poisons. Any druggist selling

such drugs is responsible for any errors which are committed; it matters not whether the fault is his directly or not. Thus, he may have bought strychnine, and it may have been labelled "quinine" by the manufacturers in mistake. If this is dispensed, poisoning may result, and the druggist is liable to punishment because he should have tested the drug, and have seen that it was not quinine. A druggist may refuse to dispense a prescription if he is of opinion that it is to be used for an improper purpose. Thus, a man who was peculiar in his manner asked a druggist to supply him with sugar of lead. The druggist gave him a harmless powder, and informed the police, who found that he had administered it to his children with the object of poisoning them. The druggist may know that the purchaser, say of laudanum, has acquired the drug habit, and may refuse to sell it.

Scheduled Poisons.—By the Pharmacy Act of 1868, two groups of poisons appear in the Schedule. Such poisons may not be sold to strangers. They may only be sold to persons introduced by some one known to the druggist; if so, the latter must enter in a book kept for the purpose the name of the poison, the name of the person to whom it is sold, the quantity, the purpose for which it is to be used, and the date of sale. This entry must be signed by the purchaser and by the introducer. The word "Poison" must be affixed to the bottle or box, as well as the name and address of the vendor.

Errors in Prescribing Poisons.—It is not uncommon for medical men to make errors in prescribing poisonous drugs. If a dose is prescribed which would be dangerous on account of its size, then the druggist *must not* dispense such. If he does, and any harm results to the patient, then the druggist and not the prescriber is liable. When such errors are found in prescriptions, it is usual for the dispenser to communicate privately with the writer of the prescription, drawing his attention to the mistake. In order that a claim for damages may be instituted, it must be proved that actual injury has been sustained by the complainant, and that the latter was free from contributory negligence.

Statistics of Poisoning.—By far the largest proportion of cases of poisoning are due to accident, or to the employment of poisonous substances in manufactures ("industrial poisons"). Lead and anæsthetics account for the greatest number of fatalities. About five hundred cases of suicidal poisoning

occur each year in Great Britain. Carbolic acid accounts for the great majority of these; opium and its preparations are also largely employed, and the cyanides are made use of by medical men, chemists, and photographers.

Action of Poisons.—Poisons may act (1) *Locally* as (*a*) caustics, *e.g.* the corrosive poisons; as (*b*) irritants causing congestion and inflammation, *e.g.* the metallic and vegetable irritants; as (*c*) nerve stimulants or sedatives, *e.g.* aconite, conium, cocaine. (2) *Remotely*; this action may be *reflex*, as in the shock produced by pain (corrosive poisons), or the poison may exert a *special action* on certain structures (belladonna on the brain cells, strychnine on the motor cells of the spinal cord). (3) *In both ways* certain poisons act as carbolic or oxalic acids.

MODIFICATION IN THE ACTION OF POISONS.

I. **Certain Bodily Conditions** may influence the action, thus:—

(1) *Age* has a marked influence. As a rule the younger the individual the greater the susceptibility; thus, 1 drop of laudanum has killed an infant. As exceptions, however, calomel and belladonna may be cited, children being able to take large doses of these with impunity.

(2) *Idiosyncrasy.*—This usually shows itself in increased susceptibility to small doses. Thus, 5 grains of antipyrine may produce profound collapse, or a few grains of grey powder may cause salivation.

(3) *Tolerance* is often acquired by habit. Thus, opium-eaters or laudanum-drinkers consume large amounts. De Quincey latterly took 360 grains of opium daily. The peasants of Styria frequently swallow 4 or 5 grains of arsenic at one dose to improve their stamina.

(4) *Diseased Conditions* usually lessen the susceptibility to drugs; thus, large doses of opium may be given in cholera and tetanus, or strychnine in paralysis. Increased reaction to drugs may, however, be observed, as opium in cases of granular contracted kidney, or mercury in Chronic Bright's Disease.

II. **Form and Quantity of Poison.**—Poisons in the gaseous condition exert the most rapidly fatal action. Poisons given in solution act much more rapidly than when taken in the solid state; indeed, in the solid form some poisons (as

phosphorus) are almost innocuous. The more of the poison which is retained in the stomach the more powerful is the action: a large dose of oxalic acid may cause death at once from shock, while a smaller dose acts more slowly by lowering the cardiac action. Large doses of certain poisons may act as emetics, and thus serious symptoms may be averted. If taken when the stomach is full, absorption is hindered, and the onset of symptoms may be delayed. When mixtures of poisons are swallowed, each may exert its influence separately, or again they may antagonise each other to a greater or less extent, and but little toxic effect may ensue (*e.g.* opium and belladonna).

III. **Application of Poison.**—The action is very rapid when the poison is inhaled or injected into the circulation The action is slower when it is absorbed through the gastro-intestinal mucous membrane. If the poison is excreted as rapidly as it is absorbed then no poisonous symptoms may ensue. If the latter process is more rapid than the former, then accumulation takes place in the body with poisonous results.

EVIDENCES OF POISONING IN THE LIVING.

A knowledge of these is most important so as to be able to differentiate between cases of illness and poisoning, and if the latter, to administer the proper antidotes. Certain circumstances point to poison being the cause, thus:—

(1) *Suddenness in the Onset of Symptoms.*—The individual may have been in perfect health, or the poison may have been conveyed in medicine if he has been already sick. In cases of suicide or murder a large dose is usually swallowed, and hence the symptoms are well marked. Ordinary illness often commences very suddenly however, as apoplexy, heart failure, or cholera. On the other hand, if small doses of poison are given during a long period the symptoms develop gradually, or if given to a person already sick, the result may be a mere aggravation of the ordinary symptoms (as arsenic given in cases of gastritis). Such cases are difficult to diagnose, and many escape detection until after the death of the patient. Certain articles of food may give rise to acute symptoms of poisoning (ptomaine poisoning). Some poisons cause immediate symptoms (strychnine, prussic acid, oxalic acid), while in the case of others, several hours may elapse (arsenic or

phosphorus). It is a safe rule to follow, that if a healthy person is suddenly seized with violent vomiting and purging, irritant poisoning should be suspected.

(2) *The Symptoms Usually Ensue after Food, Drink, or Medicine* has been taken. If the poison has been present in food then all those who have partaken of it will suffer from similar symptoms; the degree of severity of the symptoms will vary with the amount each has taken. The poison may have been introduced per rectum or per vaginam, and thus will have no relation to food.

(3) Poison may actually be *discovered* in the food, vomit, urine, or medicine.

(4) *Conduct of Suspected Persons.*—The medical man has the best opportunity of watching the behaviour of the attendants. Thus, the suspected person may have kept all relatives away from the patient; may have prepared, and given all the food and medicines; may have bought poisons; may be seen to throw away incriminating articles, *e.g.* bottles, glasses, vomit, fæces; may endeavour to hurry the burial, etc.

EVIDENCES OF POISONING IN THE DEAD BODY.

(1) **The Post-mortem Appearances** after death from certain poisons are characteristic, *e.g.* corrosives, phosphorus, etc. Great skill is necessary, however, not to mistake the appearances due to post-mortem change or to disease for those caused by poisons. The contents of the stomach and bowels must be carefully examined with the naked eye, and by the microscope, as many poisons can be detected by such means.

(2) **Chemical Analysis.**—The excreta may afford proof of the presence of poison during life. After death, however, a careful analysis must be made of the contents of the stomach and bowels, as well as of other tissues of the body. The person may have died from poison, though none may be detected on analysis, all having been rejected by vomiting. Certain organic poisons are very difficult to detect, or they may become split up into other bodies during putrefaction. No poison may be found in the stomach or bowels, or quite a different one may be detected from that which caused death; the true poison may be discovered in the liver, muscles, bones, etc.

(3) **Experiments on Animals.**—Mice or rabbits may be fed on the suspected food, or the poison after isolation may be

given to them. It has to be remembered that solanaceous plants or their alkaloids are not toxic to rodents.

CLASSIFICATION OF POISONS.

No system of classification will fulfil all requirements, but the following grouping allows of a classification according to the *chief* symptoms induced by each poison. Many poisons act in two or more different ways according to the form or strength of solution in which they are taken, and consequently such may appear under more than one heading.

I. Inorganic.

1. Corrosive.
    Strong acids, Alkalies, and Caustic salts (Carbolic and Oxalic acids are included).
2. Irritant.
    Salts of Potassium, Sodium, Barium, etc.
    The metalloids—P, Cl, Br, I.
    Arsenic, Antimony, Mercury, Lead, Copper,
    Tin, Zinc, Silver, Iron, Bismuth, Chromium.

II. Organic.

1. Irritant.
    (*a*) Animal.
        Snake and Insect bites,
        Ptomaines, Cantharides.
    (*b*) Vegetable.
        Aloes, Colocynth, Gamboge, Jalap,
        Castor-oil seeds, Elaterium, Croton oil,
        Hellebores, Savin, Yew, Ergot, Hemlocks,
        Laburnum, Arum, Daphne, Ranunculus,
        Bryony, etc.
2. Neurotic.
    (*a*) Somniferous.
        Opium and its alkaloids.
    (*b*) Deliriant.
        Belladonna, Hyoscyamus, Stramonium,
        Solanum, Cannabis, Cocaine, Cocculus,
        Camphor,
        Poisonous fungi.

(c) Inebriants.
Alcohol, Ether, Chloroform, Chloral, Carbolic acid,
Nitro-benzol, Anilin, Benzene,
Turpentine, Nitro-glycerine.

3. Sedatives or Depressants.
(a) Neural.
Conium, Lobelia, Tobacco,
Physostigma, Curara.
(b) Cerebral.
Hydrocyanic acid, Oil of bitter almonds.
(c) Cardiac.
Aconite, Digitalis, Colchicum,
Veratrum.

4. Excito-motory or Convulsives.
Nux Vomica, Strychnine.

5. Vulnerants.

III. Asphyxiants.
Poisonous and Irrespirable gases.

Group Symptoms and Post-mortem Appearances Pertaining to the Different Classes of Poisons.

1. **Corrosives.**—*Symptoms*: sour, acid, alkaline or metallic taste; burning pain in the mouth, throat, gullet, and abdomen complained of *at once*; vomiting of brown or black material, consisting of altered blood with shreds of detached epithelium and mucous membrane; purging of mucus and blood; eructations of gas; dyspnœa, cough, voice weak, intense thirst; tenesmus, dysuria; pulse rapid and small; collapse; consciousness is usually retained until death, though occasionally delirium or spasmodic twitchings are seen.

Post-mortem Appearances.—All the tissues with which the poison has come in contact are corroded, hardened, or softened; the mucous membrane of the lips, mouth, throat, gullet, stomach, and intestines is reddened, inflamed, hardened, shrivelled, blackened, gangrenous, or separated, leaving raw, bleeding surfaces; the underlying muscular fibres have been so irritated that they have contracted, and caused corrugation of the mucous membrane. In the œsophagus this is usually so marked that the mucous lining is thrown into folds, and a

worm-eaten appearance results from the corrosion of the free edges of these folds.

2. **Irritants** (inorganic and organic).—*Symptoms*: burning pain and feeling of constriction in the throat and œsophagus; severe pain in the stomach, intense thirst; vomiting of food, bile, and later altered blood; purging, tenesmus; pain and tenderness over the abdomen; dysuria; dyspnœa, hoarseness, cramps, collapse or fever if the person survives for some time. Death may take place at once from shock.

Differential Diagnosis.—Certain diseases may simulate poisoning by irritants, *e.g.* acute gastritis, acute gastro-intestinal catarrh, cholera, appendicitis, peritonitis, rupture of abdominal organs, renal colic, etc.

Post-mortem Appearances.—The mucous lining of the throat, gullet, stomach, and intestines is red, inflamed, and congested; it may be hard and shrivelled, and in rare cases it may be black, ulcerated, and even gangrenous in patches. It is usually covered with a tenacious glairy mucus; the mucous and submucous coats are thickened.

3. **Neurotic Poisons.**—(*a*) *Narcotic Poisons* chiefly affect the brain (opium). *Symptoms*: giddiness, dimness of vision, headache, contraction of the pupils, confusion of thought; drowsiness, insensibility, coma, and occasionally convulsions.

Differential Diagnosis is to be made from apoplexy, injuries to the brain, uræmic or diabetic coma.

Post-mortem Appearances.—Death takes place usually from failure of respiration; the appearances of death from asphyxia are consequently present.

(*b*) *Deliriant Poisons.*—*Symptoms*: active delirium; illusions of sight or disturbances of hearing; dilatation of the pupil; dryness of the mouth and throat, redness of the skin, coma.

Post-mortem Appearances are not characteristic; examine contents of stomach and intestines for leaves, berries, roots, etc.

(*c*) *Inebriant Poisons* produce great excitation of brain, circulation, and respiration; loss of co-ordination, staggering gait, and double vision; mania may follow, and later sleep, insensibility, and coma. The post-mortem examination reveals little.

4. **Depressants.**—(*a*) *Neural Poisons* act chiefly by paralysing the spinal cord.

(*b*) *Cerebral Poisons* act by inhibiting the functions of the brain.

(*c*) *Cardiac Depressants* may kill by producing sudden shock, or by the syncope or collapse which they give rise to.

5. **Excito-motory Poisons** produce twitchings of the muscles, and finally convulsions.

Period of Survival after Taking a Fatal Dose.—A medical witness may be asked to state the usual period of time which elapses between taking the poison and death. This varies with different poisons, and with their state: thus, liquids act more rapidly than solids; on the condition of the stomach (empty or full), or whether the person is healthy or diseased. At best, therefore, only an approximate idea can be given. Thus, a large dose of prussic acid kills at once, while, with a small yet fatal dose, death may be delayed for fifteen minutes. Half an ounce of oxalic acid swallowed in powder may be recovered from, while if dissolved, it usually kills in from fifteen to thirty minutes.

Chronic Poisoning results from the absorption of small doses during a prolonged period. The evil effects of drugs may be seen in ordinary medical practice where patients may poison themselves by continuing for too long a period such drugs as arsenic, digitalis, etc. The patient's strength gradually declines, and such are frequently mistaken for cases of ordinary chronic disease, and may end fatally before suspicion has been aroused. The amount of poison recoverable from the dead body in cases of chronic poisoning may be so small that doubt may be cast on the medical or expert evidence as to its being the cause of death. It must be remembered that the poison has acted for long on the tissues, and has interfered with their normal functions or has caused their gradual destruction.

Feigned Poisoning.—In order to bring a charge against some one with whom he has a grudge, an individual may feign that he has been poisoned, and to substantiate this he may place poison in his own food or vomit. The symptoms complained of are seldom referable to any one poison, and none may be detected in the urine or fæces.

Notification of Cases of Poisoning.—It is the duty of the medical attendant to notify to the Chief Inspector of Factories all cases of industrial poisoning which come under his observation (Factory and Workshops Act 1895, sect. xxix.). For each case so notified the fee of 2s. 6d. is paid. The obligation is compulsory, and is done in the interests of the work-people. Every case of poisoning by lead, mercury, arsenic, etc., in manufactories, smelting works, etc., must be so notified.

Duty of a Medical Practitioner in Cases of Suspected Poisoning.—He should not give any verbal or written opinion as to his suspicions unless he is certain that they are true, otherwise an action for damages may be brought against him. A thorough examination of the case and a chemical analysis of the excreta should be made. If possible the patient should be removed to an hospital, where he will be away from the attention of his friends. The hospital physician should be told of the suspicions. If the patient be well-to-do, a consultation with one or two brother-practitioners should be held; a day and a night nurse should be installed, and they must be instructed to prepare all the food, and see it taken, as well as administer all medicine, which they must also keep in their possession. If the case is undoubtedly one of criminal poisoning, the practitioner should act at once in the above manner else the person may die. In certain cases it is expedient to tell the patient of the suspicions so that he may help in his own treatment. The Criminal Authorities should then be informed, and they will take further action. The patient may die in spite of treatment; if so, all suspected articles (bottles, cups, glasses, etc.) must be taken charge of by the medical attendant and handed over to the Criminal Authorities, who should be at once apprised of the event. If the patient dies under suspicious circumstances, the practitioner who has been in attendance may refuse to grant a certificate of death, and may refer the case to the Procurator Fiscal, or Coroner.

Procedure in Cases of Poisoning.—A medical man should go at once to any case of poisoning, having first inquired what the nature of the poison is, so as to take the appropriate remedies; if this be not known, the emergency and antidote case should be taken. On arrival, he should note the condition of the patient and his surroundings, and allow nothing to be thrown away or emptied out, but lock all up and attend to the sufferer. Treatment should be commenced at once, and continued although the case may appear hopeless. If it is likely that treatment will be prolonged, the services of another practitioner should be obtained. As soon as opportunity presents, notes of the case should be made, *e.g.* the time when the symptoms commenced; their order and relation to food, drink, or medicine; if there were remissions; if the patient had suffered from similar symptoms on previous occasions; what was the nature of the food taken; if need be, the vessels in

which the food had been cooked should be inspected, described, or preserved.

Treatment in Cases of Poisoning.—1. *Empty the Stomach* by using the syphon elastic tube or by emetics. The tube may be used to wash out the stomach as well as to administer antidotes. In the absence of true emetics, mustard or common salt may be employed (one tablespoonful of either in a tumblerful of warm water). The bowels should also be emptied by means of purgatives.

2. *Antidotes* may then be given to neutralise such of the poison as still remains. These may act (*a*) chemically, forming more or less insoluble compounds or harmless salts, *e.g.* lime in oxalic acid poisoning, sodium sulphate in lead poisoning, etc. (*b*) Physiological antidotes or antagonists. These are never complete in their action, but in practice may act well; thus, in morphine poisoning, atropine is employed; in strychnine poisoning, chloral hydrate, etc.

Multiple Antidotes.—Many formulæ have been devised for the purpose of neutralising unknown poisons, or where a mixture of poisonous drugs had been swallowed. The following is an example:—

Powdered charcoal .	2 parts	*Mix.*—The dose is a large teaspoonful in a tumblerful of water frequently repeated.
Tannic acid . .	1 part	
Magnesia . . .	1 ,,	

The charcoal acts physically by absorbing alkaloids; tannic acid precipitates many of the metals and alkaloids; magnesia neutralises acids, and hinders the absorption of arsenic.

3. *Demulcents* or soothing agents are necessary where the poison has corroded or inflamed the gastro-intestinal mucous membrane, *e.g.* oils, starch and water, white of an egg, milk, etc.

4. *Stimulants* (brandy, ether, sal volatile) may be necessary where the heart's action is greatly depressed, or in cases of collapse.

5. *Saline Infusions* may be required in conditions of great collapse; 1 drachm of sodium chloride dissolved in a quart of boiling water may (when cool) be injected intravenously, subcutaneously into the submammary tissues, or into the rectum.

6. *Elimination* of the poison may be furthered by purgatives, sudorifics, and diuretics.

7. *Pain* may be relieved by hypodermic injections of morphine.

The Antidote and Emergency Case.

Every medical man should provide himself with a case or bag containing those appliances and drugs which are necessary in cases of accident, sudden illness, or poisoning. When called to an emergency case, it is a comfort to know that all that may be required is ready prepared for instant use.

Contents of the Antidote Case.—*Instruments.*—Stomach tube with funnel, hypodermic syringe, two bistouries, transfusion apparatus, tracheotomy tube, artery forceps (three pairs), catgut in reel, horsehair, needles, catheter.

Dressings.—Compressed aseptic dressings, bandages, disinfecting powder, adhesive plaster.

Emetics put up in measured doses or as compressed tablets. Ipecacuanha powder, 30-grain doses; sulphate of zinc, 30-grain doses; sulphate of copper, 10-grain doses. These are given in half a tumblerful of warm water.

Sedatives.—Chloral, 30-grain doses; opium, $\frac{1}{2}$ a grain; potassium bromide, 2 drachms; chloroform by inhalation.

Stimulants.—Spiritus Ammoniæ Aromaticus, dose ♏ 30 to 60; Liquor Ammoniæ Fortis (for inhalation or for preparing ferric hydrate).

Antidotes.—Glacial acetic acid; adrenalin solution. Liquor ferri perchloridi, to be used as a local hæmostatic or for the production of ferric oxide in poisoning by arsenic. Heavy magnesia for neutralising acids. Magnesium sulphate in doses of 2 drachms for cases of poisoning by lead or barium. Nitrite of amyl capsules (♏ ii.) for hæmoptysis, or in aconite or chloroform poisoning. Nitro-glycerine tablets, $\frac{1}{100}$ of a grain. Potassium permanganate in 2-grain doses. Sodium bicarbonate in 10-grain doses. Tannic acid in doses of 1 drachm, used in poisoning by alkaloids. Turpentine (old or French), dose ♏ xxx., used in phosphorus poisoning. Oil of eucalyptus, used for strychnine poisoning in doses of ♏ ii.

Hypodermic Remedies.—Apomorphine hydrochloride, $\frac{1}{10}$ of a grain, as emetic. Atropine sulphate, $\frac{1}{100}$ of a grain (for aconite, morphine, pilocarpine, fungi poisoning, etc.). Cocaine hydrochloride, $\frac{1}{6}$ of a grain. Digitalin, $\frac{1}{100}$ of a grain, for aconite poisoning. Ergotinine citrate, $\frac{1}{100}$ of a grain; morphine sulphate, $\frac{1}{3}$ of a grain (for belladonna poisoning or to relieve pain). Pilocarpine nitrate, $\frac{1}{3}$ of a grain (for belladonna poisoning). Strychnine sulphate, $\frac{1}{60}$ of a grain.

Accessories.—Sterile concentrated saline solution or compressed tablets for injection. Antiseptics (lysol, izal, etc.). Flexible collodion.

DIFFERENTIAL DIAGNOSIS OF CASES OF POISONING FROM DISEASED CONDITIONS.

	Poison.	*Disease.*
1. Coma.	Opium, morphine, chloral, alcohol, camphor, chloroform.	Apoplexy, brain injury, uræmia, diabetes, epilepsy, fever.
2. Collapse.	Corrosives ; arsenic, antimony ; aconite, tobacco, lobelia, antipyrine, exalgin, etc.	Diphtheria, cholera, fevers.
3. Delirium.	Belladonna, hyoscyamus, cannabis, alcohol, camphor.	Pneumonia, phthisis, meningitis, fevers ; acute mania.
4. Paralysis.	Conium, aconite, gelsemium, physostigmine ; arsenic, lead.	Injury to cord or brain, apoplexy, hysteria.
5. Convulsions.	Nux vomica, arsenic, antimony.	Tetanus, hysteria.
6. Cyanosis.	Anilin, antifebrin, exalgin.	Valvular heart diseases.
7. Pupil dilated.	Atropine, hyoscyamus, aconite, alcohol, chloroform, conium.	Paralysis of 3rd nerve. Irritation of sympathetic.
8. Pupil contracted.	Opium, eserine, chloral.	Irritation of 3rd nerve. Paralysis of sympathetic.
9. Skin dry.	Belladonna, hyoscyamus.	Fevers ; pneumonia.
10. Skin moist.	Opium, aconite, antimony, tobacco, lobelia, alcohol.	Acute rheumatism.
11. Vomiting.	Corrosive and irritant poisons generally.	Gastric ulcer, acute gastritis, etc.
12. Purgation.	Irritant poisons, digitalis, colchicum.	Dysentery, cholera, typhoid, tubercle.
13. Colic.	Lead, copper, arsenic.	Volvulus, obstruction.
14. Cramp.	Lead, arsenic, antimony.	Cholera, diarrhœa.

Post-mortem Examination in Cases of Poisoning.—Have ready several perfectly clean large glass jars with accurately fitting lids, string, parchment paper, and labels. Having opened the abdomen, note the position and condition of the viscera. Ligature the lower end of the œsophagus and the pylorus, and having separated the stomach, place it in a jar. Remove the whole of the intestines after ligaturing each extremity, and place them in another jar. Remove and preserve the gullet and tongue, part of the liver, kidneys, spleen,

muscle, bone, brain, and blood. These should be placed in separate jars, sealed and delivered by the examiner to the analyst who is to make the analysis, and who will give a receipt for them. Before being sealed up, the stomach and intestines may be opened, and their contents examined. Certain poisons (as prussic acid) give off a very distinct odour. Note the condition of the mucous membrane, and whether corroded or inflamed, or whether there are evidences of the presence of poisons (seeds, leaves, berries, white powders, coloured deposits). Be careful not to mistake post-mortem changes for signs of poisoning. Thus, lividity of the posterior wall of the stomach has been mistaken for inflammation, and post-mortem digestion or ulcer of the stomach for the corrosive action of acids, etc. Make the autopsy very complete so as to eliminate any chance of the person having died from natural disease.

Chemical Analysis for the Detection of Poisons.—In most cases the detection of poisons when mixed with organic matter in the stomach or bowels is a very difficult matter, and reliance could only be placed on an analysis made by a skilled chemist. However, in the ordinary treatment of a patient it may be necessary to examine the vomit, urine, or fæces for the presence of a poison, and hence the practitioner ought to be able to apply simple tests for its detection. At any rate, he ought to have a general knowledge of the methods of toxicological research.

1. *Naked Eye Examination.*—A careful scrutiny should be made of the contents of the stomach and bowels, as well as of their mucous lining, for the presence of poisons.

2. *Microscopical Examination* may reveal characteristic crystals, seeds, fragments of glass, etc.

3. *Chemical Analysis.*—The investigator has usually obtained an indication of what poison to search for, and this may simplify the proceeding. The contents of the stomach or bowels is diluted with water, or the liver or other organ is finely chopped up, and macerated in water. The mixtures are divided into three portions.

(*a*) *Volatile Poisons.*—One part is acidified with tartaric acid and heated in a retort. The vapours are condensed and collected. The poisons which distil over by such a process are carbolic acid, bromine, iodine, phosphorus, chloroform, chloral, hydrocyanic acid, benzene, nitro-benzene, alcohol, ether, anilin (note if phosphorescence be present). If the remainder in the retort be made alkaline by the addition of magnesia, and

distillation be continued, then ammonia, conine, nicotine, and volatile bases come over.

(*b*) *Mineral Poisons.*—The residue in the flask may contain mineral poisons. The organic matter in this residue may be oxidised, and destroyed by heating carefully with nitric and sulphuric acids. Appropriate tests will then detect any mineral poisons.

If to the second portion of the mixture one-third of its volume of hydrochloric acid be added, and it be heated carefully with potassium chlorate, the organic matter becomes oxidised. The residue on a filter may include silver, lead, barium, or strontium, while the filtrate may contain any of the other metals.

(*c*) *Stas-Otto Process for the Separation of Alkaloids.*—The process depends on the fact that all alkaloids are practically insoluble in water but are soluble in ether, while the salts of the alkaloids are soluble in water but are insoluble in ether. Taking advantage of these properties, the alkaloids can be separated from organic matters with which they may be mixed. The third part of the original mixture is twice digested by the aid of heat in a flask with rectified spirit, and subsequently for several times with spirit acidulated with acetic or tartaric acids, so as to obtain the freely soluble salt of the alkaloid. These filtrates are evaporated to the consistence of a syrup, when absolute alcohol is added to precipitate the albumins and fat, which are then filtered off. This process is repeated until a pale clear fluid is obtained, which is evaporated until it is nearly dry. It is redissolved in a little water, and shaken up with ether, which removes glucosides, colouring matter, etc., and this ethereal solution is then separated. Caustic soda is now added until the watery solution is alkaline, when the alkaloids are precipitated, being insoluble in water. Ether is again added, and on shaking, the alkaloids pass into solution in the ether, and by the use of a "separating funnel" can be isolated. On evaporating off the ether the alkaloid is left, and can be recognised by appropriate tests. Ptomaines are separated by the same process.

(*d*) *Dragendorff's Process for the Separation of Alkaloids, Glucosides, and Vegetable Principles.*—The semi-liquid mixture is digested with dilute sulphuric acid at 40° to 50° C. for several hours. It is filtered and evaporated to a syrup, and then heated for many hours with alcohol, which is subsequently

distilled off. This acid watery residue is shaken up with solvents in the following order. (1) Petroleum ether, which dissolves out carbolic and picric acids, aconitine, etc. The ether is allowed to separate, and on evaporation the foregoing may be found. (2) Then with benzene, which dissolves out cantharidin, digitalin, colchicine, santonin. (3) Then with chloroform, for papaverine, picrotoxin, etc. The watery solution is then rendered alkaline with ammonia, and the same processes are repeated.

(1) Ether gives strychnine, brucine, conine, nicotine, etc.

(2) Benzene gives strychnine, atropine, veratrine, aconitine, quinine, etc.

(3) Chloroform gives narceine, etc.

(4) Amyl alcohol yields morphine.

(5) Evaporate the residue to dryness; chloroform will then extract curarine.

General Reactions for Alkaloids.—(1) Iodine dissolved in a solution of potassium iodide (Wagner's reagent) yields a reddish-brown precipitate.

(2) Mayer's reagent (potassio-mercuric iodide) gives a yellowish-white precipitate.

(3) Phospho-molybdic acid gives a yellow precipitate.

(4) Platinic chloride, an abundant brown precipitate.

(5) Tannin, picric acid, or mercuric chloride all precipitate alkaloids.

Character of the Vomit.—The colour of the vomit may in certain cases help towards a diagnosis of the poison which has been taken. Thus, it may be more or less:—

Blue in colour from copper sulphate, arsenic (when mixed with indigo), phosphorus (when mixed with fat and indigo in "Rat paste"), iodine (if there has been starchy food in the stomach).

Green in poisoning by carbonate or arsenite of copper; digitalis gives rise to a grass-green vomit.

Black in poisoning by the corrosive acids (chiefly sulphuric acid), arsenic (when mixed with soot); the vomit induced by nitrate of silver becomes dark on exposure to light.

Yellow in poisoning by iodine, chrome salts, gamboge.

Bloody Vomit results from the action of the corrosives, irritants, or from gastric ulcer.

CHAPTER II.

POISONING BY THE CORROSIVES.

THE strong mineral acids and alkalies owe their deadly properties chiefly to the intense local action which they exert on the tissues with which they come in contact. They are usually swallowed accidentally, and in mistake for some innocuous fluid or medicine, or may be taken with suicidal intent. Their chief property lies in the charring of organic matter which they bring about. Articles of clothing are consequently discoloured or actually destroyed. Death usually takes place at an early period from shock, perforation of the stomach or bowels, œdema glottidis, or later from exhaustion due to inflammation of the stomach and bowels, with inability to retain or digest food. Stricture of the œsophagus may follow the destruction of the tissues, and gradual starvation may cause death. The widespread destruction of the glandular structures of the stomach and bowels may lead to faulty digestion and marasmus, death not taking place for weeks or months subsequently. If the immediate effects be recovered from, feverish symptoms develop, vomiting and diarrhœa continue, and shreds or patches of mucous membrane are passed. The strong acids are also employed criminally as disfiguring agents when thrown into the eyes or face.

SULPHURIC ACID (VITRIOL, OIL OF VITRIOL, ESSENCE OF VITRIOL), H_2SO_4.

This acid is employed in various trade processes, and so may be taken suicidally by workmen. It has been mistaken for castor oil, syrup, or glycerine, and has been injected into the rectum as an enema, and into the vagina as an abortifacient.

Properties.—The strong acid is a colourless, heavy, oily liquid which emits no fumes; it evolves much heat on the addition of water, and chars organic matter.

Symptoms.—The symptoms are those common to corrosives; where the acid has come in contact with the skin, as at the angles of the lips, dark brown stains are produced; the mucous membrane of the mouth is whitened as if it had been smeared with paint. The vomit is dark from the action of the acid on the blood, and contains shreds of blackened mucous membrane. When thrown on the face, lasting scars result unless the acid is washed off at once, and permanent opacities may be left in the cornea.

Fatal Dose varies from 1 drachm to 4 ounces, depending on the fulness of the stomach.

Fatal Period.—Death usually takes place in from eighteen to twenty-four hours, but it may take place within an hour either from shock or from œdema glottidis.

Post-mortem Appearances.—The epithelial surfaces with which the acid has come in contact are dark brown or black in colour, upon which are scattered small white patches. The mucous lining of the stomach is thrown into folds through the contraction of its muscular coats; the summits of these folds are charred, while the furrows are red and inflamed; the contents are brown or black, and grumous. Perforation is rare. If the person survive, ulcers form at various points, and may lead to contraction of the œsophagus, while the stomach walls become thickened, and denuded of their mucous coat.

Tests.—(1) The strong acid chars wood, while dilute acid chars blotting-paper. (2) The addition of a solution of barium nitrate causes the precipitation of white barium sulphate which is insoluble in hydrochloric acid. (3) If heated with copper filings, sulphurous acid gas is evolved. (4) Wormley's test consists in boiling the suspected acid with a little veratrine. If this be evaporated by heat on a porcelain dish a crimson deposit is obtained.

Stains on Clothing are reddish-brown in colour, and always feel damp; the cloth is charred and falls to pieces. If soaked in alcohol, a solution is obtained, and tests may be applied. Stains on wood remain damp for weeks.

Treatment.—(1) Neutralise the acid by giving finely-powdered chalk in water (whiting, camphorated tooth powder), magnesia, soap and water. Washing soda or bicarbonate of

soda may be given, but they produce great distress from the evolution of carbonic acid gas. Plain water may be used merely to dilute the acid. (2) Soothing agents (demulcents) should follow to protect the mucous membranes, *e.g.* white of an egg, oil, starch and water, thin gruel, milk. (3) Morphine injections may be required to ease the pain, and tracheotomy if œdema glottidis threatens. The stomach tube must never be used in poisoning by the corrosives.

NITRIC ACID (AQUA FORTIS, SPIRITS OF NITRE), HNO_3.

This is used as a solvent for tin in the manufacture of mordants for dyeing, and by hatters; engravers use it for etching copper. In water gilding and in the manufacture of nitro-compounds (nitro-cellulose, picric acid, etc.) it finds a place.

Properties.—It is a colourless, fuming, heavy liquid with a penetrating odour. When old it becomes yellow from the formation of oxides (=nitroso-nitric acid). It readily oxidises organic matter.

Symptoms.—The usual symptoms are present; the blood in the vomit is yellowish-brown, and the shreds of mucous membrane are yellow; the lining of the mouth is softened, and white, brown, or yellow in colour. The acid produces great evolution of gas in the stomach with resulting pain. Dyspnœa is due to inhalation of the fumes.

Fatal Dose varies from 2 to 4 drachms.

Fatal Period is usually twenty-four hours.

Post-mortem Appearances.—The mucous membranes are rendered yellow by the acid, or greenish if bile has been present. They are also hardened and thickened; perforation or ulceration may be present. Yellow stains are left on the skin.

Tests.—(1) The strong acid emits white fumes, and oxidises wool to a yellow colour. (2) If a crystal of ferrous sulphate be dissolved in this acid, a brown ring is formed at the junction when strong sulphuric acid is poured below it. (3) With brucine a blood-red colour is produced, and a rich orange with morphine. (4) Copper filings dissolve in it, and form a green liquid with the evolution of nitric oxide, which appears as a brown gas from its union with oxygen (NO_2).

Stains on Clothing are yellow or orange red in colour. On

the addition of a few drops of a solution of caustic potash the stain becomes orange if due to nitric acid; it disappears if caused by iodine, and no change results if it has been a bile stain.

Treatment is the same as for sulphuric acid.

Poisoning by the Fumes of Nitric Acid.—Such accidents may occur in chemical works, in wiping up the spilled acid, in water gilding, etc. If the fumes (chiefly N_2O_2 and N_2O_4) be inhaled for some hours, death may follow, the symptoms being irritation of the eyes, cough, burning in throat, nausea, vomiting, pain over stomach with distension, dysuria, delirium, and death.

The Post-mortem Examination shows congestion of the mucous membrane of the lungs and intestinal tract.

HYDROCHLORIC ACID (MURIATIC ACID, SPIRITS OF SALT), HCl.

This is used frequently as a suicidal agent.

Properties.—The strong acid is almost colourless when fresh, but becomes yellow with age; it emits fumes, and often contains arsenic as an impurity. On dark fabrics it gives rise to reddish-brown stains.

Symptoms of corrosive poisoning are present; the tongue is dry, and covered with a white coating.

Fatal Dose.—A drachm has caused death.

Fatal Period.—Death usually occurs within twenty-four hours.

Post-mortem Appearances.—The mucous membrane of the mouth, tongue, and throat is white, dry, and shrivelled; that of the gullet is much corrugated and worm-eaten in appearance; the lining of the stomach is yellowish or greenish in colour, and much inflamed. Ulceration or patches of gangrene may be present if the patient has survived for some time.

Tests.—(1) The addition of solution of nitrate of silver produces a white precipitate, insoluble in excess or in nitric acid, but redissolved on adding ammonia. (2) Copious white fumes are produced on bringing ammonia near the acid. If present in the vomit, it may be recovered by distillation. Small amounts are normally present in the gastric secretion (0·2 per cent).

Treatment as in the preceding.

ACETIC ACID, $C_2H_4O_2$.

This forms the basis of Coutts' acid cure. The ordinary symptoms are present, but great irritation of the nose, eyes, and respiratory mucous membrane results from its volatilisation. It is readily detected by its smell, or the characteristic odour of acetic ether may be obtained by heating it with alcohol and a few drops of sulphuric acid.

OXALIC ACID, $H_2C_2O_4 \cdot 2H_2O$ (*an organic acid*).

Oxalic Acid or Acid of Sugar closely resembles the acicular crystals of magnesium or zinc sulphate, and has thus been swallowed accidentally in mistake for a saline aperient. It is well known as a powerful poison, and being easily purchased is often used by suicides. It is employed to clean metals, as it dissolves their oxides; it is used by dyers, leather and brass workers, and bonnet makers; it dissolves indigo, and is used in the production of laundry blue; it removes iron rust stains, and is, therefore, employed by washerwomen.

Symptoms depend upon its (1) local caustic action when in large amount and concentrated, and (2) on its remote effects on the nervous system either as a convulsive or as a narcotic. An intensely sour taste is experienced; the throat feels tight; the vomit is dark-coloured and bloody; the thirst is intense; the mouth is white and painful, and pain over the stomach and abdomen is extreme; diarrhœa is not present as an early symptom. The pulse becomes rapid, irregular, and feeble; respiration is shallow and frequent. Cramps and convulsions may be present; the chief symptom is collapse, passing into coma and death. If the dose be smaller, nervous phenomena (convulsions, twitchings, etc.) are more often observed. If the history of the case is that the person swallowed a crystalline salt which had an acid taste, that he had a bloody vomit, an imperceptible pulse, and died within half an hour, a diagnosis of poisoning by oxalic acid may safely be made (Christison).

Fatal Dose.—One drachm has caused death.

Fatal Period.—A large dose usually produces death within an hour; almost instant death may result, however. In other cases the patient may survive many days.

Post-mortem Appearances.—When the acid has been taken in strong solution the mucous membrane of the mouth, throat,

and œsophagus is whitened and shrivelled; the worm-eaten appearance of the corrugated membrane is well seen in the gullet. The contents of the stomach are snuff-coloured or green, while the mucous membrane is either whitened, greatly inflamed, or almost black, and the peritoneal covering is usually congested.

Tests.	*Oxalic Acid.*	*Magnesium Sulphate.*	*Zinc Sulphate.*
Taste.	sour.	bitter, nauseous.	bitter, metallic.
Reaction.	very acid.	neutral.	slightly acid.
Heated.	disappears.	no change.	no change.
Sodium carbonate added.	effervesces.	white ppt.	white ppt.
Tannate of iron.	bleaches.	no change.	no change.

Treatment.—Endeavour to form an insoluble oxalate by giving lime water, chalk and water, whiting, magnesia, or even copious draughts of plain water. Ordinary alkalies, as soda or potash, are useless. Then apply the usual remedies.

Binoxalate of Potash, Salts of Sorrel, Essential Salts of Lemons, $KHC_2O_4 . H_2O$, is used for the same purpose as oxalic acid, and gives rise to similar symptoms and post-mortem appearances.

Fatal Dose may be $\frac{1}{2}$ an ounce, and this has caused death in eight minutes. It is much more soluble than the acid. When heated on platinum foil it leaves a white residue of carbonate of potash.

Tartaric Acid, $C_4H_6O_6$, is only poisonous in massive doses.

CARBOLIC ACID (PHENOL), C_6H_5OH.

This poison is the one most frequently employed for suicidal purposes. In a crude form it is largely used as a disinfectant, and is thus easily purchasable. Accidental poisoning often results from swallowing carbolic lotions. Intrauterine douches have caused poisonous symptoms, and fatal results have followed the application of carbolic dressings owing to absorption of the poison. All preparations which contain more than 10 per cent of carbolic acid are included in the Poison Schedule, and must be sold with the same precautions as other poisons.

The Local Action of carbolic acid produces (1) anæsthesia and (2) necrosis. In surgical practice it is by no means infrequent

to find that a carbolic dressing has caused a deep necrosis of the underlying tissues, and in the case of the digits, amputation is sometimes required. This is more apt to happen if evaporation has been prevented by the application of indiarubber tissue.

Symptoms.—(1) When swallowed, the strong acid acts locally as a corrosive, causing the mucous membrane of the lips, mouth, throat, and stomach to become hard and white. An intense burning pain is complained of, and the individual soon passes into a condition of shock, the skin being cold and clammy, the pupils contracted, the urine suppressed or dark in colour, the breathing stertorous; the lips, ears, and eyelids are very livid; insensibility passes into coma and death. (2) When the poison has been absorbed through the skin or mucous membranes it acts as a depressant; headache and dizziness are the first symptoms; a mild form of delirium ensues, with great weakness, and livid blueness of the skin; the pulse is feeble; vomiting and unconsciousness then follow, with subnormal temperature, and contraction of the pupils. The urine may be green in colour, and this may give warning of toxic effects in the surgical use of carbolic acid.

Fatal Dose.—One drachm swallowed or injected into the uterus as a douche has caused death. Creolin, lysol, izal, etc., are poisonous when taken in excess.

Fatal Period.—Death usually takes place within six hours, though in some cases it may occur within three minutes.

Post-mortem Appearances.—When the strong acid has been swallowed, the mucous membranes with which it has come in contact are hardened, corrugated, and whitened, with the superficial layers detached, and numerous small submucous hæmorrhages are present. These conditions are very well marked in the stomach, where the tops of the rugæ are white, and the intervening folds intensely red. The blood remains fluid, the meninges and the cerebral substance itself are congested, and the odour of the poison is very marked on opening the cavities.

Tests.—The acid may be obtained from the vomit by distillation after acidification with sulphuric acid. If a trace of ferric chloride be added, a violet blue colour is produced if phenol be present. If the solution be heated with a little ammonia and a piece of chloride of lime, the latter becomes blue in colour. The addition of bromine water gives rise to

the production of tribromophenol—a whitish or yellowish-white precipitate.

Treatment.—The stomach should be washed out with a solution of magnesium sulphate, or this salt may be given in doses of ½ an ounce, with the object of forming the harmless sulpho-carbolate. Dilute alcohol inhibits the local action of phenol, and is useful if it be given soon after the poison has been swallowed; it must, however, be removed immediately. The stomach tube should be used with care. Saccharated solution of lime is useful; demulcents and stimulants are also to be employed.

Creosote acts much in the same way as carbolic acid. Its powerful odour forms the best test for its presence.

Lysol is a disinfectant solution containing 50 per cent of cresol in soap solution. It has not nearly so strong a local action as carbolic acid, and acts mainly as a heart and nerve poison.

Chloride of Antimony, Nitrate of Silver, Chromic Acid, Chloride of Zinc, and some other salts exert a local corrosive action when in strong solution.

CORROSIVE ALKALIES.

The Alkalies, their Hydrates and Carbonates act as corrosives by virtue of their dehydrating and saponifying action on the tissues.

Caustic Potash and Caustic Soda are usually met with as sticks which are soapy to the touch, very deliquescent, and evolve much heat on being moistened.

Carbonate of Potash (*Syn.* Potash, Pearl-ash).

Carbonate of Soda (*Syn.* Washing Soda. "Concentrated lye" is a mixture of this and caustic soda, and is used in laundry work).

Symptoms which the above give rise to are those common to the group, but the taste is acrid and soapy. The mucous membranes are whitened, softened, and shed off; the vomit is often frothy and brown in colour. Death may take place long afterwards from stricture of the œsophagus.

Fatal Dose.—Forty grains is the least dose which has caused death.

Fatal Period.—The patient usually succumbs within the first day.

Post-mortem Appearances.—The mucous membranes affected are softened, whitened, and often exfoliated. This is chiefly seen in the gullet, while the stomach may be almost dissolved.

Tests.—The strongly alkaline reaction, and the colour (violet or yellow) produced in a bunsen burner indicate the poison. Stains on dark clothes are red or brown.

Ammonia (Hartshorn), Liquor Ammoniæ Fortis, Spirits of Hartshorn, (NH_4OH), **and Carbonate of Ammonia** ($(NH_4)_2CO_3$. —Ammonia in solution is largely employed for domestic purposes, *e.g.* washing clothes, paint, etc. (Scrubb's Cloudy Ammonia has caused several deaths.) Fatal accidents have happened from swallowing the strong liquor or liniment in mistake for sal volatile.

Properties.—The pungent odour of ammonia is well known.

Symptoms are manifest immediately on swallowing the liquid. The person is in great distress, and feels as if about to be suffocated, the face is flushed and puffy, the eyes red, injected, and watering; the nose running, with constant sneezing; dyspnœa, aphonia, cough, and profuse salivation are present. These are due to the irritation produced by the volatilisation of the gas. The lips and tongue are swollen, red, and glazed; the vomit is bloody, and the salivary glands are swollen and tender. The other usual symptoms are present.

Fatal Dose and Period.—One drachm of the liquor fortis has proved fatal, and this within a few minutes. Usually several hours elapse before death takes place.

Post-mortem Appearances.—The local action is that of saponification; the mucous membranes affected are softened, whitened, and often shed in patches, leaving raw surfaces behind; the blood remains fluid, and dark in colour.

Tests.—(1) The odour is characteristic, and is rendered more evident by distillation. (2) White fumes of ammonium chloride are formed on hydrochloric acid being brought near. (3) The blood is dark red or black in colour, owing to the production of alkaline hæmatin.

Treatment of all Cases of Poisoning by Alkalies.—Neutralise by giving dilute acids (acetic acid or vinegar, the juice of lemons or oranges), and subsequently the usual remedies.

The Vapour of Ammonia may cause death. Ammonia gas is employed in the artificial manufacture of ice; when condensed, it is led in pipes throughout the building. If these

burst, large volumes of this gas escape, and may result fatally to the workers in refrigeratories, etc.

Symptoms.—Death may take place at once from suffocation (œdema glottidis), or it may be delayed for two or three days, the individual dying from broncho-pneumonia.

CHAPTER III.

INORGANIC IRRITANT POISONS.

PHOSPHORUS.

Yellow phosphorus is found moulded in sticks, and preserved from oxidation in water. It is soluble in oils, fats, alcohol, ether, chloroform, etc. It fumes on exposure to air, forming phosphoric and phosphorous acids, and giving off its characteristic odour. In the dark it is luminous, and ignites at a very slight elevation of temperature. It is very poisonous. By heating yellow phosphorus at 240° F. in an atmosphere of carbonic acid it becomes reddish-crimson and amorphous, and in such a condition it is not poisonous. Phosphorus is used for the destruction of rats and other vermin when mixed in amounts of 1 to 2 per cent with flour, sugar, lard, etc., and coloured with indigo ("Rat paste"). In lucifer match heads it is incorporated with potassium nitrate or chlorate, and with gum, sugar, and sulphur. Phosphorus poisoning is usually suicidal, though children are occasionally poisoned by sucking the heads of matches, and cases of industrial poisoning by this agent are not uncommon.

Symptoms.—The earliest symptoms are a garlicky taste in the mouth, and pain in the throat and stomach. These may come on within half an hour, or, on the other hand, may not be complained of until the lapse of six or seven hours. The odour of phosphorus is well marked in the breath. Thirst is very intense, and the vomit is luminous and bilious or brown in colour. Purging is constantly present. On the second day the vomiting ceases, but later, jaundice becomes well marked, and urticarial rashes may be noted. The liver is enlarged and painful; vague pains are complained of, and the heart's action

is feeble. The urine becomes very scanty and albuminous; insomnia is the rule; prostration is great; delirium or coma with convulsions may precede death, which usually occurs within fourteen days. Sudden failure of the heart may be the cause of death. If recovery takes place, convalescence is very slow. Hæmorrhages are usually present in cases of poisoning by phosphorus, and in some cases they are a very marked feature, leading to profound anæmia. Blood may be present in the vomit, fæces, or urine. Epistaxis or metrorrhagia may develop. Extensive subcutaneous or small petechial hæmorrhages may be present. This loss of blood may lead to the death of the patient in from two to eight months. It may, however, be the nervous system which is chiefly affected by the poison, hence along with the ordinary phenomena of an irritant, cramps, formication, tremors, convulsions, drowsiness, paralysis, or acute delirium may be observed. These symptoms are chiefly seen in those poisoned by inhaling the fumes.

Fatal Dose.—Lumps of yellow phosphorus may be swallowed, and produce no ill effects, as they remain unoxidised. The more finely divided the phosphorus is, the more lethal its action. Less than 1 grain has caused death. A child died from sucking two match-heads or certainly not more than $\frac{1}{50}$ of a grain.

Fatal Period.—Four hours is the shortest recorded period. Death usually takes place within a fortnight, but it may be delayed for many months.

Post-mortem Appearances.—The skin is yellow, with numerous subcutaneous petechial hæmorrhages. The contents of the stomach and intestines may reveal the presence of phosphorus by the smell or by the luminosity. A blue colour may point to rat paste; red, yellow, or green to coloured match-heads. The mucous membrane of the stomach and intestines is yellow, softened, thickened, and inflamed. Submucous hæmorrhages are largely present in these organs, and perforations are occasionally found. The mesenteric glands are enlarged and softened, and extravasations of blood may be present in the serous cavities. There is a widespread fatty degeneration of all glandular and muscular structures. The liver is chiefly affected, being enlarged, soft, yellow in colour, and containing many hæmorrhages; fatty degeneration of the hepatic cells is present. In very chronic cases the liver becomes atrophied from the contraction of the interlobular

connective tissue. The kidneys, heart, voluntary muscle fibres, and gastric follicles are all the seat of fatty degeneration. The blood remains fluid, and is dark in colour.

Acute Yellow Atrophy of the Liver must be distinguished from poisoning by phosphorus. In the former gastro-intestinal irritation is not so pronounced; the nervous symptoms are more marked; the liver becomes smaller from day to day, and in the urinary deposit leucin and tyrosin may be found.

Tests.—(1) The odour and (2) the luminosity are characteristic. The former may be masked by such food as onions or garlic, and the latter prevented by alcohol, turpentine, or ammonia (as in putrefaction). (3) The contents of the stomach or bowels may be shaken up with bisulphide of carbon, which dissolves out phosphorus. Globules remain on allowing the solvent to evaporate. (4) If a strip of blotting-paper be moistened with nitrate of silver solution, and hung in a flask containing the suspected fluid, the paper becomes black from the formation of silver phosphide if the flask be heated (*Scherer's test*). (5) If the fluid be rendered acid with tartaric acid and distilled, a luminous flame is seen in the condenser (*Mitscherlich's test*). This test is of extreme delicacy, and will reveal 1 part in 200,000. (6) If nascent hydrogen be passed through the warmed suspected fluid, phosphuretted hydrogen gas, PH_3, is produced, and will burn with a green flame; or if the gas be passed into nitrate of silver solution a precipitate of silver phosphide is formed (*Phosphine test*).

Treatment.—If the patient is seen at once after swallowing the poison, doses of sulphate of copper (3 grains) should be given every five minutes until vomiting is produced. This also forms with phosphorus a somewhat insoluble compound, phosphide of copper. The stomach may be washed out with a solution of permanganate of potassium (4 grains to each ounce). This leads to the production of non-poisonous phosphoric acid, phosphate of potassium, etc. Old oil of turpentine (French oil) may be given in $\frac{1}{2}$-drachm doses every half-hour; with phosphorus it forms a wax-like substance (phosphoro-terebinthinic acid), and owes its action to the presence of oxygen. As this antidote is very difficult to obtain, peroxide of hydrogen (1 to 3 volumes) may be employed instead. Mucilaginous materials should also be given, but on no account oils, as they are solvents of phosphorus.

Chronic Poisoning by Phosphorus.—Makers of matches,

vermin killers, phosphor bronze, or any persons exposed to the fumes of phosphorus are liable to become affected.

Symptoms.—Marked cachexia develops with sallow complexion, emaciation, indigestion, diarrhœa, fever. In many cases a local periostitis of the jaw develops, leading to necrosis; piece by piece the lower jaw dies, and separates. This may continue until half the jaw has separated as a sequestrum. It is supposed that the phosphorus gains access to the jaw ("phossy jaw") through a carious tooth. The person may die from exhaustion, from a superadded tuberculosis, or pyogenic infection.

Prevention lies in insisting on cleanliness of the person, and of the premises; thorough ventilation; the use of extraction fans; turpentine may be diffused through the workrooms; the amorphous variety should be employed instead of yellow phosphorus whenever possible. A careful examination of the teeth of the operatives should be made systematically for the purpose of stopping or extracting carious teeth.

IODINE.

Poisonous symptoms may ensue from swallowing the Liquor Iodi Fortis or the Tincture by mistake, or from the injection of these into cysts, etc.

The Symptoms of Acute Poisoning are those common to irritants, but the thirst is very intense; the urine may be suppressed, and convulsions may be present.

Chronic Poisoning is usually accompanied by catarrhal symptoms, emaciation, salivation, wasting of the mammæ, testicles, and other glands, enlargement of the liver with pain, bloody discharge from the bowels, pemphigus-like eruptions, etc.

Fatal Dose.—Twenty grains of iodine or 1 drachm of the tincture have led to a fatal issue.

Fatal Period.—Usually some days elapse before death takes place.

Post-mortem Appearances.—Acute congestion and inflammation of the gastro-intestinal mucous membrane, which may be coloured brown. The contents may be more or less blue if starchy food has been present.

Tests.—The iodine may be dissolved out of the tissues by carbon bisulphide; and on evaporating the latter, iodine is left. With solutions of starch a blue colour is obtained.

Treatment.—Empty the stomach and give starch and water to form iodide of starch.

Iodide of Potassium occurs in the form of pearly white or slightly yellow cubical deliquescent crystals.

Symptoms.—Even medicinal doses of 3 to 5 grains may lead to a copious watery discharge from the nose and eyes, with sneezing, cough, and dry sore throat. The face becomes swollen, and headache with dyspnœa and great prostration are complained of. Irritation of the stomach and bowels is also present.

Tests.—(1) The addition of a strong acid gives rise to a yellow or brown coloration from the setting free of iodine. (2) A solution of perchloride of mercury causes the precipitation of the red iodide of mercury.

BROMINE.

This is a red-brown liquid which gives off very irritating fumes.

Symptoms.—The eyes, nose, and respiratory mucous membranes are extremely irritated; cough and hæmoptysis with severe abdominal pain, vomiting and diarrhœa may result from inhaling the fumes.

Post-mortem Appearances.—Gastro-intestinal irritation along with dark brown stains on the mucous membrane.

Tests.—The colour of the fluid, and the change of starch solution from white to deep yellow.

Bromism or chronic intoxication may result from the long administration of bromides; the breath becomes fœtid; coryza and salivation are present; acne pustules or even bullæ appear on the face. Great depression of the nervous system and heart is observed.

ARSENIC.

Arsenious Acid (*Syn.* White Arsenic, Arsenic Trioxide, As_2O_3).—This poison is used very frequently by suicides; it is taken by accident, and frequently employed by murderers. A notorious female in Italy poisoned above 600 persons during the seventeenth century by means of this drug. During the years 1869-83 Frau van der Linden murdered more than 70 persons by arsenic in Germany. In Massachusetts a woman poisoned

18 persons, and in Connecticut another killed 4 husbands and 8 other persons. A woman committed suicide by introducing arsenic into the vagina in a paper bag, and a man was convicted of having poisoned his wife in a similar manner. Since 1851 it has been illegal to sell arsenic alone in smaller quantities than 10 lbs., unless it has been mixed with indigo or soot so as to prevent accidents.

Occurrence.—Many rat powders and pastes ("Rough on Rats," Simpson's rat paste, etc.), vermin-killing powders, fly-papers, "complexion powders," sheep dips (tar, soft soap, white arsenic) contain this poison. Farmers sometimes steep their wheat seed in solutions of arsenic so as to preserve it. A weed-killer which is largely used, consists of a strong solution of caustic soda and arsenite of soda. It is used as a mordant in dyeing, and hence the waste water from dye works if allowed to escape into a stream may kill the fish in it. If the arsenic is not washed out of stockings, gloves, etc., it may lead to severe irritation of the skin. Pastes sold for the cure of cancer usually contain white arsenic, which exerts a strong local action on the tissues, leading to great inflammation and necrosis, with perhaps a partial destruction of the growth. The brightly-coloured compounds of arsenic are sometimes used in the manufacture of crayons, and these have been swallowed by children. Arsenic is largely present in ores, and its fumes may give rise to poisonous symptoms amongst smelters. It has been found in beer in amounts varying from $\frac{1}{20}$ to 2 grains per gallon. In such cases it has been present in the sulphuric acid used in the conversion of starch into glucose. The latter is used in fermentation for the production of alcohol and carbonic acid gas, and in this way arsenic has found its way into beer. During the years 1900-1 above 130 persons were fatally poisoned in England through drinking beer containing arsenic. The bright colours of wall papers are sometimes produced by arsenical compounds. Chronic poisoning may affect those who live in such rooms, from inhaling the fine powder which is shed off or from the volatilisation of the arsenic, brought about by the action of moulds producing gaseous arsines. Arsenic is largely employed in therapeutic practice. Both Liquor Arsenicalis and Liquor Arsenici Hydrochloricus contain 1 per cent of arsenious acid, while Donovan's solution contains the same proportion of the iodide of arsenic.

Properties.—White arsenic is found as lumps which resemble

broken pieces of porcelain. It is usually ground down into a fine powder which is without taste. One ounce of cold water will dissolve almost 1 grain, while if boiled for one hour it will dissolve permanently 16 grains.

Symptoms usually commence within half an hour; occasionally they may be delayed for ten hours. An acrid burning pain in the throat, with faintness and depression, is complained of. Vomiting is persistent, and is usually bloody or blue or black. Severe abdominal pain, tenesmus, with bloody or watery diarrhœa; scanty and bloody urine; cramps, intense thirst, constriction in the throat, and painful respiration are present. The pulse is small and irregular; the face is shrunken, pale, and cold; collapse, convulsions or paralysis, and death follows. In some cases vomiting is incessant, simulating poisoning by antimony tartrate. In other cases the person dies in a few hours from collapse; in another group diarrhœa is the most marked symptom; while again nervous symptoms (tetanic spasms, convulsions, paralysis, delirium, or coma) may be the most prominent features. In cases which recover, chronic peripheral neuritis may persist, ending in paralysis from degeneration of the nerves extending up to the nerve centres.

Fatal Dose.—Two grains have in many cases caused death.

Fatal Period.—The average period is twenty hours. Death has taken place within two hours in certain cases.

Post-mortem Appearances.—The mucous lining of the stomach is acutely inflamed in streaks or in patches. It is thickened, and covered with bloody mucus. Submucous hæmorrhages are present in large numbers. Arsenic is found firmly adherent to the mucous membrane, and on removing these white masses, intensely inflamed or ulcerating areas are found. These gritty particles should be examined chemically. The yellow sulphide of arsenic may be produced during decomposition. The mucous membrane of the intestine may be inflamed, and this is found chiefly towards the duodenum and rectum. The glands of the intestine are swollen. If the person has lived for some time, fatty degeneration is widely present in the liver, stomach, muscles, etc. In chronic cases of poisoning, decomposition may be entirely prevented, and the body may remain fresh for months or years.

Tests.—If some of the powder be (1) heated in a reduction tube, it sublimes as a white ring, and if this be examined by

the microscope it is seen to be composed of the octahedral crystals of arsenious acid. (2) If a little be mixed with charcoal and heated in a reduction tube, the arsenic is reduced, and forms a metallic dark brown or black ring of arsenicum. By heating this, it may be forced up the tube, and oxidised into white arsenic with its characteristic crystals. A garlic odour is also evolved. (3) If it be heated with acetate of potash, the disagreeable smell of kakodyl is perceived. The reduction test is applicable to any compound of arsenic.

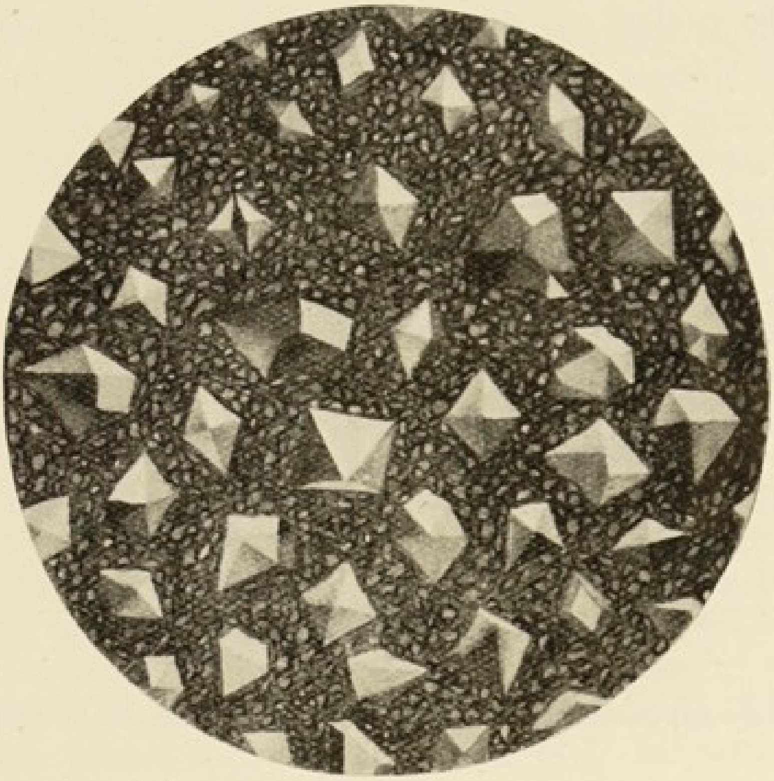


FIG. 17.—Crystals of arsenious trioxide obtained by sublimation. × 350.

Liquid Tests.—(1) The addition of the ammonio-nitrate of silver to a solution of arsenic yields a yellow precipitate of arsenite of silver, which is soluble in ammonia or nitric acid. (2) Ammonio-sulphate of copper causes the precipitation of the green arsenite of copper, soluble in excess of ammonia. (3) Sulphuretted hydrogen in acid solutions precipitates the yellow sulphide of arsenic, which is soluble in ammonia.

Reinsch's Test can be applied to the vomit, urine, fæces, etc., without previous destruction of the organic matter, and thus is extremely useful to the medical attendant in suspicious cases. A little of the suspected liquid is placed in a test tube,

and about one-eighth of its bulk of pure hydrochloric acid is added ; a strip of bright copper foil is dropped in, and the whole is boiled for five or ten minutes. If arsenic be present, it is deposited on the foil as a steel-grey coating. If no deposit occurs within ten minutes then it may be presumed that arsenic is absent. The foil is removed, washed, dried, cut into fine strips, placed in a reduction tube and heated; if the deposit is arsenic it will volatilise, and form a white deposit of arsenious oxide crystals further up in the tube. Even $\frac{1}{5000}$ of a grain may be detected by this test. If the coating be dense, it may be peeled off, dissolved in acid, and the liquid tests

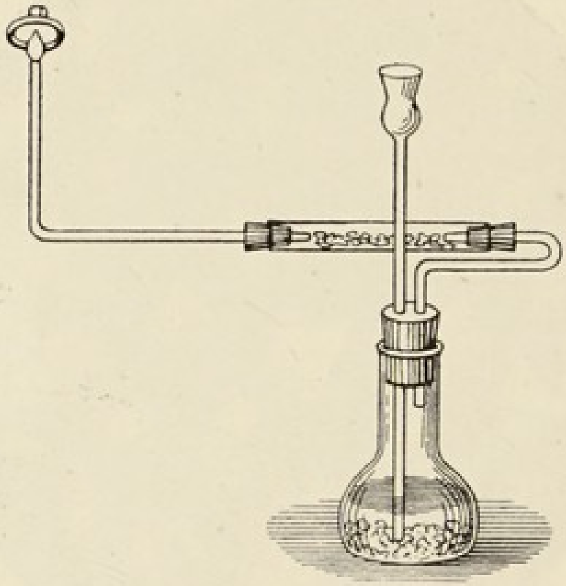


FIG. 18.—Apparatus for performing Marsh's test. Capsule held in flame to obtain a "mirror."

applied. A blank experiment should be made first to test the purity of the reagents.

Marsh's Test consists in the production of arseniuretted hydrogen. Hydrogen is evolved from granulated (arsenic free) zinc by treating it with pure dilute sulphuric acid in a Woulffe's bottle. The gas is led along a narrow glass tube drawn to a point, and when all the oxygen in the bottle has been driven out, the escaping hydrogen is lighted. The suspected fluid is added, a few drops at a time, through the funnel, and if arsenic is present the flame becomes pale bluish purple in colour. If small porcelain capsules be held in the flame, a metallic "mirror" is deposited of a brown or steel-grey colour. In the

case of antimony the mirror is sooty black in colour. These mirrors may be distinguished as follows :—

	Arsenic Mirror.	*Antimony Mirror.*
1. If the capsule be heated.	soon disappears with garlic odour.	slowly disappears.
2. Bleaching solution added.	dissolves rapidly.	no change.
3. Ammonium sulphide.	slowly dissolved.	rapidly dissolved.
4. Stannous chloride.	no change.	slowly dissolved.
5. Dissolve in HNO_3: dry, add silver nitrate.	red colour.	no red colour.

If the gas be extinguished, and a flame applied to the exit tube, a metallic brown or black deposit of arsenic appears a little way beyond the flame. In the case of antimony the deposit is tin-coloured, and is formed close up to and on each side of the flame. The gas may be led into a solution of silver nitrate, when black metallic silver is precipitated, and arsenious trioxide is left in solution.

There are several other methods of detecting arsenic (*e.g.* Gutzeit's, Fleitmann's, etc.), but the above are sufficient. Arsenic has a special affinity for the bones and hair, and may be detected in these while not recognisable in the other tissues.

In Exhumations it is necessary to test for arsenic in the soil in contact with the body. One or 2 pounds of soil are boiled in acidulated water for some time. The water strained off is evaporated to a small volume, and Reinsch's test applied.

Detection in Wall Paper.—If 5 square inches of the paper be cut into small pieces, and boiled in dilute hydrochloric acid, the arsenic passes into solution, and may be tested for by Reinsch's method.

Treatment.—The stomach should be emptied, and freshly prepared hydrated sesquioxide of iron given in unlimited amount. This can be easily made by adding ammonia or carbonate of soda to the Liquor or Tinctura Ferri Perchloridi, when a copious precipitate of this ferric oxide is formed. This is filtered off by means of a muslin handkerchief, and given in tablespoonful doses. It forms ferric arsenate, which is sparingly soluble. The ordinary demulcents, stimulants and anodynes must follow.

Chronic Arsenical Poisoning may result from the medicinal use of arsenic or in those who work where it is employed, *e.g.* artificial flower makers, wall-paper manufacturers, anilin dye workers, zinc or copper smelters, etc.

Symptoms.—The order of onset is as follows: injection of the conjunctivæ with watery discharge from eyes and nose; œdema of the eyelids; irritable cough; emaciation; silver fur on tongue, anorexia, salivation, nausea, colic, diarrhœa, melæna, cramps, headache, suppression of urine, drowsiness, prostration; peripheral neuritis, paralysis; eczema, and other skin affections, pigmentations and desquamation of skin; falling out of the hair; exfoliation of nails, hectic fever, death from asthenia. The *post-mortem appearances* closely resemble those seen in acute poisoning by arsenic. In medical practice one should stop the drug as soon as the eyelids become puffy and the bowels loose.

Arsenite of Copper (Scheele's Green), $CuHAsO_3$.

Aceto-arsenite of Copper (Emerald Green, Schweinfurth, Brunswick, Paris, or Vienna Green).

Arsenate of Sodium ($Na\ AsO_4$); Liquor sodii arsenatis (4 grains to ℥i.).

Realgar, As_2S_2 (or Red Arsenic).

Orpiment, As_2S_3 (Yellow Arsenic), or "King's Yellow."

All these preparations give rise to the ordinary symptoms of arsenical poisoning.

Arseniuretted Hydrogen (AsH_3, Arsine) is an extremely poisonous form of arsenic. When inhaled in dilute amounts it gives rise to the usual symptoms, together with jaundice, hæmaturia, coma, and death. It is formed when sulphuric acid acts on impure lead, and may arise in such processes as tinning sheet iron (galvanising), bronzing, etc. In chemical laboratories several deaths have occurred from inhaling the gas evolved from Marsh's apparatus.

ANTIMONY.

Tartar Emetic.—Tartarised Antimony, $KSbC_4H_4O_7$, is the salt of antimony which most usually leads to cases of poisoning. It has been mistaken for Epsom salts; it is a constituent of many quack pills, and "drink cures"; over-doses have often led to fatal results. It has been the poison employed by such murderers as Pritchard, Bravo, and Chapman.

Properties.—It occurs as a white crystalline powder, having an acrid metallic taste, and deflagrating when heated. It is freely soluble in water.

Symptoms of Acute Poisoning.—They closely resemble those of arsenic, but a metallic taste is complained of very shortly

after the poison has been swallowed; great pain over the stomach, with nausea and vomiting, commence within half an hour. The vomiting is *incessant*, and later is bloody; the mouth and throat are sore, swallowing is painful; diarrhœa is often bloody, urine is suppressed; cramps; great depression; respiration accompanied by pain; collapse, delirium, coma, and death follows. Tetanic spasms may be observed, and in cases where death is delayed a pustular rash may appear. In rare cases, where a massive dose has been taken, vomiting may be absent.

Fatal Dose.—Less than 2 grains has proved fatal.

Fatal Period.—Usually death takes place within twenty-four hours.

Post-mortem Appearances.—Congestion and inflammation of the gastro-intestinal mucous membrane with submucous hæmorrhages and ulcers are found. In many cases the large intestine and cæcum are the chief seat of these lesions. The yellow antimony sulphide may have been formed through the action of sulphuretted hydrogen evolved during decomposition.

Tests.—(1) If the solid be heated it decrepitates and chars, or if a drop of sulphuretted hydrogen fall on it an orange-red colour is produced. Liquid tests may be applied, as (2) the addition of sulphuretted hydrogen to an acid solution causes the formation of the orange-red sulphide of antimony; this is soluble in caustic potash or hydrochloric acid. (3) Hydrochloric, sulphuric, or nitric acids all give a white precipitate which is soluble in excess. (4) If the fluid be placed in a platinum dish, and stirred with a zinc rod a black deposit of antimony forms; this changes to yellow on the addition of ammonium sulphide.

Reinsch's Test yields a violet deposit on the copper. If dried and sublimed, either amorphous granules or needle-shaped crystals are seen by the microscope.

Marsh's Test (*see* Arsenic).—If the gas be led into a solution of nitrate of silver, a black deposit of silver antimonid (Ag_3Sb) is obtained.

Treatment.—After emptying and washing out the stomach, tannic or gallic acids should be administered so as to form the insoluble antimony salts. In their absence strong tea or coffee will suffice, and this must be followed by the routine treatment.

Chronic Poisoning.—Antimony in repeated small doses is a most lethal and insidious poison, closely resembling in its

symptoms ordinary gastro-intestinal catarrh. Murderers most frequently make use of this method of dosage. The usual symptoms are nausea, vomiting, purging, great exhaustion, loss of voice, collapse, and death from exhaustion. Inunction of the ointment for some time may give rise to a local pustular eruption and symptoms of chronic poisoning.

Other Preparations of Antimony.—*Vinum Antimoniale* (2 grains of tartar emetic to 1 fluid ounce of sherry ·4 per cent). *Yellow Sulphide*, Sb_2S_5. *Black Sulphide*, Sb_2S_3.

Chloride or Butter of Antimony, $SbCl_3$, has been swallowed in mistake for Vinum antimoniale.

Properties.—It is a soft crystalline solid which easily deliquesces to a brown liquid. When dissolved in hydrochloric acid it is known as bronzing liquid; it is used by farriers and others.

Symptoms are very intense on account of the corrosive action of the poison; severe pain over abdomen with vomiting and purging; and drowsiness merging into coma.

Post-mortem Appearances.—The mucous membranes with which it has come in contact are charred, and the appearances are similar to those seen in death from the corrosives.

Fatal Dose.—Two ounces.

MERCURY.

All salts of mercury are poisonous though their intensity varies greatly.

Mercuric Chloride, Corrosive Sublimate, Perchloride of Mercury, $HgCl_2$.—This salt is so largely used in manufactures (felting of hats, by furriers, taxidermists, instrument makers, etc.) that it is accountable for the largest number of cases of poisoning from mercurial salts. It has been prescribed in mistake for calomel; lotions have been swallowed accidentally. Suicides also employ this agent.

Properties.—It occurs as crystalline masses or small prismatic crystals. It is freely soluble in water, and much more so in solutions of sodium chloride. Alcohol and ether dissolve it freely.

Symptoms commence in a few minutes with a metallic taste in the mouth, and constriction in the throat; the lips become white and swollen; severe pain is complained of in the stomach with distension, nausea with bloody vomit; tenesmus, purging

of much bloody mucus; dysuria with albuminous and bloody urine, or suppression of urine; the pulse is small and irregular; the person becomes unconscious, and may have convulsions before death.

Post-mortem Appearances.—The mucous membrane of the throat, gullet, stomach, and bowels is white or greyish-blue in colour. The gastric mucous membrane soon becomes inflamed or ulcerated with submucous hæmorrhages, while the small intestine may appear more or less healthy. The large intestine and rectum are often the seat of ulcers or gangrenous sloughs. Acute nephritis is usually present.

Fatal Dose.—Three grains have proved fatal.

Fatal Period.—Half an hour is the shortest recorded period, but three to four days are by no means unusual.

Poisoning in Surgical, Gynecological, or Obstetric Practice.—This may result from the use of too strong solutions or leaving too large a quantity in the cavities or sinuses.

Symptoms.—The earliest is a watery, and later a bloody diarrhœa, constant tenesmus, colic, nausea, and vomiting, scanty urine, insomnia, wandering of the mind, fœtid breath, stomatitis.

Poisoning from Medicinal Administration or from its Use in Manufactures.—Salivation is the earliest symptom; brassy taste in mouth, fœtor of breath; inflammation, ulceration, and even gangrene of gums and buccal mucous membrane; loosening of teeth, blue line in gums, swelling of tongue; eczema, anæmia, weakness. These toxic effects are most prone to affect those suffering from renal or nervous diseases.

Mercurial Tremors chiefly affect those who inhale the fumes of this metal, as mirror makers, water gilders, barometer makers, hatters, etc. The muscles of the arm are first affected, and complete paralysis may supervene. Peripheral neuritis is the condition present. The mind becomes affected, the speech stuttering, and mania or melancholia may follow.

Tests.—If to the *crystals* of mercuric chloride (1) a drop of caustic potash be added, a yellow or brown colour is produced; (2) solution of iodide of potassium gives a red colour. If in *solution* (3) hydrochloric acid and sulphuretted hydrogen be added, a yellow precipitate is formed, which rapidly changes to brown and finally to black; (4) stannous chloride, a white changing to a black precipitate; (5) potassium iodide gives a red precipitate soluble in excess; (6) a drop placed on a gold

coin, and touched with a steel key causes metallic mercury to be deposited.

Reinsch's Test.—Heat is not necessary in this case. A grey film of mercury forms on the copper, and if this be cut up, and heated in a reduction tube, round globules of mercury volatilise, and can be recognised by the microscope.

Treatment.—Albumin in such forms as the raw white of an egg stirred up in water, milk, flour and water, barley water, etc., should be given. Albuminate of mercury is formed, but, as it

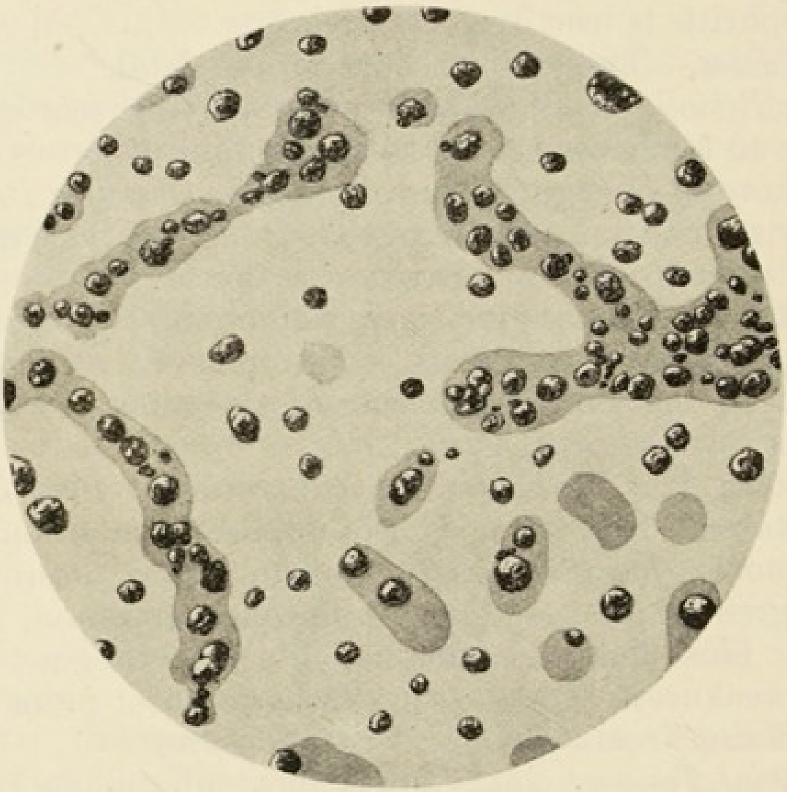


Fig. 19.—Sublimate of metallic mercury. × 350.

is soluble, it must be removed by emetics or the stomach tube. Hypodermic injections of hyposulphite of soda may be given. In chronic poisoning, promote elimination by diuretics, etc. Potassium iodide given cautiously may help in this way.

Mercuric Iodide is not nearly so poisonous in its action as the perchloride.

Calomel, Subchloride of Mercury, Mercurous Chloride, HgCl, is usually safe except in massive doses. If old and exposed to light it may have been changed into the perchloride of mercury, and hence may be toxic.

Tests.—Ammonium sulphide, caustic potash, or ammonia all give black reactions. It is insoluble in water.

White Precipitate. — Ammonio-chloride of mercury, NH_2HgCl, is only poisonous in large doses. If boiled with caustic potash, ammonia is evolved.

Red Precipitate.—Red Oxide of Mercury, HgO, occurs as small red crystals. **Cinnabar.**—Vermilion, HgS. **Nitrates** (mercurous and mercuric) are very toxic. **Bicyanide of Mercury** is an intensely active poison. The chemical toy, "Pharaoh's serpent's egg," which burns leaving a very copious ash, consists of the sulphocyanide.

LEAD.

Acute poisoning by lead salts is rare, while chronic poisoning is a common occurrence. Acute poisoning most usually results from swallowing acetate of lead; carbonate of lead comes next; and the subacetate (Goulard's solution) still less frequently. The symptoms are common to all the soluble lead salts.

Lead Acetate—Sugar of Lead, $Pb(C_2H_3O_2)3H_2O$, occurs in white masses of needle-shaped crystals. It is freely soluble, and has a sweet, styptic, and metallic taste. It is a constituent of the Pilula Plumbi cum Opio; the Compound Suppository, Liquor Plumbi Subacetatis Fortis (Goulard's extract).

Symptoms of Acute Poisoning.—Metallic taste; constant vomiting and retching; intense thirst; colic relieved by pressure; the most prominent feature is *constipation*; cramps; scanty urine, severe headache, convulsions; paralysis of the lower limbs.

Post-mortem Appearances.—Gastro-intestinal congestion and inflammation.

Subacute Poisoning leads to the death of many workers in lead, and especially if females, the chief symptoms being headache, neuritis, convulsions, coma, and death usually within three days. If the workers recover, optic neuritis may leave permanent blindness, or hemiplegia may be a sequela. Gastro-intestinal symptoms may also be present.

Chronic Poisoning (plumbism; Saturnine poisoning) may arise even from insoluble lead compounds being acted upon by the acid of the gastric juice. A metallic or saturnine taste is complained of; the breath is offensive; a black or dark-blue line is seen on the gums close to the teeth, and

is due to precipitation of lead sulphide by sulphuretted hydrogen in the tartar. (This line is not seen in edentulous subjects or in those with clean teeth.) The patient becomes emaciated, anæmic, sallow; vomiting may be present with persistent constipation. The pulse is slow and hard, arterio-sclerosis with albuminuria is present, and gouty conditions frequently develop. Certain features may be most prominent, thus, (1) colic may be intense ("painter's colic," Colica pictonum), especially round the umbilicus; the belly is hard; cramps may also be present in the limbs, penis, uterus. (2) Rheumatism or arthralgia in the bones and joints. (3) Saturnine encephalopathia or intense headache. Other nervous symptoms may arise, as anæsthesia, convulsions, optic neuritis, delirium, coma, insanity, etc. (4) Peripheral paralysis may be the chief symptom; it affects mainly the extensors of the fore-arm or all the muscles supplied by the musculo-spiral nerve with the exception of the supinator longus ("wrist drop" resulting). The extensors of the foot may also be affected, or those of the larynx. Tremors are seen in these muscles before paralysis. The lesions closely resemble those of poliomyelitis anterior acuta.

Those Liable to Chronic Poisoning by Lead.—The poison may be inhaled, swallowed in food or drink, or absorbed through the skin. All operatives in works where lead is present are liable to its toxic effects. Thus, workers in white lead, litharge, or red lead; electric-light workers, colour makers, painters, plumbers, enamellers of iron ware, smelters of lead ores, glass-blowers, potters from employing lead glaze; workers with glazed cards, and thus card players; compositors, barmen, fish salesmen; workers in yarn died with chrome yellow; those who use lead hair dyes or lead face powders; from drinking water or cider containing lead, or from eating tinned foods (especially if oily) which have acted on the solder. Lead plaster (diachylon) made into pills is taken to induce abortion, and gives rise to many cases of lead poisoning in the Midlands of England.

Post-mortem Appearances in Chronic Poisoning.—Cirrhotic conditions of the liver and kidneys (granular contraction) are often present, together with anterio-sclerosis. The nerves show the changes incident to peripheral neuritis, and in the brain and cord a large amount of lead accumulates, and may be isolated. The paralysed muscles show marked degeneration.

The cells of the bone marrow are very specially affected, granular myelocytes and nucleated red cells undergoing a great increase in number. An early diagnosis of lead poisoning may be made in suspected cases by finding basophile granular red blood corpuscles in the blood.

Tests.—(1) Sulphuretted hydrogen gives a black precipitate insoluble in dilute acids or in caustic potash. (2) Sulphuric acid yields a white precipitate insoluble in nitric but soluble in hydrochloric acid. (3) Either chromate or iodide of potassium when added give beautiful yellow precipitates. (4) A characteristic lead tree is formed on a microscope slide if a fragment of zinc be placed on a drop of a lead salt.

Preparations of Lead.—Carbonate or white lead, $2PbCo_3$ $Pb(OH)_2$, forms the basis of paints; acetate and subacetate; the sulphate is very insoluble; litharge, PbO; red lead or minium, Pb_3O_4; nitrate; chromate, etc.

Fatal Doses.—Lead is not very active as a poison, hence recovery has followed the swallowing of 1 ounce of the acetate or of the carbonate, or 15 ounces of Goulard's solution.

Treatment of (1) *Acute Poisoning.*—The stomach should be washed out with solutions of magnesium or sodium sulphate, alum, or even with dilute sulphuric acid. These produce the insoluble lead sulphate.

(2) *Chronic Poisoning.*—Rules must be drawn up for cleanliness in manufacture. Wet grinding should be used wherever possible; if not, exhaust fans or the use of a respirator should be insisted on. Basins with soap and water should be provided for the use of the operatives, and they ought not to be allowed to eat their food in the workrooms. Magnesium sulphate should be given each morning as a purgative. Women are more susceptible to the poisonous effects than men. All cases of subacute or chronic lead poisoning *must* be notified by the medical attendant to the Chief Inspector of Factories so that he may take action to suppress the evil. The sum payable for each notification is 2s. 6d.

COPPER.

As all the salts of copper are brightly coloured, poisoning from their use is rare. Copper cooking vessels, if put aside damp or dirty, are apt to cause poisoning from the hydrated oxide or carbonate which is formed. Acid foods or fruits cooked in copper

vessels may cause solution of the metal. Tinned vegetables (peas) or pickles are often bright in colour from the addition of a small quantity of sulphate of copper ($\frac{1}{8}$ to 1 grain per tin or bottle); such amounts are perfectly harmless.

Symptoms.—The ordinary symptoms of a metallic irritant are present in acute cases of poisoning, together with certain nervous phenomena.

Post-mortem Appearances.—The mucous coats of the stomach and bowels are thickened, inflamed, ulcerated, and of a blue or green colour; the colon is specially liable to ulceration. Coloured salts of copper may be present; acute nephritis and fatty degeneration of the viscera may also be found.

Fatal Dose.—Half an ounce of verdigris or 1 ounce of the sulphate.

Fatal Period.—The shortest is four hours, but days usually intervene.

Chronic poisoning by copper salts is so rare that most authorities believe that the symptoms are really due to lead or arsenic present as impurities.

Salts of Copper.—Sulphate, bluestone, or blue vitriol, $CuSO_4 . 5H_2O$; subacetate or artificial verdigris is found in bluish green masses; carbonate or natural verdigris is green in colour; arsenite of copper is pale green.

Tests.—(1) The addition of ammonia gives a white precipitate of the hydrated oxide, which dissolves in excess to an intensely blue solution. (2) Ferrocyanide of potassium causes the formation of a gelatinous mahogany-coloured precipitate. (3) A steel instrument immersed in the solution becomes covered with a deposit of metallic copper.

Treatment.—One drachm of ferrocyanide of potassium dissolved in a pint of water should be given, and followed by emetics or the syphon tube. The usual remedies are then to be employed.

ZINC.

Zinc Sulphate, ($ZnSO_4 . 7H_2O$), **White Vitriol, or White Copperas** occurs in white crystals, closely resembling oxalic acid or Epsom salts, for which it has been mistaken. It is often used as an emetic, and so may act as a poison in overdoses.

Symptoms are those common to the group.

Fatal Dose.—An ounce and a half has caused death.

Fatal Period.—The shortest recorded is four hours.

Chloride of Zinc ($ZnCl_2 . 2H_2O$) is found as sticks which, because of their caustic action, are employed in "cancer cures." In solution it is used as a flux by plumbers. Burnett's Disinfecting Fluid contains 230 grains per ounce.

Symptoms.—In addition to the usual irritant symptoms, it acts as a caustic, burning the mucous surfaces with which it comes into contact.

Post-mortem Appearances.—The usual appearances are present, or with corrosion if the chloride has been employed.

Tests.—(1) The sulphide is white, and dissolves in hydrochloric acid. (2) Both ammonia and ferrocyanide of potassium give white precipitates soluble in excess.

Treatment.—The carbonate of potash or soda should be given freely, dissolved in warm water. Tannic acid is valuable, and demulcents (eggs or milk) form zinc albuminates.

Chronic Poisoning may really be due to arsenic as an impurity because the symptoms are almost identical. Zinc may be dissolved from galvanised iron vessels by food (milk, soup, oil, etc.).

SILVER.

Nitrate of Silver ($AgNO_3$), Lunar Caustic.—Accidental poisoning may result from swallowing a solution, or from a piece of lunar caustic being swallowed while the throat is being cauterised. The *usual* symptoms are present. The vomit on standing may become black through the action of light on the silver salt. The mucous membranes are whitened, and corroded.

Chronic Poisoning may result from its employment as a medicine. A blue line is seen on the gums, and the skin where exposed to the light, takes on a dark grey colour (*argyria*).

Fatal Dose.—Thirty grains have proved fatal.

Fatal Period.—Varies from six to twenty-four hours.

Tests.—(1) Sulphuretted hydrogen causes a black precipitate. (2) Ammonia, a brown precipitate soluble in excess. (3) Hydrochloric acid, a white precipitate soluble in ammonia but insoluble in nitric acid. (4) On a strip of copper, metallic silver is deposited.

Treatment consists in administering water containing ordinary common salt, and the other usual remedies.

CHROME SALTS.

Chromic Acid (CrO_3) is a powerful local caustic. Death has resulted from its too free application to warts.

Chromate (K_2CrO_4) **and Bichromate of Potassium** ($K_2Cr_2O_7$). —These are bright-coloured salts often used by dyers. Poisoning may occur in those engaged in their manufacture, in dyeworks, or in those who charge electric batteries.

Symptoms are those of a strong irritant with marked nervous phenomena.

Post-mortem Appearances are those common to severe irritants; acute nephritis is present.

Fatal Dose.—Two drachms of the bichromate.

Fatal Period.—One hour is the shortest recorded.

Tests.—(1) Lead acetate solution gives a yellow precipitate. (2) Silver nitrate a red precipitate. (3) It is reduced when boiled with dilute sulphuric acid and alcohol, giving a green colour.

Treatment.—Give emetics and magnesium or calcium carbonate followed by demulcents.

Chronic Poisoning.—This occurs in those exposed to its dust during manufacture. The mucous membrane of the nose, eyes, and throat, becomes irritated and inflamed. "Chrome sores" resembling hard chancres, appear on the hands and other parts of the body; the centre of each sloughs out, leaving ulcers with hard edges. Rashes resembling eczema or psoriasis may appear; the nasal septum is often perforated by the ulceration.

BISMUTH SALTS.

Bismuth Salts rarely give rise to poisonous symptoms when pure. They frequently, however, contain arsenic, antimony, lead, or tellurium, as impurities, and these may give rise to toxic effects. A peculiar odour in the breath observed in those taking bismuth is probably due to tellurium.

Fatal Dose.—Two drachms of pure bismuth caused death in one case.

IRON SALTS.

Iron Salts only give rise to gastro-intestinal irritation when taken in large doses.

TIN.

Tin Chloride ($SnCl_2$), **Perchloride** ($SnCl_4$).—"Dyer's spirit" is a mixture of both, and has been used suicidally. Accidents happen from acid fruit dissolving out the tin from the solder in preserved fruit cans; articles of clothing (silk stockings) are sometimes impregnated with the chloride, and have given rise when worn to poisonous symptoms. The usual evidences of an irritant poison are present.

Tests.—(1) Protochloride: the sulphides are black and soluble in excess. Mercuric chloride with dilute hydrochloric acid gives a yellow turning to a grey precipitate; the zinc tree is characteristic. (2) Perchloride: the sulphides are yellow and soluble in excess, and mercuric chloride has no reaction.

POTASSIUM SALTS.

Nitrate of Potassium (*Syn.* Nitre, Saltpetre, Sal prunelle (when fused into balls), KNO_3.

Bitartrate of Potassium (*Syn.* Cream of Tartar, Argol), $KHC_4H_4O_6$.

Sulphate of Potassium, K_2SO_4.

Alum (Double sulphate of Alumina and Potassium), $AlK(SO_4)_2 . 12H_2O$.—These salts are poisonous only in large doses (2 to 8 drachms). The usual symptoms of irritation are present, but the potash element gives rise to great cardiac depression.

Sulphide of Potassium (Liver of Sulphur, K_2S) is an active poison with an irritant base, and is easily decomposed into the narcotico-irritant gas, sulphuretted hydrogen. It occurs in dirty greenish-grey masses having the odour of this gas. It is used in the treatment of skin diseases.

Symptoms are those of an irritant associated with stupor, convulsions, etc., due to the gas. The breath smells of sulphuretted hydrogen.

Fatal Period.—Death has taken place in fifteen minutes.

Post-mortem Appearances.—Great lividity of the surface of the body, and congestion of the gastro-intestinal mucous membranes.

Test.—If an acid be added, sulphuretted hydrogen is evolved, and will darken a paper moistened with acetate of lead solution.

Chlorate of Potassium ($KClO_3$) is used medicinally. An overdose may be fatal; a man recently died from swallowing ½ an ounce in tablets which he had taken for a sore throat. It occurs as flat crystals, which fuse on heating and evolve oxygen.

Symptoms.—Besides its usual irritant properties it produces hæmaturia, marked cyanosis, jaundice, weakness, delirium, stupor, coma, and death.

Chronic Poisoning.—It is occasionally given in cases of repeated abortion with the object of oxygenating the blood. It may then act as a poison, causing pain over the abdomen, diarrhœa, dyspnœa, and fever.

Fatal Dose.—Three drachms have caused death.

Fatal Period.—Varies from five hours to several days.

Post-mortem Appearances.—Congestion and inflammation of the mucous lining of the stomach and bowels are present. The blood is of a chocolate-brown colour from the poison altering the hæmoglobin to methæmoglobin, and destroying the hæmocytes. The viscera and tissues are consequently stained of a dark brown colour. The kidneys are inflamed, enlarged, dark brown, and having the tubules filled with brown casts. In chronic cases, nephritis is set up, and the cortex becomes pale. The spleen and liver are inflamed or congested and brown in colour.

Tests.—(1) The fresh blood gives the spectrum of methæmoglobin. (2) If the solution of the salt be coloured blue with indigo sulphate, and acidified with sulphuric acid the colour will disappear on adding sulphurous acid.

Treatment.—Transfusion of defibrinated blood or normal saline solution is indicated. Stimulation and aids to elimination are beneficial.

CHLORIDE OF LIME.

Chloride of Lime (Bleaching powder or solution) acts as an irritant.

CHLORIDE OF SODIUM.

Chloride of Sodium.—Fatal results have followed from individuals wagering to eat large amounts. Half a pound has caused death.

BARIUM SALTS.

Barium Salts are very poisonous; the chloride has been mistaken for magnesium sulphate. The salts are used in the arts; the yellow chromate is a pigment ("yellow ultramarine"), as is also barium sulphate ("permanent white"). The green fires of the pyrotechnist are produced by the nitrate; dyers use the chloride as a mordant; the sulphide is a depilatory. Rat poison may contain barium salts.

Symptoms.—Besides the usual gastro-intestinal irritation, these poisons exert a marked influence on the heart. The ventricular contractions are rendered very slow, but increased so much in strength that the heart-beats can be heard by those around. The blood pressure is greatly increased. The nervous system is also affected, cramps, convulsions, or paralysis being observed.

Fatal Dose.—One drachm of the chloride or carbonate has caused death.

Fatal Period.—The shortest recorded is one hour.

Post-mortem Appearances are those of an irritant poison.

Tests.—(1) If a platinum loop be dipped in hydrochloric acid and then in the salt a green colour is given to the bunsen flame. (2) The addition of carbonate of soda or sulphuric acid produces a white precipitate insoluble in nitric acid. (3) Chromate of potassium when added produces a yellow precipitate which is soluble in nitric acid.

Treatment.—The stomach should be washed out with a solution of sodium or magnesium sulphate, or of alum so as to form the insoluble barium sulphate. Any of these may be given by the mouth also. Stimulants are very necessary, and the usual treatment should then be followed.

CHAPTER IV.

ORGANIC POISONS.

IRRITANTS OF ANIMAL ORIGIN.

FOOD POISONING.

Food Poisoning.—Food may give rise to poisoning in several ways. (1) The animal may have been suffering from micro-organismal disease. If the food is insufficiently cooked, these bacteria may not be killed, and so may communicate the disease to the consumer. (2) As a result of such a disease, toxins may be present in the flesh, and as cooking has no influence on these (ptomaines) they may produce poisonous symptoms in those partaking of it. (3) The food may undergo decomposition, and the toxins (tox-albumins) formed during putrefaction may induce poisoning. (4) The food may have been stored in places where pathogenic or saprophytic organisms may gain entrance to it, and so the food may become poisonous. (5) The animal may have eaten poisonous plants or may have been given poisonous drugs, and its flesh in turn is toxic to those who eat it. (6) Metallic poisoning may be caused by preserved foods dissolving the solder or material of the vessel in which they are enclosed.

The flesh may look apparently healthy, and may have no disagreeable smell, but may contain actively poisonous ptomaines. These poisonous albumoses are produced by the growth of bacteria in albuminous materials. They belong to the group of alkaloids, and as they were first isolated from dead tissues the name of cadaveric alkaloids or ptomaines was given to them (πτῶμα, a dead body). Only a small proportion are really toxic; some are, however, intensely

poisonous. They occur in the gaseous form (as methylamine), as liquids (ethylamine), or as solids (neurine).

Symptoms.—These usually come on *shortly* after the food has been taken, and though they vary greatly in their nature, the most characteristic are profuse diarrhœa and vomiting; stimulation of glands, leading to salivation, lachrymation; moist râles in the lungs; the heart's action becomes slow and weak, and the pulse consequently almost imperceptible; the nervous system is profoundly affected; paralysis ensues, and may affect the extra- or intra-ocular muscles (ptosis, dilatation of the pupils), the glosso-pharyngeal nerve, or the respiratory nerves, so leading to dyspnœa, and death.

Post-mortem Appearances are those of acute congestion of the gastro-intestinal mucous membrane. The kidneys, spleen, and lungs are similarly affected.

Certain individuals show a marked idiosyncrasy to special healthy articles of food, thus, eggs, pork, veal, shellfish, etc., may give rise to poisonous symptoms in them.

Pork, Bacon, or Ham are very liable to produce toxic symptoms. At Carlisle 25 persons suffered severely in 1889, by eating a pork pie.

Sausages are notoriously apt to produce serious symptoms, either from the use of diseased or decomposing meat in their manufacture, or from the easy growth of organisms in the damp bread with which the meat is mixed. They may be imperfectly smoked, and so may easily become putrescent. The symptoms are very severe, and may be of the narcotico-irritant type. This form of poisoning is sometimes called "*Botulism*" (*botulus*, a sausage). A specific organism (*Bacillus botulinus*) has been isolated from pickled ham and sausages.

Veal may cause poisoning either because the calf has suffered from septic pyæmia or because the flesh is prone to early decomposition. In 1898 at Oldham, 52 cases of poisoning arose from eating veal pies; 4 of these ended fatally.

Baked Meat Pie often gives rise to minor symptoms; these may be due to the imprisonment of the gases evolved during cooking. In other cases the jelly forms an excellent culture medium for extraneous organisms.

Tinned Meats may cause poisoning either owing to the use of meat from diseased animals or from faulty sealing of the tin, so allowing of putrefaction. A properly-sealed tin should show both ends concave, and should not crackle when compressed.

Cheese and Milk have given rise to poisonous symptoms from the presence of an alkaloid tyrotoxicon.

Mussels are of all shellfish most liable to produce poisoning (mytilotoxin is the alkaloid); urticaria is a marked symptom, and difficulty of breathing from an acute œdema of the bronchial mucous membrane. The relation of shellfish to enteric fever is discussed later in the Public Health Section.

Treatment of Ptomaine Poisoning.—Empty the stomach and bowels; keep the person recumbent; administer stimulants; inject atropine sulphate, $\frac{1}{50}$ of a grain hypodermically; oil of eucalyptus may also be given internally.

VENOMOUS REPTILES.

Venomous Reptiles. — In tropical countries snake-bites account for an immense number of deaths. There were nearly 22,000 deaths from snake poison in India during the year 1905. The common adder of this country occasionally causes death by its bite.

Symptoms after Snake Bite.—There is a sharp pain in the wound; the part bitten soon swells, becomes livid and œdematous, and blisters form over it. Patches of lividity appear over the body. Vomiting and diarrhœa set in with giddiness, faintness, and great prostration. The pulse becomes feeble, rapid, and irregular, and convulsions may precede death.

Cobra Poison is much the most intense in its effect; gangrene soon appears in the part bitten, and death takes place rapidly from paralysis of the respiratory centre.

Treatment.—If the bite is inflicted on the extremities, a tight ligature should immediately be placed above it so as to prevent absorption of the poison. The wound should be sucked (it is innocuous to intact mucous surfaces). A solution of permanganate of potassium should be injected into and around the wound to neutralise the poison. In the absence of this, ammonia should be used, and antivenene, if it can be obtained, injected hypodermically. Stimulants ought to be freely administered.

The Stings of Bees, Wasps, Caterpillars, etc.—These may give rise to serious symptoms, and have in several cases proved fatal to susceptible persons.

Treatment.—Remove the sting by forceps or pressure, and apply ammonia or washing soda. If the sting has been in-

flicted in the throat, œdema glottidis may render tracheotomy necessary.

CANTHARIDES.

Cantharides has been given as an abortifacient, as an aphrodisiac, as a "joke," or homicidally. The tincture has been swallowed by accident, and the medicinal use of the ointment or emplastrum has caused poisonous symptoms.

Properties.—It is a brown powder containing bright green shining particles, and having a disagreeable pungent odour.

Symptoms.—Burning in throat and stomach; dysphagia; irritation of salivary glands; headache; lachrymation; vomiting of bloody mucus; constant tenesmus and diarrhœa (often bloody); persistent dysuria with passage of small amounts of highly albuminous or bloody urine; pain in the loins; priapism; peritonitis; convulsions, insensibility, and death.

Fatal Dose.—Eleven grains of the powder or 1 ounce of the tincture has caused death.

Fatal Period.—Usually several days.

Post-mortem Appearances.—The whole extent of the gastro-intestinal mucous membrane is inflamed and gangrenous patches are often present. The bright green particles may be seen adhering to the mucous membrane. The genito-urinary tract is inflamed, and acute nephritis may be present.

Tests.—(1) The green particles may be collected, and on shaking up with ether or chloroform, cantharidin is dissolved. The blistering action may then be tested on the lips. (2) If they be heated in the cell of a microscope slide, cantharidin sublimes, and can be detected by the microscope on the cover glass as long quadrangular crystals.

Treatment.—The stomach should be emptied, and demulcent drinks given, but not oils, as cantharidin is soluble in fats. Elimination of the poison should be assisted by purgatives and diurectics. Morphine may be required to mitigate the pain.

VEGETABLE IRRITANTS.

The large group of drastic purgatives owes its action to the irritant properties which the plants possess. In large doses they may produce such a degree of irritation as to endanger the patient's life. Thus, **Aloes** has proved fatal in a

dose of ½ an ounce ; **Colocynth** in 90 grains ; **Gamboge** in 60 grains ; **Croton Oil** in 15 minims ; three **Castor Oil** seeds killed a child. **Jalap, Scammony, Elaterium**, etc., are all dangerous drugs. The ordinary **Holly** (*Ilex aquifolium*) is poisonous, and so are all parts of the **Hellebore Plants**, *Helleborus niger* (Christmas rose) *H. orientalis, and H. fœtidus.*

Savin (*Juniperus sabina*).—An infusion of the powdered tops or the oil is used as an abortifacient. It causes little diarrhœa but intense strangury and tenesmus. The post-mortem examination may reveal green particles, which if dried, give off their peculiar odour, and if teased under the microscope exhibit the dotted ducts and spiral vessels of a coniferous plant.

Ergot of Rye (Spurred Rye, *Secale cornutum*).—This is most universally employed as an abortifacient. In large doses (1 ounce of the fluid extract) it may produce :—

Acute Poisonous Symptoms, gastro-intestinal irritation, coldness of the body, swelling of the face, dilatation of pupils, suppression of urine, abortion, twitchings, ataxia, convulsions, coma, death.

Chronic Poisoning has occurred (chiefly in Russia) amongst people who have had to subsist on bread made from diseased grain. Two forms are observed : (1) Gangrenous form ; acute pain is felt in a limb which swells, becomes dark, and gradually a dry form of gangrene supervenes. (2) Spasmodic form ; the toes and fingers become anæsthetic ; tetanic spasms occur ; these are followed by contractures, and often dementia remains as a permanent sequela.

Test.—If ergot be rubbed with caustic potash a purple lake is produced, and the smell of herring brine is evolved (trimethylamine).

The following plants produce gastro-intestinal irritation, but also exert a profound influence on the nervous system (lividity, twitchings, convulsions, delirium, or coma).

Hemlock (Water Drop-wort, *Œnanthe crocata*), an umbelliferous native plant growing on the banks of streams ; the roots have been mistaken for parsnips. Death may supervene within five minutes.

Water Hemlock (Cow-bane, *Cicuta virosa*) is also an umbelliferous plant with the same habitat. All parts are most intensely poisonous. Convulsions form a marked feature.

Fool's Parsley (*Æthusa cynapium*) is not now believed to be poisonous.

Laburnum (*Cytisus laburnum*). The tree is well known by its bearing long racemes of flowers. The seeds in pods are sometimes eaten by children, and are very poisonous.

Arum Maculatum (Lords and Ladies, The Parson in the Pulpit, etc.) grows in shady woods; the berries are scarlet.

Yew (*Taxus baccata*); an infusion is used as an abortifacient.

Daphne Mezereon.—The berries, variegated in colour, may be eaten. The plant is an ordinary ornamental garden shrub.

White Bryony (*Bryonia dioica*), the wild or hedge vine, grows in the South of England, and bears red berries.

Black Bryony (*Tamus communis*), also a hedge plant, is unknown in Scotland or Ireland.

Ranunculus.—All varieties are poisonous.

Treatment of the Above Poisons.—Empty the stomach and bowels; give demulcents and stimulants. If the pain is intense, morphine may be required, but it retards elimination. Inhalation of amyl nitrite is useful in poisoning by ergot, and chloroform may be required where the convulsions are severe.

NEUROTIC POISONS.

A. SOMNIFEROUS POISONS.

OPIUM, ETC.

Opium and Its Preparations form the second group of poisons most frequently employed for suicide, but seldom for the murder of adults. Infants are often poisoned feloniously by the drug or through accidental overdoses of "soothing syrups."

Preparations.—*Opium* occurs in dark-brown masses with a poppy-like smell, and bitter taste. *Tinctura Opii* (Laudanum) contains 1 grain opium in 15 minims. *Tinctura Camphoræ Composita* (Paregoric) contains 2 grains to each ounce. *Extractum Opii*, 20 per cent morphine. *Pulvis Ipecacuanhæ Compositus* (Dover's powder) contains 1 grain in 10. *Pulvis Cretæ Aromaticus cum Opio* 1 grain in 40. *Pulvis Kino Compositus*, 1 grain in 20. *Pilula Saponis Composita*, 1 grain in 5½. *Pilula Plumbi cum Opio*, 1 grain in 8. *Vinum Opii*, 1 grain in 20. Various proprietary preparations contain opium in large amount, *e.g.* Battley's Liquor Opii Sedativus (double the

strength of laudanum); Collis Browne's Chlorodyne; Dalby's Carminative; Winslow's Soothing Syrup for infants.

Symptoms begin within half an hour with a feeling of pleasant mental stimulation. Soon headache and weariness are complained of; a lethargy steals over the person and he falls asleep; the face is flushed, and the breathing slow. The patient can be roused to speak, but soon falls asleep again; the pupils are contracted, and the skin warm and moist; the pulse is slow and full. The sleep becomes deeper and deeper, and the pupils more and more contracted. Gradually it becomes difficult to rouse the individual, and latterly impossible. Complete coma is the ultimate condition, and during this he sinks; the breathing becomes stertorous or Cheyne-Stokes in character; the pulse rapid and weak; the face pale, the extremities cyanotic, and death results from slow asphyxiation, and heart failure. It is rare to meet with vomiting, delirium, or convulsion.

Diagnosis is often not easy. The smell of the drug may afford assistance, and the statements of the patient, if he can be roused.

In Cerebral Apoplexy the onset is sudden; the patient cannot be roused; the pupils are dilated or unequal in size; hemiplegia is present; the condition of the heart and arteries may afford confirmation.

Acute Alcoholic Poisoning.—The two poisons (alcohol and opium) are often combined, hence the odour of alcohol affords little information. Vomiting is a frequent symptom; the pupils are usually dilated, and the individual can generally be roused. The urine may reveal the presence of either.

Compression of the Brain.—There will usually be a history of the accident, and fractures of the skull may be present; the pupils are unequal and dilated; subconjunctival hæmorrhage may be observed, and the degree of paralysis increases.

Uræmic or Diabetic Coma can best be diagnosed by an examination of the urine.

Post-mortem Appearances are merely those of slow asphyxiation, the lungs being almost black from congestion.

Fatal Dose.—Four grains of opium or 1 drachm of laudanum has proved fatal.

Fatal Period.—On an average death does not take place until the lapse of eight to twelve hours. If the patient survives forty-eight hours, the prognosis is favourable.

Tests.—Note carefully the smell; that of opium is very distinctive. A rough test, applicable to the filtered vomit or to drops left in a tumbler or phial, is to add a few drops of a weak solution of ferric chloride, when a red colour is produced if opium be present (meconate of iron). Morphine is the chief alkaloid in opium, and exists as the meconate of morphine. The constituents of this salt should be isolated and identified.

Lassaigne's Method.—Treat the vomit, etc. with acetic acid, and so obtain the acetate of morphine; meconic acid becomes free. Allow the solid matters to subside; decant the solution, and add to it acetate of lead in excess. This will cause a precipitation of meconate of lead, which filter off. (1) Take the residue on the filter and wash it into a tube; pass sulphuretted hydrogen gas in to form sulphide of lead. The meconic acid remains in the solution, and gives a cherry-red colour with perchloride of iron, which is not discharged by dilute acids or perchloride of mercury. (2) The original filtrate contains acetate of morphine. Remove the excess of lead by passing in sulphuretted hydrogen. Tests may then be applied to the acetate of morphine solution.

Morphine may be recognised by adding (1) A drop of nitric acid, when a rich orange colour is obtained. (2) A drop of ferric chloride gives a greenish-blue colour. (3) A drop of sulphuric acid and also one of bichromate of potassium give a play of colours, brown ending in green.

Treatment of Opium Poisoning.—The stomach should be washed out at once. Even if the alkaloid has been taken hypodermically, much of it is excreted into the stomach, and can thus be got rid of by gastric lavage. A solution of permanganate of potassium (10 grains to a pint of water) should be used for washing the stomach, because it has the property of oxidising and destroying morphine; 1 grain of permanganate neutralises 1 grain of morphine or 10 grains of opium. It may also be injected hypodermically (1 grain to 1 drachm of water) every half-hour. In the absence of this salt, Condy's fluid may be employed. In the early stages sleep should be prevented. The patient should be roused by making him walk about, by applying cold affusions to the head, by inhalations of ammonia, by the administration of hot coffee or beef tea either by the mouth or by the rectum. Infusion of tea, tannic or gallic acids may also be given. If

the patient shows signs of collapse, however, this treatment should not be persevered in, but his strength should be conserved. Atropine sulphate is to a certain extent a physiological antidote, and may be injected hypodermically ($\frac{1}{20}$ of a grain) together with caffeine or strychnine. Inhalations of nitrite of amyl may be useful, and in the last stages artificial respiration may be required.

Opium-eating; The Opium Habit.—Through the habitual use of the drug, marked toleration is induced. It is by no means infrequent to find individuals who swallow amounts which correspond to 50 or 100 grains of solid opium daily. De Quincey usually took 9 ounces of laudanum each day, or about 300 grains of opium. The constant use of opium leads to loss of appetite, marked constipation, great emaciation, intense neuralgia in many cases, premature senility, and mental enfeeblement. Life is usually shortened, though not markedly so.

Morphine.—Poisoning by morphine may result from an overdose or from a mistake in dispensing. The symptoms are very similar to those of opium poisoning, but irritation or itching of the skin is more often observed; tetanic spasms are also occasionally seen.

Fatal Dose.—One grain has caused death.

Morphine Habit; Morphinism; Morphinomania.—This is a habit acquired by those to whom the drug has been administered either by the mouth or subcutaneously. Often their whole bodies are covered by the punctures made in injecting the poison. Nausea and vomiting are frequent *symptoms*. As a rule, the victims become miserable, emaciated creatures, and only too often require asylum treatment on account of mania. In the *treatment* of such cases success has followed the administration of atropine along with the morphine. The quantity of the former is gradually increased, while that of the latter is diminished until the effects of the atropine predominate. Tonic drugs (strychnine) and bromides should also be administered.

Opium and Belladonna. — Poisoning may result from swallowing a mixture of these in the form of liniments either accidentally or with suicidal intention. The *symptoms* will either be narcotic or deliriant according to the relative proportion of each present. The drugs to a certain extent neutralise one another.

B. DELIRIANT POISONS.

Group Action.—The symptom common to the group is, as a rule delirium; this is of an active, happy, or furious form. The person laughs, has auditory and visual disturbances, and exhibits marked dilatation of the pupils with staring of the eyes. Flushing of the face and of the skin surface generally, with dryness of the throat and mouth, and frequent desire to pass water, are observed. In the later stages coma may be present, and if this gives place to delirium the prognosis is favourable, indicating that the toxic effects are passing away.

SOLANACEOUS PLANTS.

BELLADONNA, ETC.

Belladonna; Deadly Nightshade (Atropa Belladonna).—This is a handsome perennial which grows near villages or on old ruins. The flower is bell-shaped, and is not conspicuous (June to August). Shining black sweetish berries with a deep central furrow are borne in September. Poisoning may result from overdose of medicine, from swallowing the extract, liniment, or eye drops, or by absorption from belladonna plasters. Children may eat the berries, but they are more tolerant to belladonna than are adults.

Symptoms.—The usual group symptoms are present; the redness of the skin is scarlatiniform; paralysis may be present, and the temperature is above the normal.

Distinction has to be made between atropine poisoning, delirium tremens or acute mania.

Fatal Dose.—One half grain of the alkaloid or 1 drachm of the liniment has proved fatal, as have also fourteen berries, within twenty-four hours.

Tests.—A reliable test is to place a drop of the patient's urine in a cat's eye; the pupil will dilate immediately if atropine be present. The alkaloid after separation will give this reaction also.

Treatment.—The stomach should be emptied; tannic acid should be given. Morphine is a partial physiological antidote,

as is also pilocarpine. Stimulants are also required in some cases.

Hyoscyamus Niger ; Henbane.—This plant grows near the seashore, bears yellow flowers, and has caused poisoning by the root being cooked in mistake for parsnips. The seeds have been employed for seasoning, or the tincture has been taken in an overdose.

Datura Stramonium (**The Thorn Apple**) grows on dung-heaps or waste places. The seed-vessel is prickly, and the flower is white, and trumpet-shaped.

Solanum Dulcamara, Woody Nightshade, "The Bitter-sweet."—This is a trailing plant which is common along the roadside hedges. The flowers are small and purple, and the berries are bright red in colour.

Solanum Nigrum (**Black or Garden Nightshade**) grows in gardens, by the roadside, on manure heaps, etc. The berries are black. Gastro-intestinal symptoms may be also present in poisoning by this, and the preceding plants.

Solanum Tuberosum.—Sometimes large numbers of persons have been affected injuriously by eating the common potato. This solanisation may be due to organisms which cause the development of the alkaloid in the tuber, though the berries which follow the flower have caused death in a few instances.

Cannabis Indica; Indian Hemp.—When smoked this produces a kind of intoxication and mania which sometimes takes a homicidal form. It forms the chief constituent of *hashish* which is largely made use of in the East as a narcotic.

Cocaine is the alkaloid of *Erythroxylum coca.* Fatal results have followed an overdose hypodermically given for the production of local anæsthesia. It acts energetically as a cardiac depressant.

Symptoms.—Giddiness and faintness; the pulse becomes imperceptible; breathing is rapid and shallow; pupils are dilated; cyanosis is marked; great restlessness is present; convulsions are rarely seen; death may ensue from respiratory paralysis.

Fatal Dose.—Two-thirds of a grain has proved fatal.

Treatment.—Emetics; stimulants; nitrite of amyl; ammonia by inhalation and internally; recumbent position.

The Cocaine Habit is induced by the frequent self-administration of the drug hypodermically. It induces at first excitation, but this is followed by depression; the memory

becomes defective, hallucinations are present; itching of the skin ("cocaine bugs"); melancholia or mania are results.

Cocculus Indicus.—The Levant nut is intensely bitter by reason of its active principle picrotoxin. Formerly it was used to impart a bitter taste to beer, instead of using hops, and also on account of its intoxicating property. Poachers have used it to poison trout in streams, and these poisoned fish when eaten have induced poisonous symptoms.

Symptoms.—The chief are lethargy, stupor, and convulsions, with vomiting and diarrhœa.

Fatal Dose.—Thirty-six grains of the powdered nuts = $\frac{1}{3}$ of a grain of picrotoxin, have proved fatal in thirty minutes.

Treatment.—The usual remedies for deliriant poisons together with chloral or bromides.

Camphor has caused poisoning through children swallowing lumps, or by an overdose of the Spirit or Camphorated Oil. It acts first as a stimulant, and then as a depressant to the nervous system. It gives a marked odour to the breath. An infant died from swallowing 30 grains.

Poisonous Fungi.—The chief poisons present in fungi are (1) Phallin, which acts chiefly on the blood as a hæmolytic (*Agaricus v. Amanita phalloides*, *Mappa*, etc.); (2) Muscarin, which affects the nervous system primarily (*Agaricus muscarius*, *A. pantherinus*, *Boletus luridus*, etc.).

Symptoms.—These may come on at once or may be delayed for several hours (eight to thirty). Either severe gastro intestinal or nervous symptoms may predominate, according to the alkaloids present. As a rule, the salivary and lachrymal glands secrete actively. Vomiting and diarrhœa are severe, with cyanosis and collapse. Along with these there may be headache, giddiness, illusions, delirium, convulsions, and coma.

Fatal Period.—Death often takes place within twenty-four hours.

Post-mortem Appearances.—In those cases which result from phallin poisoning, the blood remains fluid, rigor mortis is transient; numerous subserous petechial hæmorrhages are present, and the internal organs show marked fatty degeneration.

Treatment.—If the case is seen early enough, the stomach and bowels should be emptied. Hypodermic injections of atropine should be given as it is to a certain extent antagonistic to muscarin. In the case of phallin poisoning, transfusion of

blood or infusion of saline solution is preferable. Stimulants are also to be employed.

Edible Fungi are numerous (*Agaricus odorus*, *Hydnum repandum*, *Boletus*, *Fistulina hepatica*, *Morchella esculenta*, etc.). Certain varieties, like the common mushroom, develop poisonous properties when twice cooked. Those which are edible have generally an agreeable taste and smell, and are firm in consistence.

Poisonous Fungi have often an offensive smell and bitter taste, though these may be masked by cooking. They are often bright green or scarlet, change colour rapidly, and soon become pulpy (*Agaricus phalloides*, *A. cristatus*).

C. INEBRIANT POISONS.

ALCOHOL, ETC.

In this group alcohol, ether, chloroform, and chloral are included. The group action consists usually in excitation and delirium, which is succeeded by sleepiness or narcosis; nausea and vomiting are usually signs of recovery.

Ethylic Alcohol (C_2H_5OH) or ordinary spirit, exists in varying percentage in ordinary beverages. Absolute alcohol contains 99 per cent; methylic alcohol is absolute alcohol with 10 per cent of wood spirit added to make it undrinkable. Proof spirit contains 49·24 per cent, and every $\frac{1}{2}$ per cent above this corresponds to 1° over proof. Brandy or whisky contains 53 per cent; gin, 51; port wine, 20 to 25; sherry, 15 to 20; claret, 10 to 18; hock, 8 to 10; ales and stout, 4 to 6; lager beer, 2 to 3. Many of the so-called temperance beverages contain 2 to 8 per cent of alcohol.

Symptoms.—Confusion of ideas, staggering gait, indistinct speech, flushing of face, dilatation of pupils; stupor, coma, convulsions. Death may take place suddenly during apparent recovery. The temperature of the body falls very markedly before death. Acute alcoholic insanity may be a result of its poisonous action.

Diagnose carefully from concussion, compression, apoplexy, opium poisoning, or coma due to disease.

Fatal Dose.—Children are very susceptible to alcoholic poisoning, and boys have frequently died from drinking two

or three glasses of whisky. Adults sometimes kill themselves in endeavouring to drink a large amount within a short period.

Post-mortem Appearances are merely those of congestion of the brain and internal organs.

Tests.—If to the suspected fluid (1) a small quantity of dilute sulphuric acid and bichromate of potassium be added, a green colour will result, and aldehyde can be recognised by its smell. (2) If caustic potash and iodine be added, and the mixture heated, a yellow precipitate will form. This is recognised as iodoform by the smell, and by the microscopic appearance of the crystals (hexagonal plates).

Treatment consists in emptying the stomach; preventing sleep and coma; giving rectal injections of coffee, and hypodermically strychnine, digitalin, etc.

Methyl Alcohol; Wood Spirit; Pyroligneous or Wood Naphtha, CH_3OH.—This is used as an intoxicant by painters and others because of its cheapness. It is extremely toxic either in a single dose or when taken repeatedly in small doses.

Symptoms are those usual to the group, but vomiting may persist for long; delirium is more marked, and coma may persist for days. Total or partial blindness follows in a large proportion of cases, and is due to optic atrophy subsequent to optic neuritis. Blindness may be the only symptom. The author has seen a case of complete blindness in a young man, which resulted from a single dose of four teaspoonfuls of methylated spirit.

Fatal Dose.—Half a pint has proved fatal.

Fatal Period.—This is usually one or two days.

Ether, Sulphuric Ether, $(C_2H_5)_2O$, gives rise to a burning heat and pain in the stomach and bowels, and an intense degree of intoxication results. The odour is very characteristic.

CHLOROFORM.

Chloroform ($CHCl_3$) proves much more fatal when swallowed than when inhaled. Accidents happen from swallowing the liniment, or it may be taken suicidally. Abdominal pain is complained of, and coma persists for long; vomiting and diarrhœa are usually present.

Fatal Dose.—Half an ounce has killed an adult.

Fatal Period.—This is usually long—thirty hours and upwards.

Post-mortem Appearances.—Congestion of the internal organs is present as a rule; the smell of chloroform is very marked on opening the cavities, and especially the skull. Jaundice and fatty degeneration of the internal organs is found.

Tests.—The odour and sweet taste are characteristic. It also dissolves gutta-percha and camphor. In organic mixtures, distillation is necessary to obtain it pure for testing. (1) If an alcoholic solution of caustic potash is added, and the mixture be heated with a drop of anilin, isobenzonitrile is formed, and can be detected by its disagreeable smell. (2) If the solution be heated in a flask, the vapour may be decomposed into chlorine and hydrochloric acid by heating the exit tube to redness; chlorine may be recognised by its turning an iodide of starch paper blue, and by the acid reddening litmus paper. (3) When warmed with β-naphthol in strong caustic potash, a blue colour results, which becomes green and finally brown.

Treatment.—Empty the stomach. Give copious draughts of tepid water containing carbonate of soda. Hypodermic injections of atropine, strychnine, etc., should be made; rectal injections of coffee, and artificial respiration may be necessary.

Delayed Chloroform Poisoning.—This shows itself not infrequently in children, and occasionally in adults after chloroform narcosis. It leads to fatty degeneration of the internal organs, and sudden death in from five to seven days. It is in reality poisoning by acetone.

CHLORAL HYDRATE.

Chloral Hydrate, $CCl_3CH(OH)_2$.—Formerly this drug was largely employed as a hypnotic, and fatal accidents frequently happened from overdoses. It is used as a suicidal agent, and has also been employed for the purpose of murder. It forms an ingredient of many patent medicines. The syrup contains 10 grains to each drachm.

Symptoms.—The individual soon falls into a deep sleep; the face assumes a livid and bloated appearance; the pulse is at first slow and full, but soon becomes rapid and weak, owing to the direct depressant action of the drug; respiration is laboured

and the pupils dilated. Later, the surface becomes cold and cyanosed, and the person dies slowly from asphyxia.

Fatal Dose.—Twenty or 30 grains have proved fatal.

Fatal Period.—Usually six to ten hours.

Post-mortem Appearances are simply those of asphyxiation. The smell of the drug is evident.

Tests.—(1) If a little caustic potash be added, chloroform and potassium formate result, and the former can be detected by its smell. (2) If warmed with ammonio-nitrate of silver, metallic silver is deposited.

Treatment.—The stomach must be washed out, and alkalies given to break up the drug. Non-alcoholic stimulants, strychnine hypodermically, inhalations of nitrite of amyl, and artificial respiration may be required.

IODOFORM.

Iodoform poisoning may occur from its too free use in surgical dressings or when injected into sinuses. Pills have been administered in the treatment of phthisis, and have caused poisonous symptoms.

Symptoms.—In early stages giddiness, vomiting, severe headache, double vision; irregular respiration with fever, rapid pulse, and drowsiness may be the symptoms. Delirium recurring each night, and stupor lasting many hours, or merging into coma, which may persist for days, are later phenomena. The individual may recover with impaired mental faculties; thus, dementia or permanent insanity have been observed.

Fatal Dose.—Thirty grains injected into a sinus caused death.

Fatal Period.—This varies from a few days to two or three weeks.

Test.—Fused with caustic potash, iodine is liberated. The smell is characteristic, and so are the hexagonal crystals.

Treatment.—Acetate of potash should be administered internally. Transfusion of saline solution is advisable.

NITRO-BENZOL.

Nitro-benzol; Nitro-benzene; Artificial Oil of Bitter Almonds; Essence of Mirbane ($C_6H_5NO_2$).—This is a yellow liquid having an odour of bitter almonds. It has been swallowed

accidentally, and has been used to flavour sweets in mistake for oil of bitter almonds, etc. The fumes are poisonous, and as it is employed in the manufacture of anilin colours, the operatives may suffer; it is used in perfumery, and the action of hot water on soap so scented, has induced serious symptoms. The application to cloth boots of liquid blacking containing nitro-benzene caused the death of a man.

Symptoms which result from swallowing or inhalation may not begin to show themselves for several hours. The most prominent symptoms are confusion of ideas or apparent intoxication together with marked cyanosis of the extremities. The urine is very dark; the pupils are dilated; convulsions may result, and death takes place from asphyxia.

In Chronic Industrial Poisoning weakness, cyanosis, dyspnœa, darkness of urine, affections of sight, etc., are observed.

Fatal Dose.—Eight to 10 drops have caused death.

Fatal Period.—This may be as short as four hours, but is usually delayed for from one to two days.

Post-mortem Appearances are those of death from asphyxia, together with the marked odour.

Tests.—The odour is very well marked after acidification of the stomach contents. On treatment with a reducing agent, as nascent hydrogen, nitro-benzene is changed into anilin.

Treatment.—Empty the stomach; non-alcoholic stimulants; transfusion; injections of strychnine or digitalin; artificial respiration.

ANILIN, ETC.

Anilin, $C_6H_5NH_2$, forms the basis of most of the coal tar dyes or synthetic drugs (phenazonum, exalgin, etc.). It is an oily red fluid. Poisoning may result from its use in industrial arts either from inhalation of the fumes or from local contact. Sucking an anilin pencil has produced serious symptoms.

Symptoms.—These closely resemble poisoning by nitro-benzol. A greyish-blue colour of the face and extremities is specially noticeable (methæmoglobin), and may be present even in slight cases; it may not be recovered from for five to six weeks. The *chronic* form is chiefly associated with the production of nervous symptoms, and blindness.

Fatal Dose.—Several drachms swallowed have caused death.

Fatal Period.—This may be within a few hours.

Test.—If warmed with chloroform and alcoholic solution of caustic potash, isocyanide of phenyl is produced.

Benzol; Benzene, C_6H_6.—This is a thin liquid with an odour of coal gas. It is used in "dry-cleaning," and the vapour has caused poisoning. The symptoms closely resemble those of anilin.

Fatal Dose.—Three drachms have caused death, and this within seventeen hours.

Petroleum consists of many hydrocarbons of the paraffin series, and in its effects closely resembles the foregoing.

Turpentine; Oil or Spirits of Turpentine.—This is not a powerful poison, and is frequently given as a vermifuge, or in the treatment of lumbago or sciatica. When acting as a poison, it may produce a degree of intoxication with dysuria, and the usual group symptoms.

Nitro-glycerine.—Poisoning may result from an overdose of the Liquor Trinitrini, or amongst those who manufacture the substance.

Symptoms.—Intense and persistent headache is the chief symptom, ("powder headache"), with throbbing and pulsation all over the body from dilatation of the blood-vessels. The face is flushed, and collapse may follow. Death results from syncope, and from the formation of methæmoglobin.

Treatment consists in keeping the person in the recumbent position; giving ergotin, adrenalin, or atropine hypodermically; black coffee for the headache, and saline infusions.

Such anilin derivatives as **Acetanilid, Trional, Veronal, Phenazonum, Exalgin,** etc., are poisonous in large or even in small doses to those who have a particular idiosyncrasy. Most of them act as intense cardiac depressants, causing syncope, and also act on the blood or nerves, producing skin eruptions and marked cyanosis.

Sulphonal.—In chronic poisoning gastro-intestinal symptoms appear with paralysis and delirium. The urine becomes dark-red (hæmato-porphrynuria) from the destruction of the blood cells. Death is due to cardiac failure.

Fatal Dose.—Thirty grains may cause death.

Formalin, or solutions of formaldehyde. Accidents have happened from accidentally swallowing formalin. Giddiness, nausea, pallor, cyanosis, subnormal temperature, stupor, or coma are the usual symptoms.

The Treatment is to empty the stomach, and give ammonia freely in solution by the mouth.

SEDATIVES, OR DEPRESSANT POISONS.

A. NEURAL POISONS (CONIUM, LOBELIA, TOBACCO, PHYSOSTIGMA, CURARE).

These act chiefly on the motor nerve cells of the cord, producing paralysis. This begins at the lower part of the cord and gradually spreads upwards, death taking place from involvement of the muscles of respiration. Consciousness remains unimpaired. The gait is first affected, and latterly all voluntary power is lost.

CONIUM MACULATUM.

Conium Maculatum.—This is called the Spotted Hemlock from the presence of brown spots on the stem. It is a common umbelliferous plant growing in the hedgerows. The leaves have been made into salads, and children have been poisoned by blowing whistles made of the stems.

Symptoms.—The usual group symptoms are present.

Fatal Dose.—One ounce of the succus has caused death.

Fatal Period.—This varies from one to four hours.

Post-mortem Appearances are those of asphyxiation.

Tests.—The alkaloid must be isolated, and tests applied to it.

Treatment.—Empty the stomach; administer tannic or gallic acids; stimulants; atropine hypodermically, and artificial respiration in extreme cases.

Gelsemium Sempervirens (Yellow Jasmine).—The symptoms are similar to the preceding.

Lobelia Inflata (Indian Tobacco).—In addition to the usual symptoms, vomiting is almost invariable, while diarrhœa and dysuria may be present. It has proved fatal when given as an abortifacient.

TOBACCO.

Tobacco (Nicotiana Tabacum).—The nicotine in an old pipe has sufficed to cause death, as have also infusions of tobacco employed as a vermifuge; the fumes have poisoned those

sleeping amongst bales of tobacco. The drug has an extreme action on the cardiac and respiratory centres, and death may result from their failure.

Symptoms.—Nausea, vomiting, and giddiness, with faintness and intense prostration form the initial symptoms. The person becomes intensely pale, the pupils dilated, the pulse imperceptible, and unconsciousness follows.

Chronic Poisoning may result from smoking (cigarettes chiefly) or chewing tobacco. The symptoms are mainly those of cardiac irritability and weakness. The vision may become affected, leading to amblyopia.

Fatal Dose.—A lad who smoked one pipeful at a first attempt died in consequence. A few drops of nicotine are poisonous.

Fatal Period.—This may be only a few minutes.

Post-mortem Appearances are merely those of asphyxiation.

Physostigma Venenosum ; Calabar Bean ; Ordeal Bean of West Africa.—The beans are large, and have been eaten by children. The usual group symptoms are present in cases of poisoning. Atropine is, to a certain extent, a physiological antidote.

Curara ; Woorari ; South American Arrow Poison.—This drug possesses in an extreme degree the property of paralysing voluntary muscular effort. It was formerly employed to abolish voluntary movements in animals during physiological experiments. Its use is now prohibited by the Vivisection Act.

B. CEREBRAL DEPRESSANTS.

HYDROCYANIC ACID.

Hydrocyanic or Prussic Acid (HCN).—This is the most powerful poison which exists. Medical men, chemists, and photographers, who know the extremely lethal effects of this drug, often employ it as a suicidal agent. Formerly accidental poisoning occurred through swallowing the essential oil of bitter almonds from which this acid had not been extracted. The ordinary Acidum Hydrocyanicum Dilutum contains 2 per cent of the anhydrous acid, while Scheele's solution contains 4 per cent. The acid has a peculiar and distinct odour like bitter almonds, and produces a dry sensation

at the back of the nose and throat when inhaled. Two persons were recently murdered by drinking stout to which prussic acid had been added.

Symptoms come on immediately. The individual may utter a piercing cry; feels giddy, staggers, and falls down insensible. The eyes are fixed, the pupils dilated; the jaws are rigid, but all other muscles are flaccid. Urine and fæces are passed involuntarily; the pulse is imperceptible. The facial muscles may twitch, or there may be convulsive movements; cyanosis is present, and froth appears at the mouth. A few violent gasps are made, and death supervenes.

Fatal Dose.—Inhalation of air saturated with the vapour of this acid may cause instant death. When very dilute, a fatal result may be delayed for ten or fifteen minutes. Thirty drops of the dilute acid have caused death; this corresponds to a little more than $\frac{1}{2}$ a grain of the anhydrous acid.

Fatal Period.—Death has taken place within two minutes. The longer that death is delayed the greater is the probability of recovery; if the person survives half an hour he will probably recover. Even after swallowing a fatal dose the individual may perform certain acts, as corking the bottle, and placing it in a cupboard, etc.

Post-mortem Appearances.—The skin exhibits bright red patches on the dependent parts of the corpse; there is froth at the mouth, and the body is often in a more or less convulsed attitude. The gastro-intestinal mucous membrane is bright red in colour owing to the action of the poison on the blood (cyanmethæmoglobin), the spectrum being characteristic; subserous hæmorrhages are present. On opening the cavities the odour of the acid is very evident, but it is soon lost on exposure to the air.

Tests.—On opening the abdomen or stomach odour should be identified by several persons. The stomach-contents should be heated in a retort, and the acid recovered by distillation. The following tests are applicable to the fluid or to the vapour. (1) If silver nitrate be added, a white flocculent precipitate is obtained, the crystals of which are characteristic when examined by the microscope. The precipitate is soluble in boiling nitric acid. (2) If the solution be heated with caustic potash and ferrousferric sulphate, a brown precipitate forms; on adding hydrochloric acid, Prussian blue is produced. (3) Liebig's sulphur test. If sulphide of ammonium be added, and a small

quantity be evaporated to dryness, the colourless ammonium sulphocyanate is formed. If a drop of dilute hydrochloric acid, and another of ferric chloride be added to the residue, a cherry red colour is produced. On adding perchloride of mercury this colour disappears.

Treatment.—Wash out the stomach; inject atropine; administer stimulants; give hot and cold douches; artificial respiration. Sodium hyposulphite, or old sulphate of iron with carbonate of potash may be given, so as to produce the harmless Prussian blue.

CYANIDE OF POTASSIUM.

Cyanide of Potassium (KCN) occurs in flat crystalline masses, which are deliquescent. It is largely employed in the arts; in electroplating, photography, gilding, for cleaning gold or silver lace, etc. It acts as a poison exactly as prussic acid, but has in addition a local corrosive action. The hydrochloric acid in the stomach sets free hydrocyanic acid.

Fatal Dose.—Two and a half to 5 grains have caused death.

Tests.—It gives the same series of reactions as prussic acid after freeing the acid by acidulation.

Chronic Poisoning.—A train of symptoms due to the action of this poison is seen in workmen exposed to its action, viz. headache, vertigo, anæmia, fœtid breath, dyspnœa, etc.

ESSENTIAL OIL OF BITTER ALMONDS; RATAFIA OIL.

This oil is obtained by the distillation of bitter almonds crushed in water. It owes its strong and pleasant odour to hydride of benzol; it also contains from 8 to 15 per cent of pure hydrocyanic acid. The latter must be removed before the essential oil can be used as a flavouring agent. Fatal accidents have happened from the use of such oil, the poisonous acid not having been completely removed.

Essence of Peach Kernels (almond flavour, spirits of almonds) is a dilute alcoholic solution of the preceding.

Laurel Water (*Aqua laurocerasi*) contains $\frac{1}{4}$ per cent of prussic acid.

Bitter Almonds, the Kernels of Peaches, Plums, Cherries,

Apple Pips, *Tapioca*, etc., all contain hydrocyanic acid; severe symptoms, and even death, have followed on these being eaten.

C. CARDIAC DEPRESSANTS.

ACONITE.

Aconite; Monkshood; Blue Rocket; Wolfsbane; Aconitum Napellus.—This is a very ornamental plant grown commonly in gardens. All parts are poisonous; the leaves have been made into salads; the root has been mistaken for horse radish; the tincture has been swallowed in overdoses, and the liniment has been taken by mistake.

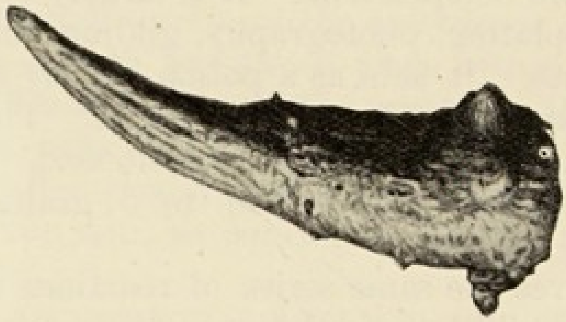


FIG. 20.—Dried root of *Aconitum napellus* (natural size).

Symptoms.—A warmth and tingling is felt at once in the lips, tongue, throat, gullet, and stomach; the throat feels constricted, and swallowing of saliva is frequent. The tingling soon extends over the whole body; the fingers feel numb, and the head enlarged. Vision and hearing become impaired; nausea and vomiting with severe abdominal pain may be present. Paralysis of motion and sensation commences in the lower limbs, and gradually spreads upwards. Respiration is at first rapid, but soon becomes shallow and slow. The pulse becomes irregular and gradually fails, and convulsions may precede death. The intellect remains unimpaired until the end.

Fatal Dose.—One drachm of the tincture, 1 ounce of the liniment, or 4 grains of the extract have caused death. The alkaloid, aconitine, is perhaps the most active of all poisons, so little as 4 milligrammes (about $\frac{1}{16}$ of a grain) has caused death.

Fatal Period.—This is on an average four hours.

Post-mortem Appearances.—The mucous lining of the stomach and bowels is congested and inflamed.

Tests.—The seeds are three-sided, and about $\frac{1}{6}$ of an inch long. One is sufficient to produce tingling in the mouth. The root is carrot-shaped, and when fresh is about 3 to 4 inches long. The root of the horse radish is cylindrical, and from 8 to 10 inches long when fresh; it has a hot pungent taste, but produces no numbing of the lips or tongue.

Treatment Applicable to the Entire Group.—Empty the stomach; give tannic acid, atropine, digitalin; amyl nitrite; keep the person at rest in bed; stimulants, strychnine, etc.

Aconite and Belladonna.—A mixture of these liniments is frequently prescribed, and may be swallowed by mistake or intentionally. The symptoms will depend on the relative proportions of each present. The drugs are to a slight extent antagonistic.

DIGITALIS.

Digitalis; Purple Foxglove (Digitalis Purpurea).—This is a handsome plant which grows on hill-sides. Poisoning has resulted from swallowing the tincture by mistake, or from the rapid dissolving of hard pills swallowed some time previously.

Symptoms.—Severe pain in the abdomen; grass-green vomit; colic, watery diarrhœa. The pulse becomes slow (down to 25 per minute), weak, and irregular; in the later stages it becomes very rapid. The pupils are dilated, the urine is suppressed; delirium, stupor, coma, or convulsions may be present. Death may be sudden from syncope, and may take place on exertion during apparent convalescence.

Chronic Poisoning.—This may be a result of the medicinal use of the drug; nausea, vomiting, headache, weakness, restlessness, sleeplessness; rapidity of the pulse and dilatation of the capillaries may be observed.

Fatal Dose.—Thirty-six grains of the leaves, 1 ounce of the tincture, or $\frac{1}{4}$ of a grain of digitalin have proved fatal.

Fatal Period.—This is usually several days.

Post-mortem Appearances are not characteristic.

COLCHICUM.

Colchicum, Meadow Saffron, Autumn Crocus (Colchicum Autumnale).—Colchicum wine has been drunk instead of ordinary sherry, with fatal results. Patent remedies for the cure of gout containing this drug have caused death (Blair's Gout Pills).

Symptoms.—Besides the intense heart weakness which this drug induces, vomiting and purging with abdominal pain are the most prominent signs. Nervous symptoms may also be present.

Fatal Dose.—One-half to 1 ounce of the wine or 1½ ounces of the tincture have caused death.

Fatal Period.—This is usually from one to three days.

Veratrum Album (White Hellebore).—The powdered root is employed as a parasiticide, and has been swallowed by mistake, or has been given with murderous intent.

The Symptoms are similar to the preceding.

Veratrum Viride ; Indian Poke ; Green Hellebore.

Santonin is the alkaloid of *Artemisia maritima* (or Wormwood).

Symptoms.—Giddiness, yellow vision, convulsions, coma, and death.

Fatal Dose.—Three grains have proved fatal to a child.

Test.—When fused with caustic potash, a red colour results.

EXCITO-MOTORY OR CONVULSIVES.

NUX VOMICA.

Nux Vomica (Strychnos Nux Vomica).—Poisoning may result from the powder or alkaloid being swallowed suicidally, or given homicidally. Mixed up with meal or flour and coloured, the alkaloid is sold as *Vermin Killers* (Battle's, Butler's, Gibson's), and these are often taken by suicides. Medicines containing strychnine have been taken in excessive doses, such as tablets of Easton's Syrup ; mistakes in dispensing have occurred, thus, 10 grains of strychnine sulphate have been given in mistake for phenacetin. Easton's Syrup contains strychnine, and has caused death when taken in an overdose ;

it has also been taken suicidally. Each seed is circular, biconcave, weighs about $\frac{1}{2}$ a drachm, and contains a fatal amount of strychnine.

Symptoms.—An intensely bitter taste is at once complained of. After a time, varying from a few minutes to several hours, the person experiences a tight feeling over the chest with sensations of suffocation. Certain muscles begin to twitch involuntarily, or painful cramps are present. Soon after this, general tetanic convulsions commence, each being ushered in with a scream of pain. These usually lead to the arching of the body backwards (*opisthotonos*), the person resting on his heels and occiput; less frequently *emprosthotonos* (bending forward) or *pleurosthotonos* (bending sideways) is met with. Each convulsion persists for from one to five minutes, during which death may take place from asphyxia, or in other cases from exhaustion. The eyeballs are prominent, and the pupils dilated; the *risus sardonicus* is present; the mind remains clear to the end of life. Any stimulus induces a convulsion, hence the patient must be kept perfectly quiet. These convulsions have to be distinguished from those of **Tetanus**; in this there is usually the history of a wound, the symptoms coming on gradually, and developing slowly to their maximum. Lock-jaw is an early symptom, the muscles of the neck and lower jaw becoming affected first, and only after some time do the muscles of the trunk and limbs become involved. Opisthotonos is a late condition in tetanus, and the intervals between the fits are never entirely free from rigidity. Severe pain is complained of in the epigastrium owing to contraction of the diaphragm, while this is absent in strychnine poisoning. In poisoning by the latter, death takes place within a few hours, while it is delayed for some days in the case of tetanus.

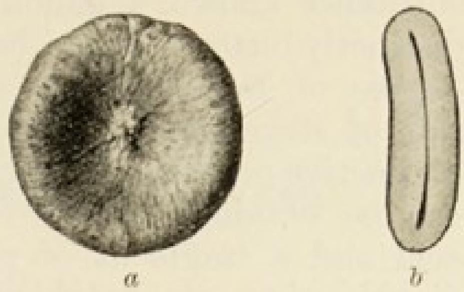


FIG. 21.—(*a*) Seed of *Strychnos Nux Vomica* (natural size). (*b*) Section through the same.

Fatal Dose.—Three grains of the extract, 30 grains of the powder, or $\frac{1}{2}$ a grain of strychnine have caused death.

Fatal Period.—This varies from two to four hours. Ten minutes is the shortest, and six hours the longest recorded period.

Post-mortem Appearances.—The stiff, convulsed attitude

may pass into rigor mortis without relaxation, and may then persist for months. The other signs are usually those of death by asphyxia.

Tests for Strychnine.—The rectangular prisms may be identified by the microscope. It is the most intensely bitter substance known, a gallon of water containing 1 grain being distinctly bitter. It can be isolated from bodies in an advanced degree of putrefaction. (1) If to a watery solution of the salt of strychnine a drop of potassium bichromate be added, distinctive octahedral crystals are formed. (2) A play of colours can be obtained by the following:—(*a*) A drop of sulphuric acid and a fragment of potassium bichromate or manganese dioxide give colours changing from blue to purple, crimson, red, and brown. (*b*) Sulphuric acid and potassium permanganate give very similar reactions. (3) Physiological test: a drop of the salt or a drop of urine from a poisoned individual, placed on a frog's back will throw it into convulsions.

Treatment.—If the case is seen very early, the stomach should be emptied by emetics. The stomach tube must not be used after twitching of the muscles has commenced until the patient has been placed under the influence of chloroform. Tannic acid, permanganate of potassium, or, better, a decoction of Eucalyptus globulus should be given. Chloral hydrate or potassium bromide is also useful. The convulsions must be prevented either by injecting stovaine or novocaine by lumbar puncture, or by continuing the administration of chloroform until all tendency to rigidity has passed away.

VULNERANTS.

Powdered Glass is not so dangerous as might be thought. The finer it is powdered the less is the danger. It has been taken with suicidal intention, or given mixed up in gruel or porridge for homicidal purposes. Professional exhibitors ("human ostriches") often come to untimely deaths from gastro-enteritis, or perforation of the stomach or bowels, caused by fragments of glass, pottery, nails, tacks, etc., which they have swallowed. A woman recently committed suicide by swallowing one hundred and forty-four needles of all sizes; twelve of these found their way to her heart, so causing death.

CHAPTER V.

POISONOUS AND IRRESPIRABLE GASES.

CARBON DIOXIDE.

Carbonic Acid Gas, CO_2.—This is a heavy gas having a specific gravity of 1·52 as compared with air. It does not tend to rise, and collects wherever organic matter is undergoing decomposition.

Occurrence.—It is found in large amount in caves, damp cellars, mines, dirty wells, brewers' vats after the fermenting wort has been drawn off, aerated water factories, etc. It forms a proportion of the gases which result from explosions in mines, "choke-damp." It is produced in charcoal stoves, and, if not removed by proper flues, escapes into the room. Vagrants have been asphyxiated by this gas while sleeping on burnt lime heaps.

Symptoms.—Inhalation of the pure *undiluted* gas causes immediate spasm of the glottis. The individual becomes insensible and falls down, death supervening in a few minutes. Such accidents happen to men who enter disused mines, wells, vats, pits, etc. The gas when *diluted* acts more slowly, and resembles a narcotic in its action. The person complains of headache, heaviness, and tinnitus aurium; he becomes giddy and drowsy. Muscular power is gradually lost, the head falls forward on the chest; sleep passes into coma, and death supervenes.

Post-mortem Appearances.—Marked lividity is seen in the eyelids, lips, ears, finger-tips, etc. The blood is dark and venous in colour from reduction of the hæmoglobin. The other appearances are similar to those met with in asphyxia.

Fatal Proportion.—If 10 to 15 per cent of this gas be present in ordinary atmospheric air, fatal results will follow.

The lethal effects of smaller proportions would depend to a large extent on the amount of oxygen present in the air. If the oxygen be reduced in amount, and the carbonic acid gas be present in excess, then fatal results are more likely to follow than when the oxygen is in its full amount. A proportion of 2 per cent of carbonic acid gas exerts deleterious action when breathed for any length of time. In a well-ventilated room the proportion of this gas should never exceed 0·06 per cent. If $\frac{1}{2}$ an ounce of lime water becomes turbid when shaken in a half-pint bottle of air, then this atmosphere contains more than 0·1 per cent of carbonic acid gas. The burning of a candle in a well affords no indication of the safety of such air, as it will continue to burn in an atmosphere containing 10 per cent of carbonic acid gas, and is only extinguished when this gas reaches 16 per cent.

Prevention of Poisoning.—Workmen should not be allowed to enter any suspicious well or mine until such has been well ventilated; this can be done by blowing air or steam down, and so driving the heavy gas out. An open umbrella lowered into a well by means of a cord, may act as a ladle, and can be used to draw up the impure air. Slaked lime may be lowered in pails, and will absorb the carbonic acid gas. It is foolhardy to attempt the rescue of any persons overcome by this gas until the air has been thoroughly diluted with fresh air.

Treatment of all Forms of Poisoning by Gases.—The person should be immediately removed into the open air, and artificial respiration commenced at once. This should be continued as long as the heart beats, which may be for an hour or two. Stimulants may be applied, as ammonia to the nostrils, mustard blisters to the soles of the feet, affusions of hot and cold water to the face and chest. Massage of the limbs, electricity, and the inhalation of oxygen from cylinders should be given also. Infusion of saline solution into the rectum or subcutaneously is often of great value, but best of all is transfusion of defibrinated blood.

CARBON MONOXIDE.

Carbon Monoxide; Carbonic Oxide, CO.—This is one of the most lethal gases which exists. A proportion of 2 per cent in the atmosphere causes immediate death, while a $\frac{1}{2}$ to 1 per cent

causes death very rapidly. In one case a proportion of 0·17 per cent caused death, but the oxygen was also reduced to 18·05 per cent. The gas is colourless, odourless, lighter than air in the proportion of 0·967 to 1, and burns with a pale blue flame.

Occurrence.—This gas is formed whenever carbon is burned with an insufficiency of oxygen. After explosions in mines it may amount to 1·5 or 2·5 per cent and thus forms the chief part of the deadly "choke-damp." Owing to the expansion of the gases caused by the explosion, it travels rapidly along the workings, and overtakes the miners who may be fleeing to the shaft. It is the most deadly agent in poisoning by charcoal fumes, and much is evolved in the smouldering of briquettes or wood; individuals may be found dead in bed as a result of a smouldering beam under the floor. When lamps are turned down too low, this gas is formed. In poisoning by coal gas, the lethal effects are chiefly due to the presence of this gas. It is produced in large amount when gunpowder is exploded. In 1886 seven persons were killed by entering a quarry too soon after a blast had been exploded, and in this case 3·6 per cent of carbon monoxide was present. Other explosives also evolve much carbon monoxide.

Symptoms.—When this gas is inhaled in large amount, immediate insensibility ensues; the coma may last several days (six to eight), and may end in death or recovery. When it is present in great dilution, and the exposure has been short, headache, giddiness, nausea, vomiting, and weakness, are complained of and may persist for long. Such a degree of mental torpor is produced, that, though the person realises the danger of his surroundings, he is unable to exert himself even to open a window. If the exposure be prolonged, these symptoms become aggravated; prostration is intense, and coma supervenes. Death may be delayed for several days. Even in cases which recover, profound changes may have been wrought in the nervous system, leading to loss of memory, mental weakness, or insanity, paralysis of various groups of muscles, localised areas of inflammation or gangrene, and herpetic eruptions. Glycosuria is a constant sequela of carbon monoxide poisoning. Partially poisoned individuals sometimes drop down dead at once on being brought into the fresh air.

Diagnosis from Poisoning by Alcohol.—In the case of a person found insensible or dead in a small room or cabin, a diagnosis must be made. If a little blood be drawn off, it is

bright red in colour, and gives other reactions if the poison has been carbon monoxide, and the urine reduces Fehling's solution because of the glycuronic acid which is present.

Post-mortem Appearances.—The face is florid, and has all the appearance of ruddy health; it is difficult to believe that the person is dead. Patches of bright red colour are scattered over the body. The blood is of a bright cherry-red colour owing to the formation of carboxyhæmoglobin (HbCO)—a very firm combination, about two hundred times more stable than HbO. The whole of the tissues of the body are thus of a bright red colour, muscles, liver, spleen, etc. The smaller blood-vessels in the brain are ruptured, and bloody points are seen in the white matter while the grey matter is pink in colour. Putrefaction is greatly retarded.

Detection of Carbon Monoxide in Air.—In a large bottle of the suspected air a small quantity of diluted blood (1 to 100) should be shaken up (away from the light). It becomes bright pink in colour if carbon monoxide be present.

Detection in the Blood of Those Poisoned.—(1) If a few drops of caustic soda solution be added to normal blood, a greenish colour is obtained; while if carbon monoxide be present, the red colour is retained. (2) In a thin layer, normal blood is yellowish, while it is pink if HbCO be present. (3) Kunkel's test consists in the addition of a solution of tannic acid (3 per cent); with normal blood a coffee-coloured precipitate is formed, while it is pink if HbCO be present. (4) Spectroscopic examination reveals two absorption bands similar to those of HbO but placed more towards the violet end. No change is produced on the addition of ammonium sulphide. No absorption bands are seen unless the blood is saturated at least to the extent of 40 per cent with this gas. Mice and canaries are very susceptible to this poison. It is usual to carry a cage of either of these animals into mines after explosions; as soon as the mouse falls over, or the canary off its perch, the explorers know that the air is becoming dangerous.

Treatment.—Make free use of oxygen, which should be pumped into the chest by artificial respiration. Cylinders of oxygen should be kept at all mines or works where noxious gases are evolved. A solution of peroxide of hydrogen may be injected per rectum, and transfusion of blood may be successful. Warmth of the body must be conserved, and care must be taken lest exertion be made by those poisoned.

COAL GAS, CHARCOAL VAPOURS.

Coal Gas.—This consists of a mixture of gases which result from the destructive distillation of coal; hydrogen and marsh gas form the chief bulk (over 80 per cent); carbon monoxide varies from 5 to 25 per cent; smaller amounts of olefiant gas (C_2H_2); bisulphide of carbon, sulphuretted hydrogen, and carbonic acid gas may be present. Its marked and characteristic odour is the greatest safeguard against it as a poison. Its lethal action chiefly depends on the carbon monoxide which is present.

Poisoning from Coal Gas.—This may readily occur by the accidental leakage from taps or broken gas fittings; from broken mains in frosty weather allowing the gas to filter through the ground, and to gain access to dwellings. A frequent method of suicide is to place the gas jet in the mouth, and so to inhale the pure gas, or to turn the tap on, and allow the gas to escape into the room.

Symptoms.—At first headache and giddiness are complained of, with confusion of thought and vomiting. Later, muscular power is lost and unconsciousness follows; the pupils are dilated and insensitive, and coma becomes more and more profound. If much carbon monoxide gas has been present, lividity is not well marked, but a ruddy complexion is usually found.

Post-mortem Appearances.—These vary. The smell of the gas is very pronounced on opening the body. In many cases the signs of death by asphyxia are alone present.

Water Gas ("producer-gas") is a mixture of hydrogen and carbonic oxide, and has acquired this name because it is produced by passing steam through red-hot coke contained in cylinders. It is used in smelting ores because it burns with great heat, but is very dangerous because of its want of odour, which hinders its recognition. For illuminating purposes it is "carburetted" or mixed with the vapour from heated oils which gives it a high illuminating power. As it is very cheaply produced, this carburetted gas is largely used as an addition to ordinary illuminating coal gas.

Charcoal Vapours.—These consist chiefly of a mixture of carbonic acid gas (20 to 25 per cent) and carbonic oxide gas (2 to 3 per cent), together with marsh gas, watery vapour, etc. As charcoal stoves are commonly used on the continent, many

cases of poisoning occur every winter because of these vapours escaping into tightly closed sleeping-rooms. The French writer Zola, met his death in this way. The inhalation of these vapours produces such a degree of lethargy that though the individual knows that he is being asphyxiated he cannot rouse himself to escape; in some cases a degree of delirium is produced. The effects of these vapours on different individuals vary according to their idiosyncrasy. In the same room a person may be found dead, another may be comatose, and a third only drowsy. It is a painless form of death, and these gases led into the "lethal chamber" are used for the execution of stray dogs and cats.

Post-mortem Appearances.—Usually there is marked lividity of the lips, eyelids, nose, ears, finger-tips, and a bloody froth may exude from the nose and mouth.

Coal and Coke Vapours.—These consist chiefly of carbon dioxide and carbon monoxide gases, together with sulphurous acid, sulphuretted hydrogen, and tarry matters. Fatal cases of poisoning by these vapours are rare because of their irritating character, sneezing and coughing awakening the individual. Accidents have, however, occurred from chimneys becoming obstructed by slates falling into them, bricks becoming dislodged, dampers being blown down, etc.; if the occupant of the room be in a deep sleep from alcohol or narcotics, death may supervene from inhalation of these gases. Similar accidents have happened on board ship owing to the flue from a cabin becoming obstructed.

SULPHURETTED HYDROGEN.

Sulphuretted Hydrogen Gas, H_2S.—This is very poisonous, but its smell is so intense and so characteristic that even 1 part in 10,000 of air can be detected. The presence of less than 1 per cent may cause fatal consequences, and this within a brief period.

Symptoms.—(1) Inhalation of the pure gas causes instant death. (2) When present in very small amounts it produces great irritation of the nose, mouth, and throat, with headache, nausea, vomiting, and pain over the abdomen. *Chronic poisoning* through inhalation of small amounts gives rise to conjunctivitis, dyspepsia, headache, anæmia, furunculosis, etc. (3) When present in larger amount these symptoms soon

give place to great muscular prostration, and coldness of the extremities; the breathing becomes laboured; tetanic spasms may be observed; delirium and coma follow, the pupils being widely dilated.

The symptoms may not manifest themselves until some time after exposure to the poison.

Post-mortem Appearances.—The blood remains fluid, and is of a brownish-black colour, the hæmoglobin having been reduced and changed into sulph-methæmoglobin, which can be recognised by its spectrum. The viscera and tissues are dark in colour, and there is œdema of the lungs. The smell on opening the body is very offensive, and decomposition of the body is rapid.

Those Liable to be Poisoned.—Workers in chemical factories; workers in sewers are sometimes poisoned by a rapid evolution of this gas, occasioned by an inflow of acid liquid. Chronic forms of poisoning are sometimes seen in those engaged in vulcanising india-rubber, or in those who live in cottages built over iron slag—the sulphides of iron or calcium becoming decomposed.

Test for this Gas.—A card coated with lead carbonate, or a bright coin soon becomes blackened on exposure to the fumes of sulphuretted hydrogen, or when placed in the tissues of an individual poisoned by this gas.

SEWER GAS, ETC.

Sewer Gas; Cesspool Emanations.—The composition of the gases in sewers or cesspools varies very greatly. In many sewers the air is perfectly fresh owing to free ventilation. When badly ventilated, however, the oxygen becomes diminished, the nitrogen increased, carbonic acid gas is present in large amount, as well as the sulphides of hydrogen and ammonium. The gas of cesspools sometimes consists merely of nitrogen and carbon dioxide.

Symptoms.—These will largely depend on the proportion of the lethal gases present. If concentrated mixtures be inhaled, death may be immediate; but if dilute, lividity is usually well marked, fixation of the eyes, and insensibility with convulsions. If small amounts escape into sleeping-rooms, the occupants begin to suffer from morning nausea, anorexia,

headache, sore throat, coldness of the extremities, diarrhœa, and boils.

Post-mortem Appearances.—These may resemble those seen in poisoning by sulphuretted hydrogen.

Acetylene, C_2H_2.—This gas is produced by acting on calcium carbide with water, and is also formed when hydrocarbons are burnt with an insufficiency of air as in a Bunsen burner when the flame has "retreated." It has little or no poisonous property.

Chlorine.—Accidents may happen in the manufacture of bleaching powder. The latter is made by spreading lime on a cement floor in a closed apartment, and passing chlorine gas in until the lime has absorbed as much as it can. Irritation of the eyes, nose, and bronchial mucous membrane may result from inhalation even of small amounts of chlorine.

Carbon Bisulphide.—This volatile liquid of disgusting odour is employed as a solvent for india-rubber. The workers often suffer from symptoms of chronic poisoning such as anæmia, digestive disorders, nausea. It acts chiefly on the nervous centres, however, producing muscular weakness, tremors, spasms, ataxia; mental troubles also develop, as giddiness, irritability, delirium, or even dementia in extreme cases.

Nitrous Oxide, Ethyl Chloride, Somnoforum, are gases used in minor surgery and dentistry. Deaths have resulted, during their use, from respiratory paralysis.

SECTION III.

PUBLIC HEALTH.

CHAPTER I.

METEOROLOGY.

Meteorology means the observation and interpretation of atmospheric phenomena (*meteora*).

Climate, depending as it does on geographical and topographical position as well as on meteorological conditions, has the most intimate relation to Public Health.

Five varieties of climate are met with—(1) *Warm*, or those near the tropics, with very dry and very wet seasons. (2) *Temperate*, or those having a mean temperature of 60° F. and between the 35° and 40° latitude. (3) *Cold*, or from 50° latitude to the poles. (4) *Marine*, as Great Britain; and (5) *Mountain*, or those districts about 3000 feet above sea-level.

Climate is also classified as:—

I. *Insular*.—Where the land is in contact with much water, which modifies the climate, and renders it more equable. The air is generally pure and moist. The west coasts of continents have insular climates as they are much broken up by inlets from the ocean.

II. *Continental Climates* are characterised by a great daily and annual range of temperature, the summers being unduly hot and the winters intensely cold (Canada, Russia, etc.).

By itself, climate seems to exert but little influence on the health of the inhabitants; thus the Esquimaux exist in the frigid north in perfect health, as do also the natives of the Andaman Islands close to the equator.

It is different, however, with the natives of warm or tropical climates who transfer their residence to cold regions. They adapt themselves with difficulty, and often fall victims to phthisis. Natives of colder climates find it easier to live in warm climates, and of all races Anglo-Germans seem to bear changes of climate most easily. Of course they may contract the local endemic diseases to which the natives may be more or less immune, but the change of climate seems to have little effect on their general health.

The climate of a particular locality depends on certain factors :—

(1) *Elevation.*—The mean temperature falls 1° F. for every 180 feet above sea-level, consequently the higher the elevation the colder the climate (Buxton, Davos Platz, hill stations in India). Winds are more frequent and stronger on elevated stations, and, as the humidity of the air becomes less with increasing elevation, the sun's rays more easily penetrate the atmosphere, and warm the ground.

(2) *Influence of Winds.*—The locality may be exposed to cold or warm winds; thus, Edinburgh is noted for the prevalence of the east wind in spring. On the other hand, a range of hills may cut off prevailing cold winds and so shelter the locality; thus invalids resort to the south coast of England or to the French or Italian Riviera. The constant trade-wind exercises a well-marked influence on the climate of certain stations.

(3) *Fresh or Salt Water.*—The presence of a large body of water (lake or sea) equalises the temperature by creating an insular climate. Water absorbs heat more slowly than soil, but parts with it equally slowly. In other words, the specific capacity for heat is five times greater in the case of water than in the case of land. The proportion of land to water on the globe is as one to four, and by far the largest part of the former is in the northern hemisphere. Ocean currents exert a marked influence on climate; thus, the cold Arctic stream from Greenland keeps Labrador and Newfoundland icebound for the greater part of the year, although they are in the same latitude as France and England. The Gulf Stream coming from the Gulf of Mexico keeps our own western coasts warm, and, striking as far north as 71°, keeps the harbour of Hammerfest, the most northern town in Europe, free from ice.

(4) *Character of the Soil.*—A clay soil is damp and cold,

and increases the humidity of the air. Rheumatism and catarrhs (nasal, bronchial, intestinal) are frequent on such soils, and phthisis is markedly more common in damp localities. The level of the subsoil or ground water should be at least 100 feet from the surface. If less than this, there is a danger that its level will rise in wet weather, and that it will become polluted by surface sewage. If this subsoil water be used for drinking purposes, diseases may result. The basis of *Pettenkofer's theory* of infection is, that on the rapid sinking of the ground water, the organisms of disease are left stranded near the surface of the ground, and become active (typhoid and cholera). Malaria and dysentery have also an indirect relationship to dampness of soil. Dry and sandy soils are always much warmer and healthier.

Endemic Diseases are more or less confined to certain parts of the globe, as yellow fever to the West Indies, or cholera to the Delta of the Ganges. Such diseases have little tendency to spread as a rule but at times become pandemic.

Pandemic Diseases occur over the whole globe, *e.g.* rheumatism, phthisis, influenza, pneumonia.

Epidemic Diseases arise from one or a few cases (sporadic), and spread to an excessive extent in the locality but for a limited time.

WIND.

Winds have a very great effect on climate. In a still atmosphere little cooling of the body takes place, and very low temperatures may be borne with impunity, as during the Canadian winter. Winds cool the body, and the higher their velocity the greater is their cooling power. Warm dry winds favour evaporation from the body.

Wind is produced by differences of pressure in the atmosphere, and the latter are caused by differences of temperature. Wherever the ground is heated the air in contact with it expands, rises, and so lessens the pressure, thus allowing the air from colder localities to flow in as a current or wind.

(1) *The Direction* of the wind is observed by an easily moved wind vane or weather-cock.

(2) *The Pressure* of wind is determined by the difference in level of the fluid in a manometer, or by the extent to which a plate (moved at right angles to the wind) is driven in against

an opposing spring or weight (Osler's, Cator's), or the angle of displacement of a hinged sign-like plate may indicate the pressure (Hooke's). Buildings should always be made to withstand a pressure of 40 lbs. per square foot. The highest recorded pressures are 60 to 90 lbs., but these have been exerted over comparatively limited areas.

(3) *Velocity.*—This is determined by the velocity of movement of four hollow cups fixed horizontally on a shaft. The cups move with a velocity one-third less than that of the wind, but the correct velocity is recorded on a dial below (Robinson's Cup Anemometer), in terms of parts of a mile per hour. The velocity of wind depends on the barometric gradient. Pressure and velocity are convertible terms. The pressure varies as the square of the velocity, and is equal to $\frac{1}{200}$ part of it.

If V = velocity in miles per hour ;
P = pressure in lbs. per square foot ;
then $P = V^2 \times \cdot005$ or $V^2 = 200\ P$.

Beaufort's Scale of Wind Velocities ranges from 0 or still air, to 12 or a hurricane. Calm air may move at 3 miles per hour ; a fresh breeze moves at 28 miles, and exerts a pressure of $4\frac{1}{2}$ lbs. per square foot. A strong gale or storm has a velocity of 50 to 60 miles, and exerts a 20 lbs. pressure. A hurricane moves at 75 to 150 miles per hour, and exerts a pressure of 80 to 90 lbs. A velocity of 8 miles per hour is the average in Great Britain. At noon, the wind blows from plains towards hills, or from the sea towards land, while the reverse holds good in the evening. These variations are brought about by the difference in the specific capacity for heat of land and water.

Classification of Winds.—(1) Permanent, *e.g.* trade and antitrade winds. (2) Periodic, or those which occur only at certain seasons, *e.g.* the monsoon of the Indian seas ; typhoons of Chinese seas ; simoom or desert whirlwind, etc. (3) Variable winds of high latitudes.

A Wind-rose shows diagrammatically the relative proportion and directions of winds, by the length and position of arrows converging to one point.

Trade-wind.—Owing to the excessive heating of the earth at the equator, the air over this region rises, and colder air rushes in from the higher latitudes to the lower to replace

it. Were the earth stationary, these winds would seem to travel directly from north or south to the equator. Owing to the earth's rotation, however, in the northern hemisphere the north trade-wind seems to blow from the north-east, and in the southern from the south-east. They are chiefly observed in the Atlantic and Pacific Oceans, and are greatly broken up during their passage over continents. There is an equatorial belt of calm air.

Antitrade-winds.—The heated air which rises at the equator runs off towards either pole, and descends to the earth about the 30th or 40th degree of latitude as the antitrade-winds. In the northern half of the globe they are only felt over oceans, because over continents the heated air alters their direction entirely. In the great seas of the southern hemisphere they are known as the "roaring forties."

Forecasting of Weather.—This can be done by the observation of cyclonic and anticyclonic disturbances.

Cyclone.—This means an area where the atmospheric pressure diminishes towards the centre. These areas are formed by the two great atmospheric currents, the polar and the equatorial, which flow side by side, the eddies along the junction giving rise to storms. Each cyclone is a circular or oval area with a depressed centre, and may be many hundreds of miles in extent. At the centre the barometric pressure may be 29·4 inches, and this may rise rapidly towards the periphery to 30 inches, or the "barometric gradient" is "steep." Winds blow from a high to a low barometric reading with a force proportioned to the barometric gradient. The result is that wind tends to rush in, but as the whole system in the northern hemisphere is travelling from west to north-east at a velocity of about 20 miles per hour, the inrushing wind takes a spiral course in the direction against the hands of a watch. Such a cyclone is associated with bad, wet, or stormy weather until the area of greatest depression has passed. Bad weather in certain regions can be predicted because the direction and rate of movement of such cyclonic disturbances can be calculated. "Ill news travels fast." Weather forecasts are issued from Washington, and are deduced from the reports obtained each morning and evening from several hundred stations over the whole continent of America. Forecasts in Great Britain are based on telegrams received from some sixty observation stations in Great Britain and Ireland, and on the

Continent, detailing the state of the weather at each station at 8 A.M. Depending on the steepness of the gradient the cyclone may be mild in type or of hurricane violence.

Anticyclones are the reverse of the preceding. They are areas in which the pressure increases towards the centre. Each is an area of elevation, the highest barometric pressure being at the centre. As the barometric gradient is slight the force of the wind is moderate, and such anticyclones are associated with settled fine weather. As they are either stationary or move very slowly, it is impossible to forecast good weather from them.

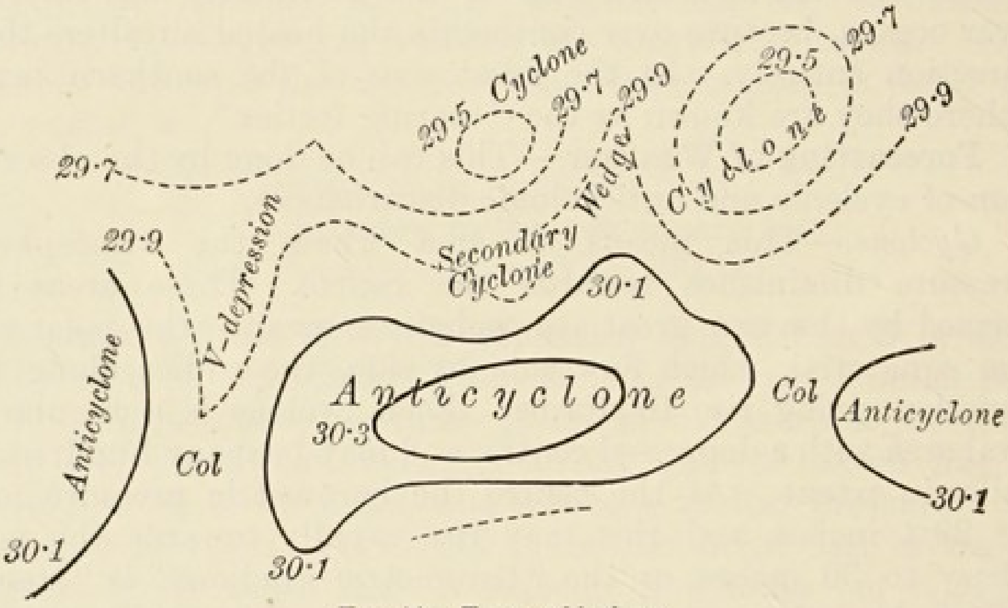


FIG. 22.—Types of isobars.

Isobars are lines drawn through areas where the pressure is the same. These may extend in straight lines for hundreds of miles, or may exist as circles, ovals, or curves (cyclones or anticyclones). Isobars may project as loops of low pressure into a higher pressure area (*secondary or subsidiary depressions*), or these low pressure areas may be V-shaped. Unsettled thundery weather is the usual accompaniment of such depressions. Cyclones may follow one another, but a tongue of high pressure from an anticyclone may insert itself between them. This is called a "wedge," and the isobars enclose an area of high pressure, which travels with extreme rapidity. Wedge-shaped isobars usually project towards the north. Two anticyclones may be joined together by a furrow (or *col*) of relatively low pressure. Where the isobars crowd together, the gradient is

steep, and the violence of a storm is felt most severely; but where these lines are widely separated, the winds are light.

TEMPERATURE.

The climate of a district derives its chief character from the temperature. Certain conditions regulate the temperature of a particular area, as—

(1) Geographical Position.—The highest temperature is found at the equator, and for every degree of latitude from this the temperature falls almost one degree. This is not invariable, however, and places on the same latitude have not all the same mean temperature. The presence of mountains, water, prevailing winds, etc., cause an alteration in the temperature of stations in the same latitude. The lines of equal temperature (*isothermals*) do not, therefore, run in straight lines round the globe, but take more or less sinuous courses. These isothermals change their relative positions almost every day.

(2) Relative Amount of Land and Water; (3) Elevation; (4) Prevailing Winds; (5) Ocean Currents; (6) Amount of Rainfall; (7) Character of the Soil.

Registration of Temperature.—This is carried out by self-registering thermometers.

I. The Maximum Thermometer registers the highest temperature which has been reached. It is made on the same principle as the clinical thermometer, the column of mercury being broken by a constriction near the bulb (Negretti), or by a tiny bubble of air (Phillips), so preventing it from being drawn into the bulb during the contraction caused by cooling.

II. The Minimum Spirit Thermometer records the lowest temperature reached by the spirit dragging back a small glass index immersed in the fluid during its contraction. Should the temperature rise afterwards, the spirit flows past the index. The end of the index farthest from the bulb indicates the minimum temperature. As mercury freezes easily, it cannot be used for a minimum thermometer. A pair of these thermometers is usually placed in the open air in the shade in a *Stevenson's Screen*, which is merely a box with louvred sides placed at a height of 4 feet above the ground. They should be read at 9 A.M. Six's thermometer combines in itself a

maximum and minimum apparatus, but it is not sufficiently accurate for reliable observations.

Mean Temperature.—The daily mean temperature may be obtained by taking a single reading at 9 P.M., or by taking the mean of the maximum and minimum recorded temperatures. The mean temperature of the week, month, or year is obtained by a summation of the daily mean temperatures, and dividing this by the number of days or months. Practically this gives but little information regarding the climate of any locality.

Range of Temperature.—This corresponds to the difference between the maximum and minimum thermometers, and may be expressed as the *daily range.* The mean *monthly range* is got by adding together the daily ranges and dividing by the number of days, and the *yearly mean* by averaging the monthly means. The greatest heat is obtained from the sun at noon, but the warmest time of the day is really about 2 P.M., when the sun's heat is reinforced by radiation of heat from the earth. For the same reason July is the hottest month of the year and not June. The coldest time of the day is before sunrise, for terrestrial radiation has been going on for long, and, for the same reason, January is a colder month than December.

Solar Heat.—The amount of heat radiated from the sun may be estimated by some form of pyrheliometer or solar radiation thermometer. The most common is Herschell's Black Bulb Maximum Thermometer, enclosed in a glass tube from which the air has been exhausted. It is exposed freely to the sun 4 feet from the ground ; the bulb and adjoining part of the stem are coloured dull black so as to absorb all the heat rays which fall on it. The difference between the reading given by this thermometer, and that given by the maximum thermometer indicates the amount of solar radiation. Aqueous vapour in the atmosphere acts as a powerful screen to the sun's heat rays, while dry atmospheres have a high degree of diathermancy, as at Davos Platz, where in the sunshine the temperature may be 100° F. and in the shade 0° F.

Sunshine Recorder.—The effect of sunshine on health is very marked, absence of it leading to ill-health, owing to deficiency in the chemical rays, to the unrestrained activity of bacterial growth, etc. The length of time the sun shines may be recorded by Campbell's Recorder, which is merely a large glass sphere which acts as a lens, concentrating the heat rays, and charring a paper strip (ruled into divisions corresponding

to hours) behind it. The sunshine is recorded as a percentage of that possible; thus, if the sun is above the horizon eight hours, and the record is two hours, then there has been 25 per cent. In Jordan's Recorder the sunlight acts on sensitive photographic paper.

Terrestrial Radiation.—Much heat is radiated from the earth into space, and this is furthered by the presence of vegetation. The amount of heat lost is greater on clear dry days than on dull damp days. It is measured by a minimum thermometer placed 6 inches from the ground. The difference recorded between this and the shade minimum is taken as the amount of terrestrial radiation.

Effect of High Temperature Climates on the Bodily Functions.—The temperature of the body rises from $\frac{1}{2}$ to 1° F. at first, but soon the heat-regulating mechanism accommodates itself to the higher temperature. Respirations are lessened in number but increased in depth; the carbonic acid gas expired is diminished in amount. The rapidity of the heart's action is lessened; the appetite becomes less, while thirst is increased. The skin becomes very active, and the urine is scanty in amount, as is also the urea. There is lassitude of mind and body.

In Cold Climates the bodily metabolism is more active; the excretion of carbonic acid is increased, and so is the amount of urine and urea. Fatty and starchy foods are required in large amount as heat producers.

HUMIDITY.

Moisture in the atmosphere has a great effect on the climate. It acts as a non-conductor, preventing the sun's rays from passing too readily to the earth, and at the same time greatly lessening the amount of heat radiated from the earth; in other words, water vapour lessens the diathermancy of the atmosphere. The more moisture there is in the air, the less evaporation takes place from the skin and lungs, thus accounting for the oppression felt in very humid conditions of the atmosphere. The amount of moisture in the air rapidly lessens as we ascend, and at high elevations the air contains very little watery vapour.

Hygrometry is the determination of the amount of moisture present in the air as water vapour. It is measured directly or indirectly.

1. *Directly.*—This is done by noting the temperature of a glass surface (artificially cooled) at the moment when the moisture in the air condenses upon it as dew.

(*a*) *Daniel's Hygrometer* consists of two bulbs connected together by means of a glass tube. One bulb is coloured black, and contains a small thermometer immersed in ether. The other bulb is covered with muslin. If ether be poured on to the muslin, the air in the bulb is cooled, and the ether distils over from the black bulb, at the same time abstracting heat from it, so that when a certain temperature is reached, the polished black surface becomes dull from the deposition of moisture from the surrounding air. The thermometer in the interior is read at this instant, and this corresponds to the *dew-point.*

Regnault's Apparatus acts similarly by the evaporation of ether causing condensation on a bright silver cup.

(*b*) *Dines' Hygrometer* is cooled by running cold water through it. These direct hygrometers are, however, seldom employed now.

2. *Indirect Methods.*

(*a*) *Hair Hygrometers* as devised by Saussure. A human hair elongates on being wet, and contracts on being dried. The amount of its extension can be experimentally determined for each degree of humidity, and if this be recorded on an index dial, the apparatus will show the amount of moisture in any room into which it is carried.

(*b*) *The Hygrometer or Wet and Dry Bulb Thermometers* are now almost always used. The apparatus consists of two precisely similar thermometers ; the bulb of one being covered with muslin, which is kept constantly wet by means of a cotton thread which dips into a receptacle of water below. The thermometers are placed in a Stevenson's Screen. The principle depends on the fact that as long as the air is not saturated with watery vapour, evaporation will take place from the muslin, and will cause a lowering of the temperature as recorded by the wet bulb thermometer. If the air is saturated, both thermometers will give similar readings ; while if the air is not saturated, the temperature of the wet bulb thermometer will fall until it reaches a point intermediate between the temperature of the dry bulb thermometer and that of the dew-point. The drier the air, the greater the difference between the two thermometers will be. As the instruments are not

self-registering, they must be read at 9 A.M. and 3 P.M. A reading of these enables one to determine the *dew-point*, the *weight of a cubic foot of vapour*, and the *relative humidity*, not directly, but by reference to numerical tables and factors (Glaisher's), or they may be calculated by Apjohn's formula.

Dew-point.—This is the temperature at which the air is saturated with moisture, so that the least further fall would result in the precipitation of water. From the dew-point, the amount of water present in the air or the degree of humidity may be calculated. A given mass of air can only contain a certain quantity of water as vapour under certain conditions of temperature and pressure, or until it is saturated for that temperature and pressure. If the pressure is increased or the temperature lowered, condensation takes place. If the pressure be reduced or the temperature raised, more water can be contained as vapour. When the vapour is just at the point of condensation, it is said to be at its *maximum density*, the air is *saturated, and the dew-point* is reached.

1. *Absolute Humidity* means the actual weight of moisture in the air. This may be measured by weighing the water vapour present in a known volume of air (see Examination of Air).

2. *Relative Humidity* expresses comparative dryness. It is expressed as a percentage or relation between the amount of water vapour present, and the amount which would be present if it were saturated at that temperature. Thus, 4 grains of water vapour per cubic foot will give an atmosphere saturated, or 100 per cent at 50° F.; this is only 66 per cent at 62° F., and 50 per cent at 70° F. A reference to Glaisher's tables gives the relative humidity for each reading of the wet and dry bulb thermometers. The most suitable amount for living rooms is 75 per cent of relative humidity. Complete saturation of air is expressed as 100. The colder the air is the less water vapour can it hold, even when saturated. When warm air is cooled, it becomes saturated at a certain temperature; and if the temperature be still further lowered, precipitation of water will take place in the shape of mist, dew, or rain. The capacity which dry air has for moisture increases in geometrical progression; thus, at 0° F. the weight of a cubic foot of vapour is 0·55 grains; at 16° F. it weighs 1·06; at 33° F. 2·21 grains, and so on. This accounts for the thirst experienced by Arctic explorers, because the air escaping from

the lungs is heated to 100° F. and is saturated with moisture; the body is, therefore, robbed of moisture. There may be a far larger amount of moisture in the air on a hot dry day in summer than on a cold damp day in winter. Work becomes laborious when the air is saturated with moisture, because evaporation from the skin is hindered. A dry hot climate is to be preferred to a hot moist one, the former being invigorating, the latter enervating.

Defect of Saturation.—This corresponds to the difference between the amount of moisture observed in the atmosphere, and the amount which would be present were the air saturated at that temperature.

Atmometry is the determination of the amount of water which passes into the air by evaporation. The amount of evaporation depends on—(1) Humidity of the air. This is the chief factor; the drier the air the more rapid the evaporation. Moist air is lighter than dry air, hence it ascends, thus allowing the dry air to come into contact with the water surface, and so furthering evaporation. (2) Winds, which remove the vapour as rapidly as it is formed. (3) Temperature; the higher this is, the greater the evaporation. Evaporation is estimated by weighing a quantity of water and exposing it for a certain time in a shallow tray, and then noting the amount of decrease. Atmometry is of importance in reference to the amount of water which has to be collected in reservoirs for the use of a community.

RAINFALL, DEW, ETC.

Rain is produced by the mingling of warm moist air with cold dry air, or by the cooling of moisture-laden air in its ascent over high mountains. The rainfall is measured by a gauge or circular funnel the area of whose inlet is accurately known (this being usually 8 inches in diameter). It conveys the rain to a bottle sunk into the ground. A measuring glass allows one to estimate the amount collected, and a calculation gives the amount which has fallen on an acre or on a mile. A fall of 1 inch corresponds to 100 tons per acre. The average annual rainfall in England and Wales is 33·76 inches; in Ireland, 38·5 inches; and in Scotland, 46·5 inches. The west coasts have a much higher rainfall than the east coasts, in the proportion, it may be, of 60 to 20 inches,

this being due to the fact that the warmer winds coming laden with moisture from the ocean have to ascend over the mountainous coast, and in doing so become cold, and part with their vapour as rain, giving out at the same time much latent heat, and so producing a milder climate. Any day during which 0·01 inch of rain falls is considered a "rainy day." During thunderstorms 2 to 3 inches may fall in as many hours. There is no relation between the amount of rainfall and the humidity of the air.

Greatest Rainfall Occurs—(1) Near the tropics, where it may amount to 260 inches per annum. (2) On the west coasts of continents.

Dry Regions are such as those protected from moist winds by mountain chains, or are at the centre of continents, as the Sahara desert, Arabia, Tartary, interior of Australia.

Dew is the precipitation of moisture coming from the ground on grass, flowers, shrubs, etc. Radiation of heat also from the ground on clear nights is so rapid, that the layer of air next the ground becomes so cold that its moisture is deposited on the cold grass or other vegetation as dew.

Fog or Mist (Wells's theory) results from the precipitation of moisture on particles of dust in the air, and is brought about by the cooling of warm air below its dew-point by a cold current. If the particles of dust be large in proportion to the amount of moisture a dry or town fog is produced.

Snow.—One foot of snow when melted yields about 1 inch of rain, but a fall of this depth at one time is very unusual in this country.

Hail is of two varieties: (1) soft, which falls chiefly in spring and winter, and (2) hard or true hail, which falls in summer-time.

CLOUD.

These are masses of fog, made up of minute particles of water (often frozen into ice spicules) floating in the air. There are three primary varieties, according to Howard's classification :—(1) Cirrus (curl cloud), or the thin filamentous clouds which are associated with south-westerly winds (*mare's tail cloud*). They are the loftiest in elevation of all clouds—20,000 to 30,000 feet above the earth. (2) Cumulus or wool-pack cloud—like balls of cotton or wool. They occur

at elevations of from 4000 to 6000 feet. (3) Stratus or continuous horizontal bands of cloud. These are usually seen at sunset, and foretell fair weather. They are the lowest in elevation of all clouds. These varieties may be grouped together as (*a*) cirro-stratus, (*b*) cirro-cumulus (mackerel sky), (*c*) cumulo-stratus, (*d*) cumulo-cirro-stratus (the nimbus or rain-cloud), which is a dense horizontal gray or black cloud.

The amount of cloud present in the visible sky is estimated at from 0 to 12; the former being a cloudless sky, and the latter one wholly overcast. Clouds are similar in their formation to fog or mist. As the particles of moisture fall down in the atmosphere, they are again dissipated into vapour by the heat, to be again condensed into rain in the colder regions.

Pressure of the Atmosphere.

The Mercurial Barometer is employed to measure the pressure of the atmosphere. The tube containing mercury is made to dip into a cistern of this element. The level of the mercury in the cistern must be kept uniform, and this is obtained by making the bottom of leather, which can be raised or lowered by means of a screw. The distance between the surface of the mercury in the cistern, and the top of the meniscus in the tube corresponds to the pressure of the atmosphere expressed as inches of mercury.

Reading of the Barometer.—The stationary scale is divided into half-tenths of an inch (·05 inch), and a sliding scale or vernier is adjusted so that its lower edge just touches the convex meniscus of the mercury. This allows of a reading to $\frac{1}{500}$ of an inch. If the weight of the atmosphere becomes lighter (as in a cyclone) the mercury falls, while if the weight increases, the mercury rises (as in an anticyclone) because of the increased pressure on the mercury in the cistern.

Aneroid Barometer.—This is a small metal drum from which the air has been partially exhausted. The thin ends are kept from being forced inwards by a metal spring in the interior. Depending on the degree of atmospheric pressure, these sides are either pressed in or forced out through minute distances, and these variations are magnified and recorded on a dial by means of an index lever. An aneroid barometer is very useful in telling the height which has been ascended, because as the mercury falls 1 inch for every 900 feet above sea-level in an

ordinary barometer, the aneroid is graduated accordingly and a simple reading indicates the height of the ascent. To estimate the height of one station above another, read the barometer at each; subtract the lower from the higher, and multiply by 1000; the result gives the difference in feet between the two stations. In taking a barometric reading at any station above sea-level, this correction has to be kept in mind, and $\frac{1}{1000}$ of an inch has to be added to the reading for every foot above sea-level. The barometer falls proportionately to the elevation, because so much of the atmosphere is left below, but this fall is not uniform, because the air becomes progressively rarer the higher the ascent.

Barometric Corrections.—In order to compare the readings given by barometers at different stations, these readings must be brought down to 0° C. and 760 mm. pressure. Corrections may be obtained from tables which have been prepared, but they can also be calculated by the following formula. Let H = corrected reading in inches; h = the observed reading; t = the temperature; E = elevation in feet of the station above sea-level; then

$$H = h\left(1 - \frac{9t - 256}{100{,}000}\right) + \frac{E}{812{\cdot}86 - 1{\cdot}945t}.$$

Other corrections (capillarity, capacity, and index) have to be included, but these are usually supplied by the makers with each instrument.

Barographs are the automatic registers marked by an aneroid barometer on a paper made to rotate on a drum.

Variations in the Barometric Pressure.

(1) Daily variations. Maximum pressures are noted at 9 A.M. and 9 P.M.; the minimum being at 3 P.M. The daily range seldom exceeds 0·02 inches in this country. (2) Annual variations. In January the pressure is as a rule highest, and in July it is lowest. (3) Irregular variations induced by cyclonic or anticyclonic disturbances.

Effect of Lessened Pressure on the Body.—Aeronauts or those who ascend high mountains experience headache, with quickening of the heart's action and respiratory activity; increased evaporation takes place from the skin and lungs, and owing to the lessening of pressure the capillaries in the nose and bronchi may rupture, and bleeding may take place.

Vertigo or "mountain sickness" often attacks those who climb great heights.

Effect of Increased Pressure is seen in workmen in tunnels, caissons, diving-bells, or wherever the atmospheric pressure is increased from two to four atmospheres. The pulse and respiration become slow; the hearing is much more acute, owing to the tympanic membrane being forced inwards; ringing in the ears and pains in the head may be noticed, with muscular and articular tenderness; and paralysis or hæmoptysis may result. Anæmia may ensue if work under increased pressure be prolonged, but this condition may also be due to inefficient ventilation (see "Compressed-air illness"). When the barometric pressure is high, an increase in the mortality from apoplexy has been noted as occurring amongst the general populace.

At high elevations the air is very pure, contains few organisms, and as the watery vapour is present in small amount, it is very diathermanous, and allows of the easy passage of heat rays. As a consequence the ground becomes rapidly heated, and as rapidly cooled.

CHAPTER II.

AIR AND VENTILATION.

AIR.

The atmosphere exists as an envelope surrounding the earth; it is relatively dense at the lower levels, but becomes more and more rare at higher levels.

Composition of the Atmosphere.

Oxygen	20·96 per cent by volume,	or practically one-fifth.	
Nitrogen	78·00 ,,	,,	or almost four-fifths.
Argon, etc.	1·00.		
Carbonic acid	0·03–·04 ,,	,,	("initial impurity").

Traces of ammonia, krypton, marsh gas, acid gases (in towns), etc. Watery vapour and dust are invariably present.

Oxygen is diminished in amount in populous districts, as in the narrow alleys and lanes of cities.

Ozone is produced by electrical energy, and is present in largest amount after thunderstorms, near the sea-shore, on mountains, or near pine forests. It is a powerful oxidiser, and is, therefore, never present in towns. It may be detected in country air by exposing strips of filter-paper which have been wetted with a solution of starch and iodide of potassium, and then dried. They become blue if ozone be present. It is also easily recognisable by its smell.

Carbonic Acid Gas.—This gas results from (1) respiration of animals, (2) combustion, (3) decomposition of organic matter in or on the ground, (4) fermentation, (5) burning of limestone, (6) effervescence of natural waters, etc.

It is absorbed by plants, the chlorophyll under the action of

sunlight splitting it up into carbon and oxygen. It is also absorbed by sea-water, and by the soil. These agencies, together with the natural diffusion of gases, keep it uniform in amount in the atmosphere.

Seasonal Variation.—It is in largest amount during spring and autumn, and least during winter and summer.

It is Used as an Index for Impurity of the Air.—The amount of this gas increases directly as the impurity of the air, and hence it is used to tell whether air is pure or impure. Carbonic acid gas forms, when shaken up with lime or baryta water, the insoluble carbonates of lime or barium, and the depth of the opacity produced in these solutions may be used to determine the amount of carbonic acid present in the atmosphere or in the air of occupied rooms (methods of Pettenkofer, Wanklyn, etc.).

Ammonia is always present in air to the amount of 3 to 4 parts in the country and 4 to 8 parts per million in towns. It is most abundant in warm weather, as it results from the decomposition of organic matter. It is readily washed out of the air by rain, in which it is freely soluble.

Acid Vapours (nitric, hydrochloric, sulphurous, and sulphuric), as well as the sulphides of hydrogen and ammonia, bisulphide of carbon, etc., are products of the combustion of coal, from alkali works, etc., and are present in the air of towns.

Watery Vapour is always present in varying amounts.

Inorganic Dust, *e.g.* silica, clay, carbonate or phosphate of lime, sodium chloride, iron, carbon, etc.

Organic Dust of vegetable and animal origin (pollen, moulds, yeasts, etc.).

Micro-organisms are the most important constituent of dust from the sanitary point of view. They are almost absent in sparsely populated districts, while the more densely populated the districts are, the more numerous are the germs. This applies still more forcibly to the density of population per house. In one-roomed houses 60 micro-organisms per litre of air may be present, while in four-roomed houses only 8 are perhaps present in the same volume. The organisms are chiefly non-pathogenic. The variety and number may be determined by exposing Petri dishes containing nutrient agar gelatine for varying periods, and after incubation, counting the colonies.

Natural Purification of Air takes place owing to the diffusion of gases, action of winds, oxidation, growth of vegeta-

tion, and rainfall washing out of the air gases and suspended matter.

Effect of Respiration on the Air of an Inhabited Building.—Oxygen is reduced, while carbonic acid is increased greatly in amount. Watery vapour and heat are given off in large quantity from the lungs, and thus the humidity and temperature of the air are increased. Volatile fatty acids are evolved from the sweat, while ammonia and organic vapours come from the lungs and skin, and solid matter in the shape of epithelial and pus cells, germs, etc., are also added to the air from living animals.

	Oxygen.	*Nitrogen, etc.*	*Carbonic Acid.*
Atmospheric air . . .	20·9	79	0·04
Air expired from the lungs	16·40	79·19	4·41

Each adult gives off from the lungs approximately 0·6 cubic foot of carbonic acid per hour during rest and $1\frac{1}{2}$ ounces of watery vapour. This expired air is saturated with moisture and heated to 98·4° F. Moist air is lighter than dry air, hence expired air ascends. Each adult renders irrespirable or spoils 5 cubic feet of air per hour. During exertion metabolism is hastened, and hence the above figures are increased; the carbonic acid may therefore amount to 1·6 cubic feet per hour. Animals usually contaminate the air to a greater extent than do human beings.

The means of illumination, coal gas, paraffin lamps, candles, etc., vitiate the air of rooms, but not to the same extent as animals. Each gas burner consumes about 5 cubic feet of gas per hour, and will require 9000 cubic feet of fresh air. It consumes about five times as much oxygen and produces about three times as much carbonic acid as an adult. A lamp which burns 300 grains of petroleum per hour gives off 1 cubic foot of carbonic acid in that time. The most sanitary illuminant is the electric light, and next to it, the incandescent coal gas burner.

Determination of the Vitiation of Air.—This can be done by determining the (1) Increase of the temperature. If in an unheated but inhabited room the temperature rises 12° to 15° above that of the external air, the air has become vitiated.

(2) Excess of moisture. This shows itself as condensed water on the cold windows or walls. The limit of relative humidity should be 75°, or there should be a difference of 4°

to 8° between the wet and dry bulbs in a well-ventilated room.

(3) Excess in the amount of carbonic acid. In fresh air this gas forms 0·04 per cent; as the air becomes impure this gas increases until, when it reaches 0·1 per cent, the air is close and musty, and has a characteristic smell to any one coming from the fresh air. This odour is due to organic matters given off with the breath, as well as from the skin and clothing, and such vitiated air is injurious to health if breathed continuously. Tolerably fresh air must never contain more than 0·06 per cent of carbonic acid; the excess of 0·02 per cent is known as the "*allowable respiratory impurity.*" Any marked increase above this indicates faulty ventilation.

It has to be remembered that the evil effects of impure air are not due merely to the increased amount of carbonic acid, because in pure air one can inhale with impunity 2 to 3 per cent of this gas (*e.g.* aerated water factories), but in inhabited rooms the oxygen becomes diminished in amount, while moisture, heat, and organic emanations are added to the air, and exert a deleterious influence.

In factories, the carbonic acid must not exceed 0·12 per cent during daylight, or 0·2 per cent while gas or lamps are used. In cotton cloth factories the maximum of carbonic acid allowed by law is 0·09 per cent.

Vitiated air does not mix readily with pure air, but being hot it rises towards the ceiling, where it cools, and again descends to be rebreathed by the occupants. Organic matter in air is absorbed by wool, feathers, clothing, plaster of the walls, etc., and thus in old rooms a peculiar odour may be always present; in old hospitals this smell is well known. It is very difficult to get rid of these organic vapours by ventilation, as they do not diffuse readily or follow the ordinary laws applicable to gases.

Amount of Air Space (Cubic Space) Required for Each Individual.—When individuals are confined to one room for several hours continuously, it is necessary to supply each with a sufficient amount of air space, and, in addition, the air must be frequently renewed, so as to keep the products of respiration and transpiration within the safe or normal limits.

An endeavour should be made to allow each person (adult or child) 1000 cubic feet of air space. Draughts are the chief difficulty in ventilation, and as it has been found that the air

of a room cannot be changed oftener than three times an hour without causing draught, this amount of cubic space is desirable for each individual.

The giving of this large cubic space to each person entails, however, great expense in building institutions, hospitals, etc. In many cases, therefore, so lavish an air space cannot be afforded. In *Common Lodging-houses or Work-houses* the Local Government Board insists on a minimum of 300 cubic feet per lodger. Each *prison cell* encloses 600 cubic feet; in *barracks* 600 cubic feet is allowed to each soldier. The London School Board requires the small space of 130 cubic feet to each pupil (or 10 square feet of floor space), but the schoolrooms are emptied, and ventilated every hour. In Edinburgh and Glasgow each occupant of a one or two-roomed house must have 400 cubic feet. In *Hospitals* where sick people are congregated, organic matter and organisms are given off in large amount, hence 1200 to 1600 cubic feet should be allowed to each patient (100 feet of floor space to each bed). In *Fever Hospitals* this may be raised to 2000 or 3000 cubic feet. Each patient in a *Work-house Hospital* must have a minimum space of 850 cubic feet. In theatres, halls, etc., each individual has only, as a rule, 250 to 300 cubic feet, but such structures are occupied for short periods.

The larger the superficial area of the room the better, and in sickrooms or hospitals the floor space should be at least one-twelfth of the cubic space.

Amount of Fresh Air Required per Person per Hour.—It is found that 3000 cubic feet are required for each person per hour so as to dilute the products of respiration, and keep them within normal limits. To keep the carbonic acid below the allowable amount, the quantity of air which an adult spoils each hour (5 cubic feet) must be diluted six hundred times, and this is equal to 3000 cubic feet.

The 1000 cubic feet allowed to each individual becomes raised to the limit of impurity in twenty minutes (0·6 cubic foot of carbonic acid being produced by the individual in one hour, and therefore ·2 in $\frac{1}{3}$ of an hour + ·4 cubic foot normally present in 1000 cubic feet of air = ·6 cubic foot), and therefore 3000 cubic feet are required per hour to keep the air fresh. In actual practice, however, this ideal amount of fresh air is seldom arrived at. Thus, in a factory each workman may only receive 1250 cubic feet per hour.

The amount of fresh air required under any circumstances may be calculated from the following formula. Let e represent the carbonic acid given off by each adult per hour (0·6 cubic foot); let r represent the ratio per 1000 cubic foot of air to which it is desired to reduce the carbonic acid, or it may be the proportion found by experiment, and R = the amount of this gas normally present in 1000 cubic feet of the air (= 0·4 cubic foot); then $\frac{e}{r - R} = x$ or volume of air required in cubic feet per hour.

Examples.—If it is desired to keep the impurity down to ·06 per cent, then $\frac{\cdot 6}{\cdot 0006 - \cdot 0004} = 3000$ cubic feet. If the standard of purity is not desired to be so high, as, for example, in class-rooms, it may be allowed to reach ·09 per cent; then $\frac{\cdot 6}{\cdot 0009 - \cdot 0004} = 1200$ cubic feet per head per hour.

For example, in a workshop 50 men are employed and it is desired to keep the carbonic acid below ·08 per cent (= 0·8 per 1000), how many cubic feet must be supplied each hour?

$$\frac{\cdot 6 \times 50}{\cdot 0008 - \cdot 0004} = 75{,}000.$$

If the amount of carbonic acid has been determined by experiment, the answer corresponds to the amount of air which has entered, and been used in the room. Suppose 3·5 volumes of this gas have been detected, then $\frac{\cdot 6}{\cdot 0035 - \cdot 0004} = 1935$ cubic feet have entered.

In rooms which are only occupied for short periods (theatres, concert rooms, etc.), one may be content if the impurity does not reach above ·1 or ·15 per cent.

In Hospitals the minimum of 3000 cubic feet must be attained, and in Infectious Diseases Hospitals it may be necessary to obtain 4000 to 6000 cubic feet per patient. The open pavilion system of treating fever patients allows of an almost unlimited supply of air. In factories also, abundance of fresh air is necessary to dilute the dust and gases given off during manufacturing processes.

A horse or a cow spoils each hour 13 cubic feet of air, and, therefore, requires 10,000 cubic feet of fresh air per hour.

Minimum Floor Space and Cubic Space Required by Law.

	Floor space in square feet per bed.	Cubic space in cubic feet per bed.
Barrack-room occupied day and night	50 to 80	600
Common Lodging-house (Local Government Board)	42	300 to 400
Factories and Workshops (not special)	...	250
Hospital—General	100	1200 to 1600
,, Infectious disease	140 to 200	2000
Poorhouse	42	300
,, Infirmary	...	850
Prison cells	80 to 120	600
School dormitories	50 to 60	400

VENTILATION.

By ventilation is understood the removal by a stream of fresh air of the products of respiration and combustion *without perceptible draught.* The ultimate purity of a room will depend on (1) the rate of production of impurity and (2) the rate of inflow of fresh air. The larger the room is, the longer will it be before the standard of impurity is reached ; but the permanent condition of the air is not affected by the size of the apartment. All building materials are more or less porous, and a certain amount of imperceptible ventilation takes place through walls and ceilings. If these are varnished or painted they are rendered non-permeable, and greater care has to be taken as regards ventilation.

General Principles of Ventilation.—These depend on—

(1) The diffusion of gases (inversely proportional to the square root of their density).

(2) Differences of temperature causing increased rapidity of diffusion. The warmer the room, the greater is the expansion of the air in it, and the more rapidly will it escape. Fresh cold air then rushes in to replace it.

(3) Influence of winds producing a partial vacuum, and so sucking air out from a room (aspiration). Winds also drive air through open windows or openings (cross ventilation or perflation).

The velocity of the flow of air into or out of a room should never exceed 2 to 3 feet per second or else a draught is felt. This slow flow prevents draughts and favours uniform diffusion through the room. It is easier to ventilate a large

room than a small one. The air of a room of 100 cubic feet occupied by 1 person would require to be changed thirty times per hour to keep the air fresh, and this could not be tolerated; if the room were 1000 cubic feet, however, the air would require to be changed only three times per hour. An ordinary room is ventilated by the fire causing an upward flow of air in the chimney, and thus fresh air is drawn in by the windows and doors. When apartments are occupied by several people, and for several hours consecutively (as in workshops, factories, dormitories, etc.), special inlets for fresh air must be provided as well as outlets for foul air.

Measurement of Cubic Space.—In considering schemes of ventilation, the cubic space of the apartment must first be ascertained. The following may help in this inquiry. To obtain the cubic content of:—

(1) Squares or rectangles, multiply the three dimensions together.

(2) Triangular spaces (*e.g.* open roofs). The area of the triangle is got by multiplying the base by half the height; if the product be multiplied by the length of the triangular space, the cubic content is obtained.

(3) Area of a circle is got by multiplying the square of the diameter by 0·785.

(4) Spheres; multiply the cube of the diameter by 0·523.

(5) Dome; area of base × height × $\frac{2}{3}$.

(6) Pyramid or cone; area of base × height × $\frac{1}{3}$.

(7) Irregular areas. It is better to divide these into rectangles and triangles, and add together the cubic contents of each.

In ordinary dwelling-rooms it is useless to consider a greater height than 12 feet. Solid articles of furniture must be deducted from the cubic content; for each bed with its occupant 13 cubic feet is usually deducted.

Direction of the Air Currents.—This can be determined by noting how the smoke from burning brown paper is carried. It is most important to determine whether the currents traverse the room, and really change the air. There may be much movement in the air without renewal of it.

Rate of Movement of Air.—This is usually determined by employing a small anemometer (Cazella's) and noting the number of feet of air which it records as having passed in one minute. If it be held to an inlet for one minute, the volume

in cubic feet of air which flows in, is arrived at by multiplying the area of the inlet by the linear velocity as recorded by the instrument. Celluloid bulbs filled with hydrogen, so that they float in the air, may also be employed to estimate the rate of movement.

Natural Methods of Ventilation.—Wherever practicable, these should be employed as they are far superior to mechanical means. The laws which regulate natural ventilation in ordinary rooms depend on (1) the difference of temperature inside and outside of the room; (2) area and position of inlets and outlets; (3) height of the column of ascending heated air in the chimney. Warm or vitiated air ascends, and should be allowed to escape by outlets near the ceiling. Winds act in an uncertain manner either by forcing air in through the crevices of windows or doors, or even through the walls, or by their aspirating effects sucking air out of the room. When doors or windows are opened the wind will change the entire air of a room in a few seconds, hence the extreme value of open windows.

The Chimney is the great ventilating agent in ordinary rooms. The upcurrent in it is proportionate to the size of the fire and chimney, and as its velocity is usually 10 to 15 feet per second, 20,000 to 40,000 cubic feet of air pass up the chimney each hour. An ordinary fire will ventilate a room sufficiently for the needs of 4 or 5 persons. If the inlets and outlets be properly proportioned, it is found in practice that natural ventilation is quite sufficient to keep the air of rooms pure. The inlets should be placed as far away from the outlets as possible so that the fresh incoming air may be made to circulate through the room.

Windows should be placed opposite to each other, and should be made to open from the top close to the ceiling so that the warm impure air may escape.

Inlets for Fresh Air should always be 5 to 6 feet from the floor, and should be arranged to direct the air upwards so as not to inconvenience the occupants. They must bring in perfectly pure air, and should be short, smooth, without acute bends, and easily accessible for cleaning. The proportion ought to be 1 square inch of inlet for every 60 cubic feet of room space, or 24 square inches for each occupant.

Inlets in Windows.—(1) Hinckes-Bird's window-sash consists of a board 4 inches deep; the lower sash is lifted, and the

board is fitted in. This leaves an interval between the upper and lower window-sashes through which fresh air flows. (2) Louvred window-panes. (3) Cooper's ventilator is a circular glass disc with pear-shaped openings cut in it. (4) Double windows. (5) Hatton's Hopper Ventilator. (6) Hinged upper sash, etc.

Inlets in Walls, e.g. (1) Perforated bricks set behind the skirting—these are not good as they collect dust and soon become stopped up; (2) Sheringham's flap valve; (3) Steven's drawer ventilator; (4) Jennings' inlet, etc., all allow varying amounts of air to escape into the room by opening them to a greater or less extent.

Special Air Inlet Shafts.—The best known are :—

(1) *Tobin's Tube.*—This is a rectangular tube 6 feet high placed against or inside the wall of the room. The lower end opens on to the outside wall; fresh air is thus directed upwards. The incoming air may be purified by making it pass through a layer of wool; or moistened by impinging on a tray of water; or warmed by passing over heated pipes, etc.

(2) *M'Kinnell's Tube* consists of two tubes—one long and narrow inside a short but wide tube. The inner one acts as an outlet, and may be made more efficient by heating the air by a gas jet placed at the bottom of it. The outer one acts as an inlet, the fresh air being deflected towards the sides of the room by a flange attached to the longer inner tube. The apparatus is fixed in the roof, and is commonly used for the ventilation of halls, churches, etc.

Outlets for Foul Air.—These are almost always placed in or near the ceiling so that the heated air may escape at once.

Outlets in the Chimney.—*e.g.* Arnott's valve; this is a light metal flap placed close to the ceiling. It allows impure air to be sucked into the chimney, but closes up tightly on any down-draught in the latter. Boyle's valve consists of mica flaps. The noise may be obviated by replacing the mica by silk.

Extraction Shafts.—These are merely tubes of smaller or larger diameter, according to the required discharge, placed at the highest part of the ceiling. They may be round or rectangular with perfectly smooth walls. The velocity of the outgoing air in these tubes will depend (1) on the difference in temperature between the air of the room and the outside air; (2) on the amount of movement of the external air; and (3) on

the supply of fresh air to the room. There may be down-draught in these tubes if the wind be high, or if they are exposed to great cold, or if there be another shaft of greater extracting power. To increase the aspirating power of such shafts, (*a*) cowls may be fixed to them or some of the many varieties of Boyle's Upcast or Air-pump Ventilators, or (*b*) gas jets may be fixed at the lower opening so as to heat the air, and produce a greater upward current. When so heated, the

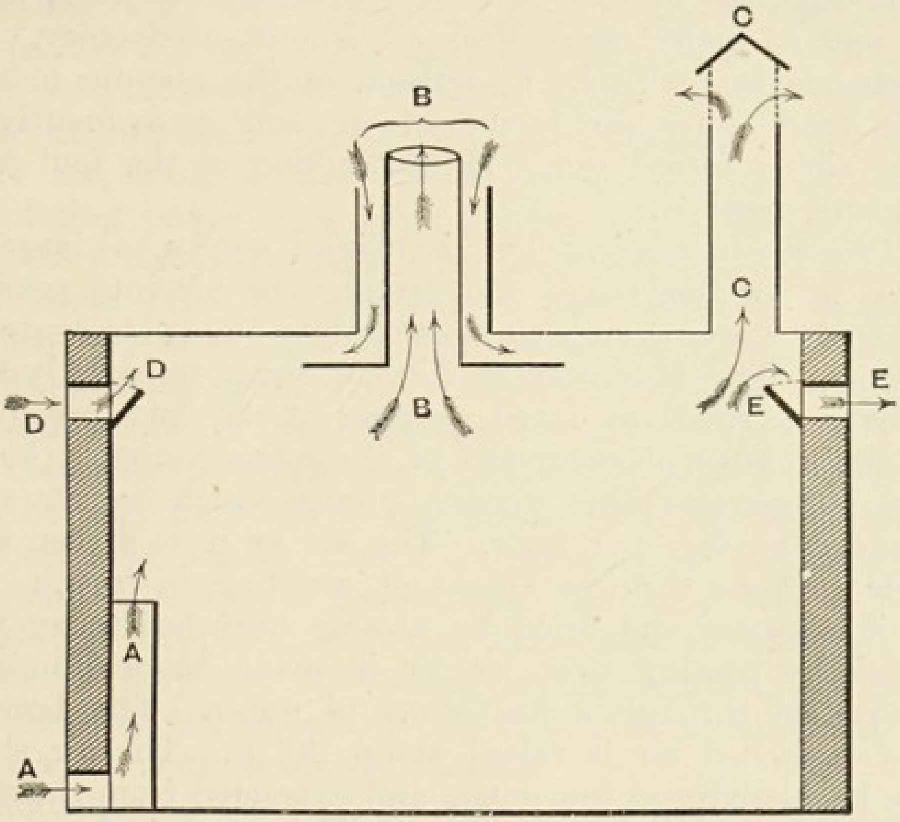


FIG. 23.—Diagram to illustrate various forms of ventilation: A A, Tobin's tube; B B, M'Kinnell's tube; C C, Ventilating shaft; D D, Sheringham's flap valve (inlet); E E, the same (outlet).

opening of the shaft may be placed in other positions than the roof (*e.g.* common chimney), and a much more constant and certain action is obtained.

"*Downward Ventilation*" means that fresh air is introduced near the ceiling, and vitiated air extracted either through the floor or by outlets a few feet from the floor. This method is not satisfactory, as it causes the warm respired air to descend, and to be rebreathed together with the products of illumination. Infectious diseases are more likely to be spread by such a means of ventilation. It is also much more expensive, as about

four times the volume of air is required as compared with upward ventilation.

Artificial Methods of Ventilation.—The natural method is generally to be preferred where possible, but in large public halls where crowds are assembled, or when rooms or factories are occupied for several consecutive hours the natural means of ventilation may prove insufficient, and mechanical means may be required to facilitate the renewal of air. It must be kept in mind that the apparatus is very expensive to fit up and to work, and in many cases after all is not satisfactory. Two methods are in use:—I. Propulsion or the plenum method; in this fresh pure air is driven in, and consequently the impure air is forced out. II. Extraction of the foul air or the vacuum method.

I. *Propulsion of Air.*—This is carried out by (*a*) large fans working in circular boxes, and driving the air into conduits, which are of varying sizes proportional to the cubic content of each room. The fans may be driven slowly or quickly so as to deliver a small or large volume of air, and are useful when the number of occupants of the rooms varies. (*b*) Propulsion pumps are large wooden pumps which deliver many thousand cubic feet per hour. The air as it is driven along is made to pass through sheets of wadding to free it from dust; it is heated and dried by passing over hot water pipes or cooled by passing over ice, or is made more humid by being passed through a fine spray of water. The temperature of propelled air is raised about 20° F. The air should always be introduced low down, and extracted from the upper part of the rooms. The Houses of Parliament in London are ventilated in this way, the air escaping into the chambers through small holes in the floor, which is covered by matting. In this method a supply of pure air can be depended on, but open fires are not admissible with this system.

II. *The Extraction Method* is used to withdraw foul air, then pure air finds its way in by appropriate inlets. Circular fans or pumps may be employed for this purpose, but it is usual to make use of a heated extraction shaft. The latter in large buildings is in the shape of a tall chimney, at the bottom of which either a furnace or gas jets are kept burning; these are fed by air brought in separate shafts from each of the rooms to be ventilated. Only those rooms which it is desired to ventilate have their shafts opened. The

higher the temperature in the chimney the more forcibly is the vitiated air drawn from the rooms. Each shaft may be made of wood or cement, and must be smooth on the inside, without acute bends, and in size proportionate to the room to be ventilated, and to the easiness of ventilating it. Rooms on the ground floor are more readily ventilated than those at higher levels. Acute angles in the air flues greatly retard the onflow; thus, a right angle diminishes the current one-half, and two right angles to one-fourth. A jet of steam may be allowed to escape into the chimney instead of the fire; it is very efficient as it sets into motion a body of air more than two hundred times its own bulk. Some of the disadvantages of the heated shaft are, that, as the fire varies in intensity, so does its ventilating power, and that the rooms nearest the chimney are better ventilated than those more remote.

Electric Fans are commonly used now to remove the polluted air of smoking-rooms or crowded apartments. These are fixed at the upper part of windows, and are only used when the atmosphere is becoming oppressive.

A system of ventilation which works well during the day may be very ineffective when means of illumination are used, as these may totally change the direction of the air currents. For each cubic foot of gas burned, 1800 cubic feet of fresh air should be supplied. In the same way an efficient system in winter may not be satisfactory in summer; the chimney is then often the coldest part and acts as an inlet, and thus a sooty smell is often noted in rooms.

Influence of Dust on Health.—Solid matter suspended in the air and constantly respired, gives rise in many cases to disease in the lungs (*pneumonokoniosis*). The particles may irritate the mucous lining of the bronchi, and so may give rise to bronchitis, or if repeated attacks occur, emphysema may be a consequence. A variety of acute inflammation of the lung substance may be due to the inhalation of very irritant particles. More frequently, however, the dust in time leads to a condensation of the lung substance (fibroid phthisis); the pleura also becomes thickened and adherent, and bronchiectasis may develop. Tuberculous disease is easily superadded, and a true pulmonary phthisis may be started.

Those Workmen Who are Liable to be so Affected are:—

(1) Miners. Coal miners formerly were frequently affected (anthracosis), but at present the disease is only found in very

badly ventilated mines. Quartz rock and granite give off a very irritating dust, and thus gold or metalliferous miners may suffer from the use of the diamond drill. Owing to the degeneration of lung tissue brought about by the dust, a very high percentage die from true tubercular phthisis; 94 per cent of deaths which occurred in men who had worked rock drills were due to phthisis and other lung diseases. The remedy is to use a water spray in the bore hole.

(2) Tool-grinders and especially needle-makers (*siderosis*). Wet grinding should be employed, or the grindstones should be enclosed in boxes with an extraction shaft from each so that the dust may be immediately sucked away, or magnetic shields may be employed.

(3) China scourers suffer from emphysema on account of the irritating flint particles on the surface of the china.

(4) "Potter's Asthma" is of the same nature.

(5) Pearl button makers, glass grinders, grinding-stone makers, cement grinders, etc., all suffer (*silicosis*, *chalicosis*).

(6) The textile factories are prone to produce lung disease. Flax and "shoddy" works give rise to paroxysmal attacks of dyspnœa in the operatives from the "pounce" dust. Cotton, wool, or silk carders also suffer severely. In cotton factories, besides the particles of cotton and size, the air is saturated with steam ("artificially moistened air").

Under other headings the diseases induced by the inhalation of phosphorus, lead, arsenic, mercury, micro-organisms, etc., are discussed.

Impurities from Certain Trades.—From alkali works hydrochloric acid vapours are evolved, and these destroy vegetation; from bleaching works, sulphurous acid; from chemical or gas works, sulphuretted hydrogen; from the burning of bricks or cement, carbon monoxide and dioxide, and sulphuretted hydrogen; in brassfounding, zinc oxide fumes are evolved; in copper smelting, arsenical fumes; in india-rubber works, naphtha vapours and bisulphide of carbon; in glue boiling, bone burning, slaughter-houses, etc., many disgusting organic gases are generated.

Air of Cesspools or Sewers.—If well ventilated the air may be innocuous, but if badly ventilated, the oxygen may be reduced from 2 to 3 per cent: nitrogen may be increased to 94 per cent; carbonic acid, marsh gas, sulphides of ammonium and hydrogen may be in large amount. Sewermen are

sometimes poisoned by the rapid evolution of sulphuretted hydrogen due to the access of acid fluid from some factory. The organisms in sewer air are mainly those derived from atmospheric air or ordinary moulds; in certain cases, however, specific organisms may be present.

Cemeteries and Vaults.—Carbonic acid, ammonia, and putrescent organic vapours are present in large amount, as are also ammonium sulphide, sulphuretted hydrogen and phosphuretted hydrogen.

Effect of Overcrowding and Want of Ventilation on Health.—When individuals dwell constantly in overcrowded rooms or factories the health suffers; weariness, heaviness, headache, and nausea are complained of, and work is slowly and badly performed. In time they become debilitated, pale and listless. Overwork and insufficient food, if associated with the above conditions, soon predispose to the development of infectious diseases and especially of phthisis. The incidence of the latter disease is far greater amongst the dwellers in one-roomed houses than it is amongst the better classes. The mortality from phthisis has fallen within fifty years almost ten per thousand in the English army, and this is due entirely to improved barrack accommodation.

If sewer or drain air gains entrance to sleeping-rooms, then in addition to the above, morning headache is often a symptom with drowsiness, slight fever, diarrhœa, sore throat, crops of boils or carbuncles, etc. The specific organisms of certain diseases (diphtheria, enteric fever, etc.) may gain entrance to the rooms from drains, and as children are specially susceptible to impure air the evil results are more marked in them. The spread of infectious disease from drain or sewer air is not now believed in to any great extent. Ophthalmia in children may be due to dust or to the inhalation of impure air.

Compressed Air Illness: "Caisson Disease"; Divers' Paralysis.—In the building of foundations for piers, etc., a large circular cylinder closed above is sunk on the site, and air is driven into this at pressures of from two to four and a half times that of the atmosphere so as to drive out and keep out the water. Workmen before entering this large tank have to spend a period corresponding to one minute for every 5 lbs. of pressure (*e.g.* six minutes for 30 lbs.) in a small room ("the lock") while the pressure is slowly increased. When the

pressure has reached that in the caisson the men then enter it, and work for some hours in this compressed atmosphere. The same precautions are taken when they leave off work ("decompression"). Some men are susceptible, however, and complain of pains in the ears, tinnitus, deafness, tightness round the head, and (almost invariably) muscular pains ("bends"). If the workmen are careless in leaving the caisson too quickly, hæmoptysis may result and even sudden death; in other cases nervous affections develop (paraplegia, paralysis of the sphincters). These are due to the sudden disengagement of nitrogen gas in the blood and tissues owing to the rapid fall of pressure. Some of the effects are also probably due to the toxic qualities of oxygen at high tension, which induces a congestion and swelling of the pulmonary alveolar walls. The best treatment is to place the men in the air-lock and to "recompress" them, so causing the gas to pass into solution in the blood, and then to "decompress" them very slowly. Paraplegia may persist for several months. The higher the pressure to which the men are exposed, the shorter must be the "shift" they work. The larger the volume of fresh air which can be given to each worker, the less liable are they to injurious pressure effects.

Practical Examination of Air.

1. *The Amount of Moisture or Humidity* may be estimated (*a*) by weighing it. By aspirating a known volume of the air through glass bulbs filled with pumice stone soaked in pure sulphuric acid, the watery vapour is absorbed, and the increase in weight of the bulbs represents the amount of water in the volume of air.

(*b*) By the direct hygrometer.

(*c*) Indirectly by the wet and dry bulb thermometers.

2. *Dust.*—(*a*) A qualitative estimation may be made by Pouchet's aeroscope. This consists of a tube drawn to a fine point, and brought almost in contact with a drop of glycerine on a microscope slide. The whole is enclosed in an air-tight chamber, and as air is aspirated through this, the dust is caught by the viscid fluid, and can be examined.

(*b*) A quantitative estimation may be made by drawing a known volume of air through a tube packed with crystals of

pure sodium sulphate. If the latter be dissolved in water, and filtered through a filter-paper of known weight, the increase in weight of the latter when dry represents the amount of dust present in the air.

3. *Micro-organisms.*—These are usually detected by exposing Petri dishes containing nutrient gelatine or agar for varying periods (ten to one hundred and twenty seconds), depending on the impurity of the air. They are then incubated and the number and kind of the organisms determined.

4. *Carbonic Acid.*—(*a*) Pettenkofer's method of estimation consists in shaking up a known volume of air with a pure solution of barium hydrate of known strength. The latter becomes changed into the insoluble carbonate in presence of this gas, and, therefore, less of the hydrate is left in solution. The strength of the barium hydrate solution is estimated after it has been shaken up with air, and the difference between the two estimations (before and after shaking) corresponds to the amount of carbonic acid in the volume of air which was examined. A standard solution of oxalic acid is used to estimate the strength of the baryta solution, and is made by dissolving 5·64 grammes of oxalic acid in 1 litre of water; each c.c. corresponds to 1 c.c. carbonic acid at 0° C. and 760 mm. pressure. A solution of phenol-phthalein is used as an indicator of neutrality, being crimson in alkaline but colourless in acid solutions. The volume of gas must be corrected for the temperature and pressure at the time of taking the sample.

(*b*) The Lunge-Zeckendorff method consists of a $\frac{N}{500}$ solution of carbonate of soda coloured pink with phenol-phthalein. The air is driven slowly through this by means of a bellows of known capacity until the colour disappears. The number of bellowsful of air used, gives, on reference to a table, the percentage of carbonic acid present.

(*c*) The Wolpert method is similar, but the air is added in definite amounts and shaken in an apparatus.

5. *The Organic Matter* may be determined by aspirating a known large volume of air through several small flasks containing ammonia-free distilled water, and then subjecting the whole to Wanklyn's method of water analysis. A modification of Tidy's method may also be employed.

6. *Carbonic Oxide.*—*Vogel's Test.* The air should be shaken

up in a large bottle with a dilute solution of blood. The position of the absorption bands should be noted in the spectroscope, and that the addition of a reducing agent has no effect on their position.

7. *Gaseous Impurities.*—(*a*) *Hydrochloric Acid.* A known volume of air should be aspirated through a dilute solution of caustic potash; then the chlorine is estimated in this by means of a standard solution of nitrate of silver.

Sulphurous Acid. The gas is absorbed as in the preceding, and titrated with a standard solution of permanganate of potassium.

Sulphuretted Hydrogen. This is absorbed by drawing air through a solution of acetate of lead, and estimated as the sulphide.

CHAPTER III.

HEATING AND ILLUMINATION.

HEATING.

The two processes of heating and ventilation are inseparable, and may, thus, be made to supplement each other. The air of ordinary living-rooms should be kept at a temperature of 60° F. during the day, while bedrooms may be kept from 5° to 10° lower. Various methods of heating dwelling-rooms or public places may be employed. In this country the open fire is the most satisfactory for ordinary living-rooms.

I. **Open Fireplace.**—The open fire heats a room chiefly by radiant heat. These rays pass directly through the air without heating it appreciably, but they warm the walls, floor, ceiling, human bodies, and articles of furniture. These in turn emit dark or non-luminous heat rays, which again warm the air of the room by conduction and convection. The walls, etc. are, therefore, warmer than the air in these rooms. Radiant heat does not dry the air of a room nearly to the same extent as does convected heat from a stove or from hot water pipes, but it is costly in comparison to these, and its heating power diminishes as the square of the distance from the fire.

The ordinary fire acts as a strong ventilating agent, heating the air in the chimney and converting it into a powerful extraction shaft. An ordinary fire is, however, an extravagant method of heating as it burns about 8 lbs. of coal per hour. Each lb. requires the oxygen of 160 cubic feet of air for its combustion. The rate of flow of heated air up the chimney varies from 10 to 15 feet per second, and consequently 1 lb. of coal in burning will set in motion somewhere between 20,000 and 50,000 cubic feet per hour. The stronger the fire

the greater the updraught and (with care) the greater the ventilating effect. Air is drawn along the floor to supply the fire; part of this passes up the chimney, part circles up in front of the fire towards the ceiling, from whence it will curve round towards the centre of the room, and part circulates round the room on either side of the fireplace. If there are two fireplaces in one room, both should be on one side to prevent down-draught, which might be caused by one fire burning more briskly than the other.

The amount of heat obtainable from an open fire is not great considering the amount of coal burnt—perhaps only one-sixth or one-eighth of the heat is available for heating the room, but its powerful ventilating action must also be remembered in reckoning the cost. A properly constructed fireplace should be lined with thick firebrick so as to retain much heat, and give it out slowly when the fire begins to fail. The sides should be splayed widely out, and the back should be bent forward at the upper part so as to direct the heat rays through the room. The "throat" or upper part of the grate should be contracted so as to induce a more powerful updraught. The space below the fire should be closed in so as to lessen the rapidity of coal consumption.

In Slow Combustion Grates the supply of air is cut off from beneath the fire, or else it is supplied in the form of hot air. These grates heat the hearth and thus diffuse much heat into the room. They are also not so liable to downdraughts of smoke (*e.g.* Teale's grate).

The burning of "briquettes" in open fires is attended with the production of large quantities of carbon monoxide gas. They are often used as "foot warmers" on the continent, and have caused many deaths.

The fire may be employed to heat the fresh incoming air, and deliver it either at the level of the mantelpiece or by openings 5 to 6 feet above the floor. There are many varieties of such "warm air grates."

In Galton's grate, fresh air is brought in from behind the fireplace, and is made to circulate behind the grate, and being led up in a shaft alongside of the chimney, the warmed air is then allowed to escape into the room near the ceiling.

The grate may be placed near the centre of the room if it be covered with a cap to collect the smoke. The latter is joined to a flue which runs under the floor. This must in turn

be connected with a vertical flue twice the length of the horizontal shaft (*e.g.* Franklin grate).

II. **Stoves.**—Coal or charcoal is burned in stoves made of iron or brick, and joined to a flue to conduct the fumes outside. To increase the heating surface the flue may be coiled many times before it is led out of the room. Stoves heat the air directly by convection, and little or no radiant heat is evolved from them. The walls and furniture become indirectly warmed from the air. Warming by stoves is much more economical than heating by open fireplaces as they expose a large heated surface to the air.

Cast-iron stoves are most insanitary and dangerous. As they are easily overheated the air becomes dried and charred, and irritating to the lungs. The gases of combustion (CO_2 and CO) escape through the joints of the stove and may cause poisonous symptoms or even death. The degree of combustion in stoves is regulated by (1) the position of the inlets, (2) by the damper controlling the inflow, and by (3) the height of the chimney.

Asphyxiation by Stoves.—The gases which cause accidents are mainly carbonic acid and carbonic oxide. The dangers consist in faulty construction, allowing these gases to escape through crevices, or faulty regulation of combustion, so that the lower and intensely poisonous oxide is formed. Fatalities from the employment of stoves are common abroad during the winter. Owing to the intense cold the inhabitants close up doors, windows, and flues, and the gases not being able to escape from the room cause suffocation.

It may be that the heated carbon in the iron unites with oxygen in the air of the room to form carbonic oxide. Carbon monoxide does not pass through red-hot iron as was formerly believed, but the organic matter of the air in contact with the hot metal may become changed into this gas. In the modern type the stove is entirely composed of or lined with firebrick. They are not so easily overheated, and noxious gases cannot escape so readily. The brickwork should be thick so as to retain heat for a considerable time. Stoves should be made quite tight, and when not of brick should be of wrought iron.

Slow Combustion Stoves are in common use. Many are arranged to deliver into the room fresh air, which has been led through them in flues, and so has been warmed (George's "Calorigen" or the "Euthermic" stove). Stoves have the

great disadvantage of not helping in the ventilation of the apartment. They likewise dry the air very considerably, so making the occupants suffer discomfort. Shallow vessels of water may be placed on the stoves, and to a certain extent this defect is counteracted.

Gas Fires.—These form convenient and useful means of warming small rooms, and especially if such are only used for short periods. There must, however, always be a flue of sufficient size to lead the gases of combustion either into a chimney or to the outside. When properly fitted in and looked after they are in all respects equal to a coal fire; in fact, a gas fire is a coal fire in gaseous condition, the gas being consumed as in a Bunsen burner and rendering asbestos, clay, or iron incandescent.

Hot Air may be supplied to the various rooms in a house. The air is heated in a basement furnace and sent throughout the house by means of flues. In Russia and America this method is common.

III. **Hot Water System.**—In this system hot water is conveyed throughout the dwelling, and by means of coiled pipes in the form of "radiators" the heat is evolved where it is required. Briefly, it consists of a boiler at the lowest part and an open hot water cistern at the highest, to allow of expansion of the water. From the upper part of the boiler the light heated water ascends by a direct pipe to the upper part of the cistern. From the lower part of this cistern the heated water is led in pipes to the rooms which are to be warmed, and in these apartments the pipe is coiled so as to increase the heating surface. The colder water then flows down and enters the lower part of the boiler. A constant circulation of hot water takes place in this way. The pipes are made of cast iron, and vary from 2 to 4 inches in diameter. A forced circulation may be required in large establishments, and where the height of the cistern is not great. This is usually carried out by placing an Archimedean screw close to the inlet in the cistern to draw the water upwards. The amount of heating surface must be proportional to (1) the volume of fresh air required, (2) the degree of heat desired, (3) the thickness and conductivity of the material. As the system is open the temperature of the water is seldom above 200° F. It is usual to allow 1 superficial foot of heating surface for every 65 cubic feet of air space to be warmed, or

12 feet of 4-inch pipe for every 1000 cubic feet so as to keep the temperature about 60° F. This system is very convenient as it requires no skilled supervision, and a whole establishment may be heated from a single fire in the basement. Any part of the system may be "cut off" when certain rooms do not require to be heated.

IV. **High Pressure System of Water Heating** (Perkins' System).—This system is an entirely closed one, hence the water is heated under pressure to three or four atmospheres, and thus attains a higher temperature than under ordinary conditions. It consists of an endless wrought-iron tube of 1 inch diameter, with thick walls to withstand the internal pressure. About one-sixth of the entire length of the tube is coiled, and heated in a furnace, this representing the boiler. The heat causes the water to expand, and to circulate through the pipes. The inclusion of air must be carefully avoided by filling the pipes from below upwards. An expansion tube containing air is inserted at the highest level, as water expands 5 per cent of its volume when heated from 40° to 212° F., and a safety valve is also added. A temperature of 300° F. may be obtained in the circulating water, and hence rooms are more rapidly warmed by this method than by the preceding, though the air is apt to become overheated. Even if a tube bursts little damage is, as a rule, done. About 8 feet of this high pressure pipe is supposed to be equal to 12 feet of the low pressure pipe.

V. **Heating by Steam.**—This is the most effective method of heating, as differences of level cause little hindrance, steam being a gas, and besides the temperature of rooms is quickly raised by this means. It is economical in institutions where an engine is already installed, as the exhaust steam may be employed for the purpose of heating, and the return steam may be used to feed the boiler. The pipes of the radiators are made larger than the carrying tubes so that the steam may condense in them, and evolve its latent heat during condensation. Steam heating requires skilled supervision, and is expensive because of the great tear and wear in the plant, and consequent depreciation.

In cold, damp climates, convection heating by hot water or steam pipes is very advantageous as it dries the air as well as warms it. Unless, however, the system is in constant operation the walls of rooms feel cold, and in order to avoid this, radiant

heat from an open fire is also desirable. For rooms which are constantly occupied a combination of open fire and hot water system is to be preferred. Halls and corridors, however, may be heated by hot pipes alone. Means of ventilation must be provided, as the above installations do not favour it. Radiators of heat are usually placed below windows, fresh air being introduced behind them; the air is thus warmed as it escapes into the room.

ILLUMINATION.

Coal Gas when burned uses much oxygen. Thus, 1 cubic foot of gas burned destroys the oxygen of 8 cubic feet of air and produces 2 cubic feet of carbonic acid, so destroying as much air as 4 or 5 men. Each burner requires an adequate amount of air to consume the volatile hydrocarbons of which the gas is composed. If the amount is insufficient the flame smokes owing to carbon being unconsumed, and such gases as carbon monoxide and dioxide, acetylene, sulphur dioxide, etc., are liable to be produced. If the burner receives too much air, the flame makes a whistling noise, and gives little light because the hydrocarbons are burnt too rapidly.

The incandescent form of gas lighting (*e.g.* Welsbach) is the most sanitary form of coal gas burner. It is really a Bunsen flame which raises a mantle (composed of oxides of the rarer metals) to a white heat. If there are many gas lights aggregated, the products of their combustion should be led off by a shaft, thus a Sunlight flame may be placed at the lower end of a M'Kinnell's tube. At the same time it acts by heating the shaft, and so favours the extraction of foul air from the room. A single gas jet may be enclosed in a globe, and fed with fresh air brought from the outside by a tube, while another shaft above it conducts the foul air outside.

Acetylene (C_2H_2) is an non-poisonous gas largely used in the lighting of tramcars, omnibuses, country houses, etc.

Oil Lamps and Candles vitiate the air, but not to the same extent as coal gas. The light of a standard candle is employed in estimating the illuminating value of gas, etc. "One candle power" is the light given by a sperm candle, burning 120 grains of its weight per hour.

Electric Light is, of course, the most sanitary form of illumination. It is also employed in the form of radiators to heat the air of rooms.

In the Houses of Parliament in London the fresh air is brought to the basement, where it is heated or cooled, freed from dust, and moistened if necessary. It then passes into the chambers through perforations in the floor. When foul, it is sucked out from the ceiling through the medium of a heated extraction shaft situated in the clock tower. In the French Chamber of Deputies the foul air is drawn out through the floor while the modified fresh air is introduced near the ceiling. It is much more difficult to ventilate downwards, as the extraction shaft requires to be kept very hot.

CHAPTER IV.

WATER-SUPPLY.

Rain is water purified by distillation, as it takes place in nature, *i.e.* by evaporation with condensation in the cold higher strata of the atmosphere. As rain falls through the denser layers of the atmosphere it becomes more and more contaminated by gaseous and suspended impurities. It then sinks into the ground, where it dissolves a little of almost everything with which it comes into contact. Absolutely pure aerated water may be collected on the tops of high mountains.

Owing to the aggregation of human beings in villages and towns, it becomes necessary to store up a supply of water so that during rainless periods they may not suffer from a water famine. Nature does this in the shape of springs, lakes, and rivers, and man supplements these by storage tanks or impounding large areas as reservoirs. A large amount of water exists in the soil as moisture, and as subsoil or underground water. This supply can be utilised by wells.

Wells are of two varieties—(1) surface, and (2) deep.

(1) *Surface Wells.*—These are more or less shallow pits (less than 50 feet deep), sunk to a basin where the rain, surface, and subsoil waters have accumulated above the first impermeable stratum. These wells are not very permanent, and easily dry up in summer as they do not drain a wide or deep area. No great amount of soil filtration or purification takes place, and hence such waters are dangerous. They are very liable to pollution, owing to their proximity to dwellings and to cesspools, privies, etc., and because they form the lowest point of a natural drainage area. Shallow wells may drain an area more than four times their depth, hence the contaminating focus may be at what might be considered a safe distance. After

a continuous rainfall, the level of the subsoil water rises, and so does the level of the water in the well. The subsoil water may reach to a level of the ground which is contaminated, and hence the water in the well will become polluted also.

Precautions in Using Them.—The inner surface of the well should be rendered impermeable, either by means of a layer of puddled clay inside a brick lining or with bricks set in hydraulic cement; the surface of the ground for a considerable distance around the well should be cemented and sloped away from the opening. The lining of brick should be carried up 3 feet above the surface, the well covered in, and the water withdrawn by a pump. To render shallow wells still safer, a layer of gravel should be placed at the bottom, and on the top of this a layer of well washed sand 6 feet in depth. To increase

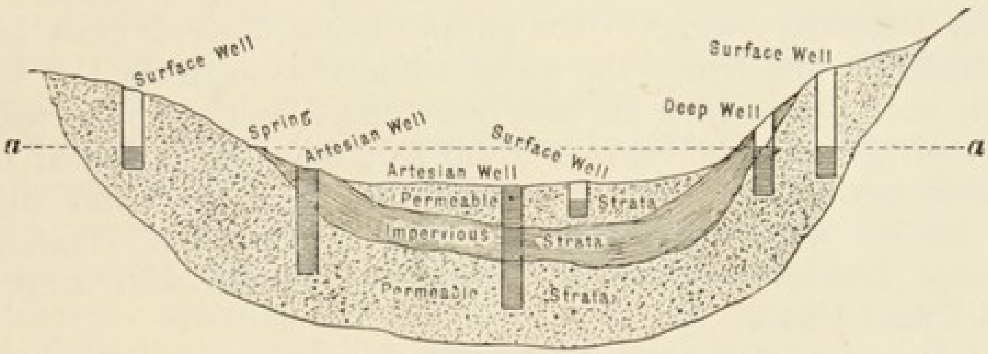


FIG. 24.—To illustrate the various forms of wells. *a a*, level of water in deeper permeable strata.

the yield, galleries or adits may be driven from the bottom of the well. Leipzig, Dresden, Bonn, etc., all depend on wells for their water-supply.

Character of Shallow Well Water.—The water is hard from the presence of lime salts, and often contains much organic matter. The temperature varies greatly. If the ground be chalky, the temporary hardness is high.

(2) *Deep Wells.*—These are usually sunk for considerable depths through an impermeable to a permeable stratum, in which underground reservoir the water collects. Such wells are usually permanent, and give a pure hard water. After heavy rainfall the level in such a well may rise so high as to become polluted by contamination from the surface layers of the soil, and this may take place at a point distant from the well. Polluted water may also gain entrance to such supply by fissures in the rock, or by filtering into the well alongside of the pump.

If this takes place, the water for long afterwards may be very dangerous. The same precautions must be taken in protecting deep wells as is taken in shallow ones.

Character of Water.—It takes up much carbonic acid from the ground air, and thus becomes a strong solvent, consequently it acts on the limestone rocks through which it filters, and may even be too hard for domestic use. The temperature is uniform, and such waters are usually very pure as regards organic matter. The typhoid bacillus can live for several weeks in water free from other organisms, and hence deep wells once contaminated may induce this disease for long afterwards.

Artesian Wells form a variety of deep wells. They are tube wells sunk to a great depth through an impermeable stratum to a permeable one. The water in the latter is at great pressure, owing to the supply being derived from high watersheds, and hence the water usually issues from the tube with such force that it may rise many feet. The artesian well of Grenelle in Paris is 1800 feet deep, and yielded 600 gallons per minute when first tapped in 1841, the water rising 35 metres above the surface. The fountains in Trafalgar Square, London, are supplied from an artesian well sunk to the Upper Chalk.

Character of Water.—As regards organic matter it is perfectly pure, but may be exceedingly hard.

Driven Tube Wells (Norton's; "Abyssinian," etc.) are made use of by soldiers on the march or for temporary purposes. They are made by driving into the ground lengths of iron tube which are screwed together, the lowest being perforated with holes. At a certain depth ground water is reached, and may be obtained by attaching a pump to the tube.

Wells may be sunk near rivers so as to get river water purified by filtration through the soil. If too near the sea, excessive pumping may draw in brackish salt water. Superficial wells in sand, gravel, or chalk are often very inconstant in supply, while those in sandstone or limestone are usually plentiful and constant.

Rain Water.—This is a water containing in solution all the gases of the atmosphere in proportions varying as their solubility. Near towns such gases as sulphurous and nitric acids, chlorine, etc., are absorbed as well as dust. The average annual rainfall for England and Wales is 34 inches,

for Ireland 39, and for Scotland 46 inches. In very populous centres in Great Britain the roof surface for each individual is only about 60 superficial feet. This, with a rainfall of 30 inches, would collect but 960 gallons in each year, or about 2½ gallons per day, not taking into account the amount lost by evaporation. In other countries (India, Turkey, etc.) rain water is collected from the roofs and stored in underground tanks; the first rain which falls should be run into the drain by means of a "separator." At first rain water is flat and unpalatable, but during storage it absorbs carbonic acid, and becomes pleasant.

Surface Water.—This is water which has run over the surface of a soil without penetrating it. When collected from *upland hilly districts*, such water affords an excellent supply, being usually soft, and containing but little chlorine.

Lowland Surface Water, on the other hand, usually contains much organic matter as well as phosphates and nitrates washed from the manures of cultivated fields.

Spring Water.—Springs depend on various geological requirements, but the essentials are, that there is an outcrop of a permeable stratum which rests on an impermeable one. Rain water is stored up in the porous soil, and when in sufficient amount will issue as a spring from the outcrop. Geologically we find dip, fissure or junction springs. (1) Surface springs often dry up, while (2) deep springs are permanent. Vienna, Bath, Malvern, etc., are supplied with water from springs.

Character of the Water.—Depending on the nature of the gathering ground, spring water may be very pure or somewhat impure as regards organic matter. In many cases it is impossible to tell how far the sources of a spring extend. If spring water be contaminated, it does not tend to purify itself, as it undergoes no further filtration. Great care must, therefore, be taken in choosing a spring water as a source of supply. Many epidemics of typhoid fever have been due to the contamination of springs by surface manure containing human excreta. In passing through the soil the water absorbs much carbonic acid, and is usually hard from the presence of dissolved bicarbonates, but cool and sparkling from aeration. The water may be warm if it comes from great depths, and so full of mineral constituents that it can only be used as a mineral spring.

River Water.—Rivers result from the drainage of upland

areas, from springs, and from underground drainage during their course. In summer they are small, but the water is purer than in winter when they are swollen by rain, and polluted by surface water. The composition of the water varies, therefore, with the season. Rivers which flow in high upland or granitic areas are very pure, but when they reach lowland agricultural districts the water becomes so foul from organic and saline impurity, that seldom can it be used directly for domestic supply. Sewage and trade refuse finding their way into rivers render the water unfit for potable purposes. The Rivers Pollution Prevention Act was passed to prevent this fouling of watercourses. Where much sewage is passed into rivers, the oxygen in the water becomes greatly lessened in amount, so much so that fish can no longer live in them, decomposition of organic matter goes on with the evolution of much foul gas, and a slimy deposit of refuse takes place on the banks and bed of the river.

Character of Water.—Usually hard, though much less so than well or spring waters. The organic matter may be large in amount, depending on the nature of the subsoil drainage.

Peaty Water.—This may be the character of river or spring water, and renders these unsuitable for a water-supply. On storing, the peaty matter becomes precipitated.

Marsh Water is unfit for a water-supply.

Natural Purification of Rivers.—It is undoubtedly true that if sewage gains entrance to a river high up, it becomes destroyed by oxidation, subsidence, dilution, bacterial action, etc., in the course of its flow downwards. The more the water is aerated, as by flowing over rocky beds, weirs, etc., the greater is the amount of natural purification which takes place. This purification, however, does not take place to any extent in any river in Great Britain, as they are not sufficiently long, and the farther they flow the more do they become contaminated.

Lake Water resembles river water very closely. Natural sedimentation takes place during the stay of the water in the lake, which is not so likely to be contaminated by added sewage as are rivers.

Method of Calculating the Yield of Springs, Streams, or Rivers:—

(1) *The Yield of an Ordinary Spring* may easily be ascertained by noting the time which it takes to fill a receptacle of known size, *e.g.* a 30 gallon cask. If a rectangular box be

employed, the yield in gallons is obtained by multiplying the cubic content in feet by 6·23.

(2) *A Small Stream or Rivulet* may be dammed up, and made to flow along an artificial uniform channel of known dimensions (*e.g.* a long wooden trough). The outflow in such a case corresponds to the velocity, width, and depth of the water multiplied together. The surface velocity is determined by noting how long a float takes to travel from one end to the other.

(3) *A Large Stream or River.*—A part should be selected where the width and depth are fairly uniform throughout a considerable length. Measure its breadth at several points, and take the average; do the same with the depth. By multiplying these two averages together the *sectional area* is obtained. Note how many seconds it takes for a chip of wood to travel over the selected distance; this gives the *surface velocity*, which is greater than that at deeper levels. The *mean velocity* of the current is got by taking $\frac{4}{5}$ of the surface velocity. The yield of the stream corresponds to $\frac{4}{5}$ of the surface velocity multiplied by the sectional area.

Example.—Average width of a stream is 25 feet; average depth, 4 feet. Surface velocity, 40 feet per minute = 32 mean. The sectional area = 25 × 4 = 100 feet, and, therefore, the outflow corresponds to 100 × 32 = 3200 cubic feet per minute, or (× 6·23) 20,000 gallons.

Amount Obtained from Rainfall.—If the area of the receiving surface (if a roof, calculate only the superficies of the area) in square feet is multiplied by the rainfall in inches and the product divided by 12, the answer gives the yield in cubic feet of rain water per annum. On ordinary surfaces a very large amount is lost by percolation, and much by evaporation.

It may be impossible to obtain a sufficient supply for a town from separate rivers, springs, or lakes, and it, therefore, becomes necessary to collect various supplies. For this purpose a collecting area must be selected. This is usually a high upland district amongst hills or mountains, and far removed from habitations. If such can be obtained near the city so much the better, but in many cases Corporations have to select areas many miles (60 to 100) distant.

Drainage or Catchment Areas.—These are areas set apart for the collection and storage of all the water which falls upon them. Reference to Ordnance maps affords help in choosing

such a locality. Each area is usually surrounded by a ridge line of hills or mountains, continuous except at the outlet, so that all the water tends to flow in one direction. Subsidiary drainage areas may be connected with the primary by bringing their collected water through mountains by means of tunnels. Brooks, springs, subsoil, and surface drainage of hill pastures form this water-supply.

In calculating the extent of area which has to be set aside for the needs of a city, the following points have to be considered :—

(1) The population to be immediately supplied, and its rate of increase. A supply adequate for the present population may be quite inadequate five years later, and as water schemes are very expensive, it is necessary to make provision for many years in advance of present requirements.

(2) The number of gallons each person is to receive per day.

(3) The least annual rainfall. This is of great importance in reference to dry years.

(4) The distribution of the rainfall during the year, and the mean annual rainfall.

(5) The longest period of continuous drought. Enough water must be collected and stored so that the inhabitants may not suffer from lack of water during a period of drought.

(6) The greatest storm rainfall. When the reservoirs are full, provision must be made for carrying away storm water, and so preventing it from entering the reservoirs, and fouling them with muddy water.

Hawksley's Rule.—The average rainfall of twenty years, less one-third, corresponds to the amount of rain in the driest year; while the average of twenty years, plus one-third, gives the amount of rain in the wettest year. When the rainfall is small in the collecting area, then a larger extent of country must be utilised as a gathering-ground, and the same will hold if the distribution of rainfall during the year be very irregular.

Dublin has a collecting area of 22 square miles, the rainfall being 53 inches; the catchment area for Birmingham is 71 square miles; while the Talla Waterworks, which supply Edinburgh, comprise 6180 acres, the rainfall being 38 inches. In dry years this yields 14,598,000 gallons per day.

Calculation of Yield from Catchment Area (Pole's formula).—Let Q = supply in gallons each day; A = catchment area in

acres; R = average rainfall of the three driest consecutive years; E = loss in inches by evaporation, absorption, and percolation, then

$$Q = 62{\cdot}15\ A\left(\frac{4}{5}R - E\right).$$

One inch of rainfall is equal to 22,617 gallons per acre. The loss by evaporation is great, and in many cases amounts to fully 50 per cent of the rainfall. It is estimated by exposing shallow trays filled with water, and noting the amount of evaporation in a given time.

Reservoirs.—Having selected a gathering-ground, and diverted all the water which falls on it towards one exit, it is necessary to store the latter up in a large lake. This may be a natural lake, though usually it has to be greatly increased in storage capacity by raising the "barrier outlet," or an artificial lake has to be made by building a dam across a valley, and so impounding the water in a reservoir. The reservoir should be situated as high as possible so that the supply may be by gravitation, and thus the expense of pumping water to high localities in towns is avoided.

Storage Capacity.—This is calculated from the number of consecutive rainless days during which the water must last, and the number of gallons required daily for the whole population. It is seldom that a drought lasts longer in this country than six weeks, but usually a reservoir is constructed to contain a supply for one hundred and fifty to two hundred days. At the Talla Waterworks the storage reservoir has a capacity of 2,800,000,000 gallons, and a superficial length of 2½ miles. A certain amount (usually one-third) has to be stored as "compensation water," or that which must be passed into streams for the use of mill-owners, etc.

Preparation of Site.—It is seldom necessary to do more than remove very rank vegetation, shrubs or trees, before commencing the collection of water.

Embankment or Dam.—This is an earthen or stone dam, and must be made very strong as the pressure of water behind is often tremendous. In some cases the reservoirs are miles in extent, and dreadful accidents have happened from the embankments giving way. The dam ought to rise at least 5 feet above the highest level of the water; the side towards the water is faced with dressed stones laid close together and

bedded in impervious (hydraulic) cement. Along the whole length, and at the centre of the embankment a layer of puddled clay or cement extends from side to side. This is to prevent leakage, and must be embedded in the solid rock beneath. It ought to be one-tenth of the thickness of the embankment. The outer side slopes gently down, and is sown with grass. No trees or shrubs must be allowed to grow as their roots might disintegrate the protecting puddle wall, and ravages by water rats must be carefully prevented. Even the slightest perforation of this impermeable layer is dangerous, as the water filtering through begins to wash away the clay, and in consequence the dam becomes undermined. The Talla embankment is 1200 feet long; the breadth at the bottom is 600 feet, and at the top 20 feet. The puddle trench is 124 feet deep and 10 feet thick. In connection with the reservoir there ought to be an *overflow weir* or channel ("bye-wash"), into which during continuous wet weather streams may be directed, and fouling of the water in the reservoir prevented.

The Outlet Conduit or aqueduct is laid at the lowest part of the reservoir, and penetrates either the bottom of the dam or is carried through a tunnel at one side of the reservoir. The outflow is controlled by a tower which stands in the reservoir, and has inlets at different levels controlled by valves.

Compensation Reservoirs are areas in which storm water is impounded for the supply of rivers which have been depleted by the accumulation of water in the ordinary reservoirs. This supply is necessary for the requirement of factories situated along the banks of these streams or rivers.

Tank Reservoirs are chambers of varying size built of brick, stone, or tiles, or of cement. They are used for the storage of water to supply villages or small towns. They ought always to be constructed below ground, and entirely covered over so as to prevent contamination. When open, they invite suicide or infanticide.

Purification of Water in reservoirs. The water becomes purified to a certain extent during its stay in a reservoir. The solid particles sink to the bottom ("*sedimentation*"), carrying with them many bacteria. For the destruction of algæ copper sulphate is useful; this is enclosed in sacks, which are drawn through the water, so furnishing a dilute solution of the salt.

Filtering Beds.—It is seldom that water can be used without

filtration; for this purpose large filter-beds are prepared. Each may be 3000 superficial yards in extent.

Structure.—A solid floor of cement is built slightly sloping towards the centre, and walls surround the floor to a height of 10 feet. At the bottom, open drain pipes lead the water to a central channel. For a depth of 2 feet above this, broken road metal or small boulder stones are placed; on the top of this a layer of small stones or coarse gravel, with finer gravel above, extends for 12 to 15 inches. Forming a top layer, coarse sand surmounted by fine sand stretches to a depth of about 2 feet. The total depth of the filtering material is about 5 feet. Water is allowed to stand above the sand to a depth of 1 or 2 feet. To prevent the filter from becoming "air-locked" when water is allowed to run over the sand, air-pipes extend from below the broken whin-stones to above the water-level; these are placed at intervals along the sides of the filter-beds. To prevent the inflowing water from washing out the sand, it is made to overflow slowly from a bell-mouthed pipe, and so floods the filter-bed equally. In cold countries the filter-beds may be roofed over.

Rate of Filtration.—To be efficient, filtration must be slow, *e.g.* 2 gallons per square foot per hour, or 8 to 10 vertical feet per day, or 2,000,000 gallons per day per acre of filter-bed. When the filter-bed is newly made, the water filters rapidly and imperfectly, but after three days it begins to act well. Its working gradually becomes slower owing to the formation of a slimy micro-organismal deposit on the surface of the sand. This deposit becomes thicker and thicker until after twelve to fourteen days the percolation almost comes to an end, owing to the thickness of this layer. The limit of efficiency of the filter depends on the character of the water. A peaty water soon chokes up the filter, while a pure water ensures the filter a long period of efficiency.

Cleaning of the Filter.—When the flow of filtered water becomes very slow, the process is stopped, and the topmost layer of sand with the slimy deposit (about ½ an inch) is scraped off with shovels, and washed with running water until it is quite clean, when it is again spread on the filter after the underlying sand has been aerated by delving. It is a rare occasion to clean out a filter-bed entirely. In "Intermittent Filtration" the filter is used for sixteen hours and allowed to rest eight hours. This is useful where nitrification is much desired.

Purifying Agencies of the Filter.—The water during filtration is purified in the following manner:—

(1) *Mechanically*, the irregularities in the particles of sand straining out the solid impurities.

(2) *Oxidation.*—An immense quantity of air is imprisoned in the interstices of the sand, and thus the oxygen in it is brought into immediate relation to the organic matter in the water.

(3) *Bacterial Purification.*—The gelatinous layer which forms on the surface of the sand consists of algæ, diatoms, and bacteria, all in zooglæa formation. It is through the agency of these organisms that purification of water mainly takes place. When the filter is new, these bacteria are not present, and the water is filtered badly. They are, however, soon strained out of the water, and rapidly multiplying, the bacterial layer is formed. No matter how much the quality of the water varies, the filtrate *must* always be uniform in a good filter.

Percentage Efficiency of the Filter.—A filter ought to remove from 98 to 99 per cent of the micro-organisms from the water. This number is known as the "percentage efficiency." A water ought not to be used for domestic purposes, if, after filtration, it contains more than 100 micro-organisms per cubic centimetre. Filtration through sand reduces most markedly the percentage of the *B. coli communis* group, including, therefore, the typhoid organism.

The most effective means of purification of water depend on (1) sedimentation in the reservoir, and (2) sand filtration. After filtration the water must be kept in cool covered tanks.

There are many other patent processes for the purification of water on a large scale. The "Candy Filters" purify water by saturating it with dissolved oxygen from the air, and then passing it through filters 5 feet deep, consisting of a porous mineral substance composed of prepared silica, and an oxidising agent. It is affirmed that waters are more perfectly purified in this way than by sand filtration, and that the cost of installation and upkeep are considerably less.

WATER-SUPPLY OF TOWNS.

Gravitation Supply.—It is much to be preferred that the water be brought from such an elevated reservoir that the highest houses in the town may be supplied, as well as a

constant pressure kept up in the water mains. If this cannot be done, then expense has to be incurred in pumping the water to the top of high towers so that surrounding tenement houses may be properly supplied (*e.g.* London). The water may be brought to the filtering-beds in open channels, but after filtration it must be distributed in closed iron main pipes. Certain parts of towns may lie very low, and the pipes supplying such localities may be subjected to very great internal water pressure. The pipes may be relieved of this excessive and dangerous pressure by the use of loaded valves in the lumen, or by making the water pass through a small inlet into a wider main. This is known as making the water suffer "*loss of head.*"

Water Mains.—These are strong cast-iron pipes coated on the interior with a tarry preparation (Angus Smith's) or a glassy coating, to prevent rusting. The spigot end of each section must be tightly jointed into the faucet end of its fellow with molten lead. The limit of safety of the pipe must be at least six times its ordinary working pressure. They must be laid sufficiently deep so that the water may not be affected by frost—never less than 3 feet from the surface of the ground.

Service Pipes.—These are made of lead and conduct the water from the main pipe in the street into each house, and each must have a stop tap at the junction. In the interior of the house these pipes should be led in wooden casings, and be readily accessible. If they are in very exposed and cold situations they should be wrapped in felt, and so placed that if the water does freeze and burst the pipe, the best rooms in the house will not suffer when the thaw comes.

Cisterns.—Usually the cistern consists of a strong wooden box lined with sheet lead. In poorer class property, galvanised iron cisterns are used. Stone or slate cisterns are very heavy, and liable to leak. They should be placed where they are easily got at for cleaning, and so covered with a lid as to allow of ventilation; light and heat should be excluded. A separate cistern should be set aside for the supply of the water-closets. The overflow pipe should be made to open directly on the outside of the house, and never into the soil pipe. A ball valve should regulate the inflow into the cistern.

Constant and Intermittent Service.—When the water mains are constantly full, a cistern is almost unnecessary. As,

however, mains burst or the water has to be cut off to make connections to the pipes, it is perhaps as well to have a small cistern in every house, even with a constant service. In the intermittent service a supply of water is only given for certain periods during the day, and in this case a large cistern must be provided for each dwelling. There are also risks to health as when the mains are empty, the pressure inside falls to minus, and hence sewage or sewer gases may be sucked in through faulty junctions, and may be carried on to the houses when the water flows anew through the pipes. The interior of the pipes are also more liable to become corroded than when constantly full. A large cistern is also more liable to become foul than a small one. On the whole the constant service is the best.

Quantity of Water Required per Head of the Population.—In this country it is found that from 30 to 40 gallons of water are required by each person per day. When the amount is reduced much below this, infectious diseases become more prevalent, owing to want of personal cleanliness, and also to defective watering of the streets and flushing of the sewers. The minimum amount should be 30 gallons.

Water-supply—Gallons per Head.

Domestic purposes	12
Water-closets	6
Public purposes	10
Trade purposes	10

For Domestic Purposes each person requires from 10 to 12 gallons daily. An adult will only drink about 2 quarts each day, while about 4 quarts may be required for cooking; 4 to 5 gallons for washing the person (an ordinary plunge bath uses from 40 to 60 gallons); 6 gallons are apportioned for dish and house washing, and laundry work. There is economy in the use of water by families, etc., as the same amount of water serves the requirements of several persons.

Water-closets are the cause of much waste of water, as it is erroneously believed that the drains can be flushed by allowing the water to run through the closet. From 2 to 3 gallons of water are sufficient, if properly delivered, to flush out the closet each time it is used; hence 6 gallons is allowed to each person for this purpose.

Public Purposes.—This means watering streets, flushing sewers, public wash-houses, urinals, extinguishing fires, public fountains, etc. From 5 to 10 gallons per head are required on this score, depending on the nature of the weather.

Trade Purposes.—In ordinary towns the amount employed averages 10 gallons per head per day. Many manufactories require very large amounts of water (*e.g.* dyers). These are, however, usually rated on the amount they actually use as determined by a water-meter. The charge is commonly 6d. per 1000 gallons.

Animals and Sick People require relatively a larger amount of water, and in warm climates the allowance must be greatly increased. Each horse or cow requires from 12 to 16 gallons daily.

A very large amount of water is not used, but is wasted by leaking taps, etc. This may amount to as much as 3 gallons per head. Various means are employed to detect this waste (Deacon Detectors, etc.), with a view to its prevention.

Estimating the Rate of Use of Water.—This can be determined by fixing up the ball-cock, and so stopping the inflow into the cistern; the time which the cistern takes to empty is then noted. This must be done on several different occasions so as to get an average. The cubic contents of the cistern in feet multiplied by 6·23 gives the number of gallons contained. The amount used per hour is thus easily arrived at.

Characters of a Good Drinking Water.

It must be perfectly clear and transparent, with no deposit, odourless, tasteless, and either totally free from, or with the merest trace of colour. It must contain but a moderate amount of dissolved solids (less than 10 parts per 100,000), be well aerated, and the organic matter must be small in amount. The chlorine should not exceed 1·5 parts, the total hardness 9 parts; the free ammonia must be under 0·002 parts, and the albuminoid 0·005 parts, all per 100,000. The oxygen required ought not to exceed 0·1 part, while nitrites should be absent, and nitrates only present if derived from geological strata. The micro-organisms should not exceed 100 per c.c. of water.

Classification of Drinking Waters.

I. *Pure and Wholesome Waters* possess the above characters.

II. *Usable Waters* have physical characters as above. The total solids must not exceed 30 grains per gallon. Chloride and carbonate of soda may be present to 50 grains per gallon, but care must be taken that they are not the result of sewage contamination. The free ammonia must not exceed 0·005 parts, nor the albuminoid ammonia 0·01 part per 100,000.

III. *Suspicious Waters.*—They may be turbid, with both taste and smell. The total solids may be above 50 parts per 100,000, and if they consist of sulphates, nitrites, or nitrates, the water is suspicious, and is to be condemned entirely if it destroys much permanganate. The free and albuminoid ammonia may together amount to 0·02 parts per 100,000.

IV. *Impure*; when the characters are more pronounced than the above.

Character of the Water according to the Geology of the Gathering-ground.

1. *Sand or Gravel.*—The water may be very pure or may contain much mineral and organic matter owing to the porosity of the sand.

2. *Chalk.*—The water is clear and sparkling from carbonic acid contained in it, and its temporary hardness is high. The water may, however, become polluted by sewage from farms or dwellings at a considerable distance away, the impurities finding their way to the water by fissures.

3. *Limestone or Magnesian Limestone.*—The water is pleasant, sparkling, and has a high permanent hardness, from 4 to 12 grains of sulphate of lime per gallon being present. Salts of magnesia occur in magnesian limestone waters. Organic matter is present in very small amounts.

4. *Granitic, Trap Rock, Clay Slate Waters; Millstone Grit.*—These all furnish very pure, soft waters, often coloured with peat or vegetable matter.

5. *Sandstone.*—The water is usually somewhat impure; the total solids may vary from 30 to 80 grains, and the organic matter from 4 to 8 grains per gallon.

6. *Alluvial Waters* are generally impure from saline matters (sulphates, chlorides, etc.), which may vary from 30 to 100

grains. Organic matter is present in large amount, also nitrites and nitrates.

7. *Surface and Subsoil Waters.*—From upland hilly districts the water is generally very pure, though it may be peaty, and so may contain much vegetable albumen. From cultivated land it is very impure owing to drainage from manure spread on the soil, and when near dwellings the saline impurity is high (chlorides, sulphates, phosphates, and nitrates from urine and sewage), and the organic matter is in large amount.

Contamination of the Water During Storage or Distribution.

Sewage may find its way into water mains through faulty junctions, or gases from drains may be led into the cistern through the overflow pipes being connected to the soil pipe. Careful supervision must be exercised when water is distributed by carts, or by the hand, as is usual in warm climates.

Action of Water on Lead Pipes or Lead Cisterns (*plumbo-solvent action*).—It may be stated generally that the purest and softest waters act most energetically on lead, while hard waters do not.

Conditions which Favour the Plumbo-solvent Action.—

(1) Highly oxygenated waters act on lead. The dissolved oxygen in pure waters acting on lead forms the readily soluble oxide of lead by erosion, and hence the danger of lead poisoning arising in newly-built houses with new cisterns. Later, however, the carbonic acid in the water reacts on the lead oxide to form lead carbonate, and this, together with lead hydrate ($Pb(OH)_2$), forms a protecting crust of insoluble oxycarbonate on the surface of the lead. In cleaning cisterns a soft brush should be employed, and the crust which has formed on the lead must never be removed.

(2) Waters containing an excess of carbonic acid may change the basic lead carbonate into the soluble bicarbonate.

(3) Ammonia, chlorides, nitrites or nitrates in sewage-contaminated water, act on lead to form their soluble salts.

(4) All acid waters are unsafe as they are liable to dissolve lead. It has been found that certain organisms in moorland waters act on peaty matter to form ulmic and humic acids, and these in turn dissolve lead. Any variation in the degree of acidity causes a variation in the plumbo-solvent power, and such acid water will dissolve old coated leaden surfaces as well

as new lead. Several epidemics of lead poisoning have occurred in the North of England, caused by the action of acid waters derived from peaty ground. Acid sulphates present in water may cause solution of lead, and even sulphate of lead is soluble to an extent which will cause poisoning. Rosolic acid becomes decolorised in presence of acid waters, and may thus be employed to indicate the dangerous character of such. To prevent this action on lead, lime or sodium carbonate is added (2 grains to each gallon) to neutralise the acidity.

(5) *Galvanic Action* hastens the plumbo-solvent action of water. Lead pipes jointed to iron cisterns or lined with tin which has cracked are prone to solution on account of electrolytic action.

Amount of Lead Dissolved.—The proportion may be minute, but even if there be $\frac{1}{20}$ of a grain of lead per gallon, the continuous use of this water may, and does lead to plumbism. Water which has stood in leaden pipes or cisterns for some time should not be used for drinking purposes. New lead is more actively attacked than old lead. Hot water acts more energetically on lead than does cold water, and water under pressure is also more actively plumbo-solvent.

Conditions which Hinder the Plumbo-solvent Action.—Hard waters and waters containing silica, carbonates, and sulphates have little or no action on lead. The mineral matters soon form a deposit on the surface, which protects the lead from further action. This crust consists of the oxycarbonate of lead, carbonates of magnesia and lime, phosphates and sulphates of these metals, etc. Waters containing more than 2 grains of carbonate of lime per gallon are said not to act on lead. If chlorides be largely present, however, this protecting crust may be dissolved off. Peaty waters also protect lead, owing to the deposit of a resinous substance.

Protective Means.—(1) Before selecting a water for a supply, test carefully its action on lead. If it has a solvent action, choose rather another supply if possible.

(2) If the water be acid, it must be neutralised with lime or soda.

(3) Making the water filter through a bed of sand, broken flints (silica), and granite so as to dissolve the silica, will prevent its acting on lead. Domestically the water may be filtered through animal charcoal, which removes lead in solution.

(4) The interior of the pipes may be coated with a tarry preparation. If lined with block tin they are liable to crack on being bent, and galvanic action is then set up with increased solution of the lead.

(5) Iron pipes and iron cisterns may be used. The advantage of leaden pipes lies in the ease with which they are bent. Iron pipes may be treated by the Barff (formation of magnetic oxide of iron in the interior) or Angus Smith's process to prevent rusting, or by an interior lining of glass.

DISEASES PRODUCED BY IMPURE WATER.

Many diseases are due to impurities in water. An excessive amount of saline constituents may render the water so hard as to make it unfit for drinking purposes, or if sulphates or chlorides are in excess, the water will have more or less the characters of a mineral water. Individuals accustomed to soft waters often develop dyspepsia on drinking hard waters; constipation may also ensue. Diseases of a calculous nature are said to be more common in districts where hard water is drunk. On the other hand, looseness of the bowels and diarrhœa may be a sequence of drinking water containing excess of sulphates or suspended impurities; it may also result from drinking soft water when one has been accustomed to drink hard water. Decomposing animal matter in water may likewise cause troublesome and continuous simple diarrhœa.

In sewage polluted waters *pathogenic micro-organisms* are often present, and great danger is associated with the drinking of such water. Such diseases as enteric fever, cholera, dysentery, are known as "water-borne" diseases. This means that the organisms having gained entrance to the water live for some time, and may induce the specific disease in those who drink it. The diagnostic points in reference to water-borne diseases very closely resemble those of milk-borne diseases (*q.v.*).

Goitre is an endemic disease, and it is believed that some constituent of the water (magnesian limestone) is the cause of this affection, or it may be produced by an amœba-form of organism.

Rickets is associated with poverty, unsuitable food, insufficiency of light, and unduly soft water.

PURIFICATION OF WATER.

For communities this has to be done on the large scale, as by :—

(1) *Subsidence.*—During its stay in the reservoir or storage tank, the suspended matter (animal, vegetable, and micro-organismal) sinks to the bottom, and so leaves the water purer. This may be assisted by the addition of insoluble matter in fine powder (fire-clay or lime). These solid particles in falling through the water entangle suspended matter, and clear the water of many bacteria.

(2) *Chemical Treatment* consists chiefly in the formation of insoluble precipitates :—

(*a*) Lime or Clark's Patent Process for the Softening of Water. Milk of lime is mixed thoroughly by fans in sedimenting tanks in the proportion of 1 ounce of the hydraded oxide (quicklime) per 100 gallons for every degree of temporary hardness present. The lime unites with the excess of carbonic acid so forming the not very soluble carbonate, and thus much of the temporary hardness is removed by the breaking up of the soluble bicarbonates. At the same time purification by subsidence takes place in tanks provided for the purpose. In the Porter-Clark process the water after softening is forced through linen cloths to remove the precipitate, and thus time is saved. A water of 20° of hardness may be reduced to 4° by these means. For the reduction of permanent hardness, sodium carbonate must be employed so that sodium sulphate, and carbonate of lime may be formed Various patent processes for softening water consist in the addition of both of these substances.

(*b*) Alum may be added. When lime is present in the water the addition of alum precipitates the insoluble sulphate of lime, and at the same time the bulky and flocculent precipitate of aluminium hydrate is formed. These precipitates in falling, free the water almost entirely from bacteria, and soften it at the same time. About 5 to 6 grains of alum are added to each gallon of water.

(*c*) Permanganate of Potassium (Condy's Fluid) is not reliable as a purifying agent. If used, the water must remain pink for twenty-four hours after its addition, to be of any value.

(*d*) Sodium hypochlorite may be added, or it may be formed by the electrolysis of solutions of common salt (see disinfectants).

(3) *Filtration.*—The employment of sand filters on a large scale has already been described. By this means suspended matters are strained off while organic matter is oxidised, and consequently the proportion of nitrates is increased.

Domestic Purification, or Purification on the Small Scale.

1. *Boiling* the water frees it entirely from micro-organisal life, and greatly reduces its temporary hardness by decomposing the bicarbonates. Distillation is also an efficient means of purification.

2. *Chemical Treatment.*—Besides the treatment by lime or alum, the germicidal power of nascent iodine may be employed (*Nesfield's process*). A solution of sodium iodide and iodate is made acid with citric acid, when a dark-coloured solution is produced :—

$$5NaI + NaIO_3 + \underset{\text{(Citric Acid)}}{2H_3C_6H_5O_7} = 3I_2 + \underset{\text{(Citrate of Sodium)}}{2Na_3C_6H_5O_7} + 3H_2O$$

This is poured into the water to be sterilised, and allowed to act for two minutes. The iodine is then removed by adding sulphite of sodium. Compressed tablets of the reagents are prepared. The process is cheap, costing only 1½d. for 3 gallons of water. Typhoid and cholera germs are killed in one minute by this method. It has been used with success by armies on the march.

3. *Domestic Filters.*—The old-fashioned sealed filters are useless, and afford a false sense of security. After a time they add more organisms to the water than it originally contained. A good filter must work slowly, be easily cleaned, retain its properties for at least a year, and its percentage efficiency must be high. A solution containing 8 grains of quinine to the gallon, should be rendered tasteless after filtration ; the organic matter should undergo great reduction, and the best filters remove all the micro-organisms.

Animal Charcoal is fairly active as a filtering medium, and is used compressed into blocks along with silica or manganese (silicated carbon filters). It adds, however, phosphates to the water, and thus encourages the growth of organisms in stored water.

Spongy-iron Filters (Bischof's) are made by heating carbonaceous ironstone. "Carferal" consists of iron, charcoal,

and clay heated together. "Magnetic carbide filters" are made by roasting iron ore, coke, and sawdust so as to form Fe_3O_4. The oxygen imprisoned in the spaces is strongly bactericidal. These filters require frequent brushing on the outside, and heating to redness or boiling in dilute acid every three months to clean them thoroughly.

The Berkefeld Filter consists of a hollow cylinder of prepared infusorial earths enclosed in a metal casing. The water to be filtered is forced through it under pressure, and escapes germ free.

Pasteur-Chamberland Filters are in the form of cylinders of fine unglazed porcelain. These also require to be supplied with water under pressure (*e.g.* as it issues from the water-mains), and furnish absolutely sterile water. The use of these filters in the French army has reduced the incidence of typhoid fever 50 per cent. To obtain a large supply of filtered water a battery of filters requires to be fitted up in a cistern, while single ones may be attached to the water-tap.

All filters must be frequently cleaned, *e.g.* by heating the iron or charcoal blocks to redness or boiling in a solution of acid permanganate, and in the case of the bougie filters by careful scrubbing and boiling.

EXAMINATION OF A WATER TO DETERMINE ITS PURITY.

The Sample must be an average one, *e.g.* not that first withdrawn from a pump or from the surface of a water. A perfectly clean Winchester quart bottle must be rinsed out with the water, then filled, corked tightly, and labelled correctly.

I. **Examination by the Senses.**

1. *Smell.*—This is detected by heating to blood heat some of the water in a flask.

2. *Colour.*—This is determined by looking through a long column of water (at least 12 inches) contained in a glass vessel, and with a white paper below. A *yellowish* tint may be due to clay or sewage impurity. Iron or peat gives a *reddish brown* colour. The colour should be compared with that of distilled water.

3. *Taste.*—Hard waters have a brisk saline taste. Very agreeably brisk waters often owe this quality to chlorides or

nitrates, hence care must be exercised in their use. Iron, when present to the extent of $\frac{1}{5}$ of a grain per gallon, imparts its chalybeate taste; sodium chloride must be present to 75 grains, and sodium carbonate to 60 grains before their tastes can be detected.

II. **Biological Examination.**—Note the presence of living forms (*Cyclops, Dytiscus, Water-flea, etc.*) in the water or sediment.

Microscopic Examination may reveal mineral matter (sand, clay, chalk), dead vegetable substances (parenchyma or ducts, cotton, linen, or flax fibres) or dead animal matter (debris of insects, wool, hair, epithelial cells, etc., indicating sewage contamination). Living vegetable and animal forms may be recognised (*e.g.* diatoms, desmids, palmellæ, infusoria, wheel animalculæ, etc.). Algæ require nitrates for their growth, while fungi grow in the presence of organic matter.

III. **Bacteriological Examination**—This should be done at once, or the organisms may multiply or die out. A definite amount of water in volume depending on the degree of its impurity ($\frac{1}{10}$ to 1 c.c.) is added to 5 c.c. of melted nutrient gelatine or agar, and having been poured on Petri dishes or on a square shallow cell, the former is incubated at room temperature, and the latter at 37° C. Colonies appear in from one to eight days. These must be identified if possible, and counted by placing the dishes over ruled squares or circles. Bacilli, micrococci, and fungi must be distinguished; note if the gelatine becomes liquefied. In good water there are seldom more than 1000 organisms per gramme, but these are of harmless variety, and may be found in absolutely unpolluted wells or springs. The chief organisms to note are those of typhoid and cholera. The former is not easily recognised, but if the *B. coli communis, the B. enteritidis sporogenes, and streptococci* (which are the common intestinal bacteria) be present, it may also occur, as these all result from sewage contamination. These organisms live for many days in water. The mere presence of one or two coli bacilli in 100 c.cm. of water is of little importance, but the presence of 50 to 60 per c.c. of water is a definite proof of animal contamination. The presence of the *B. enteritidis or of streptococci* is of prime importance in establishing the question of sewage contamination of water. Indeed, the streptococcus test is the most delicate for detecting recent, and presumably specially dangerous pollution. Water

during the winter contains more organisms than during the summer.

IV. **Chemical Examination.**—The reaction of water is usually neutral.

1. **Total Solids.**—By evaporating to dryness in a platinum basin (the weight of which is known) 100 c.c. of the water, and allowing it to cool in a desiccator, the amount of total residue is obtained on weighing the whole. The number of milligrammes of residue represents the number of parts per 100,000. If the residue be gently heated to a red heat, it chars and gives off an odour,—vegetable matters giving a peaty odour, and animal, a smell of burnt horn. With continued heating the colour becomes white, showing that all the organic matter has been incinerated; the basin is then allowed to cool, and is again weighed. The loss in weight corresponds to the organic matter present in 100 c.c. of water plus nitrites, nitrates, salts of ammonia, and combined carbonic acid, while the remaining weight is that of the total mineral solids. (Instead of 100 c.c. of water 70 c.c. may be taken. This is called the *miniature gallon*, for it contains 70,000 milligrammes, and a gallon of water weighs 70,000 grains. Hence any results showing milligrammes per 70 c.c. correspond to grains per gallon.)

2. **Chlorine.**—This is estimated by placing 100 c.c. of the water in a basin, and colouring it with potassium chromate as an indicator. A standard solution of nitrate of silver is run in while stirring until a reddish colour persists. The solution is made by dissolving 4·797 grammes of silver nitrate in 1 litre of water, each c.c. being thus equal to 1 milligramme of chlorine or 5·8 milligrammes of sodium chloride. The silver salt first replaces all the chlorine present as chloride of silver, and only after this is the chromate of silver formed, and as it is red it indicates the end of the test. Pure water usually contains less than two parts of chlorine per 100,000 of water.

3. **Hardness or Soap-destroying Power.**—The hardness of water is due to the dissolved mineral salts (*e.g.* carbonate and bicarbonate of lime and magnesia, the sulphates of these metals, salts of iron, alum, silica, nitrates, chlorides, etc.). When soap is added to hard water decomposition takes place, the mineral elements uniting with the fatty acids until they are satisfied, while sodium carbonate or sulphate is formed. It is only when all these salts have been formed that a lather begins to appear. Thus, 1 grain of chalk uses up 8 grains of soap before

a lather is formed. In estimating the hardness of water a standard solution of soap is employed, each cubic centimetre of which is equal to 1 grain of lime per gallon (*Clarke's process*). Into a bottle 100 c.c. of the water is placed, and the soap solution is run in from a burette, and shaken briskly until a lather is formed which persists for five minutes. The number of cubic centimetres of the soap employed, corresponds to the number of grains of lime per gallon or to the degrees of *total hardness*. One c.c. must always be deducted because 100 c.c. of distilled water requires 1 c.c. of soap solution before it froths. If half a litre of the water be boiled until it is reduced to half its volume, bicarbonates will be decomposed, and the carbonate of lime and other salts precipitated. If the water be made up to its original volume with distilled water, and the hardness be again estimated, this will give what is known as the *Permanent hardness* or that due to such soluble salts as sulphates, nitrates, phosphates, chlorides, etc. This hardness is injurious if above 5 parts in 100,000. *Temporary hardness* corresponds to the difference between the total and the permanent hardness, and is due to the presence of carbonic acid in the water holding the carbonates of lime and magnesia in solution. Iron is also thrown down in boiling. In brewing, a hard water is necessary so as not to dissolve the colouring matter out of the malt, while in dye-works a soft water is required. The total hardness should not exceed 30 parts per 100,000 in a water used for domestic purposes, while a soft water contains from 8 to 16 parts.

4. **Organic Matter** is invariably present in water. When of vegetable origin it is harmless unless in excessive amount, when it may produce diarrhœa. It is, however, very often of animal origin, and is then invariably associated with the presence of micro-organisms, and hence the danger of drinking water contaminated by sewage lies in the possible presence of pathogenic organisms. Organic matter in water undergoes decomposition, and much of it passes off as nitrogen and carbonic acid; a large part is united to form ammonia, and some of it at a later period, and under the action of nitrifying organisms, becomes changed into nitrites of lime, soda, potash, etc., and still later these are oxidised into nitrates. The presence of these singly or together permits of a determination as to the condition of pollution, *e.g.* ammonia shows present active contamination, nitrite that it has recently taken

place, and nitrate that some little time has elapsed. Ammonia and nitrites may, however, also result from the reducing action of lead on nitrates.

Wanklyn's Method of Estimating Organic Matter.—Into a retort 500 c.c. of the water to be analysed are placed along with a little carbonate of sodium, and a condenser having been applied, 50 c.c. is distilled over, and received into a Nessler tube ; another 150 c.c. is distilled, but is not kept.

Free Ammonia.—This is estimated by adding to this tube of distilled water 2 c.c. of Nessler's reagent measured by a pipette. The whole is shaken, and if free ammonia be present, a colour is obtained varying from light yellow to dark brown, depending on the quantity of ammonia present. The amount of ammonia is determined by filling other tubes with distilled water, and running into each from a burette known quantities of a standard solution of ammonium chloride (each cubic centimetre containing one-tenth of a milligramme of ammonia, 0·0001 gramme), and then adding to each Nessler's reagent. On looking down these tubes on to white paper the colour may be compared, and on finding one tube exactly of the same depth as that of the original distilled water, the amount of ammonia it contains is at once known. To obtain the total amount of free ammonia in the half litre, one-third of the amount estimated is added in lieu of the 150 c.c. thrown away. (Nessler's reagent is a saturated solution of mercuric iodide in solution of potassium iodide, and is very sensitive to small amounts of ammonia.) This *free ammonia* exists in the water seldom as dissolved ammonia but as the carbonate, chloride, or nitrate of ammonia. On boiling, these are easily broken up into ammonia.

Albuminoid or Fixed Ammonia.—Much organic matter may remain in the water left in the retort. This must, therefore, be oxidised and broken up into ammonia. After the contents have cooled a strong solution of permanganate of potash, rendered very alkaline with caustic potash, is added, and distillation continued. Three separate amounts of 50 c.c. each are obtained in tubes, and the ammonia in each estimated by Nessler's reagent. The summation gives the total amount of albuminoid ammonia in the half litre of water. It is found that if the ammonia comes off quickly and in large amount, it is probably of animal origin, as animal matter is richer in nitrogen than vegetable matter, and is more easily broken up,

while if it comes off slowly with no marked difference in the amounts in the three quantities estimated, vegetable organic matter is probably present in the water. In an ordinary domestic water-supply free ammonia must not exceed 0·005, nor the albuminoid ammonia 0·01 per 100,000 parts. The relation between the amount of the free and the albuminoid ammonia is more important almost than the actual amounts. The results of Wanklyn's process may be converted into "organic nitrogen" by multiplying by 0·824.

Tidy's Method, or the Oxygen-consuming Power of a Water.—This depends on the fact that the organic matter in water will use up the oxygen, and so reduce the strength of a solution of permanganate of potash. To a flask containing 100 c.c. of the water 10 c.c. of a standard solution of permanganate are added, and 2 c.c. of dilute sulphuric acid. The same is done with a comparison flask of distilled water, and both are kept at 80° F. At the end of fifteen minutes the amount of permanganate which remains is estimated in an indirect way by liberating iodine, and titrating it with hyposulphite of soda. The difference between the amount used for the distilled and that for the ordinary water corresponds to the *oxygen required to easily oxidise* the nitrogen in the water under examination (*e.g.* animal matter), and corresponds to the free ammonia in the preceding test. Another experiment is done, but the flasks are put aside for three hours at 80° F. This corresponds to the organic matter oxidised with difficulty, *e.g.* vegetable organic matter or albuminoid ammonia. There are several other methods of estimating directly the amount of organic matter in water, but the above are those usually employed.

Nitrites.—To 50 c.c. of the water in a Nessler tube, 2 c.c. of sulphanilic acid solution and 2 c.c. of naphthylamine solution are added. Within half an hour a pink or garnet colour is produced if nitrites are present, and the amount is estimated by adding to 50 c.c. of distilled water from $\frac{1}{4}$ to 2 c.c. of a standard solution of sodium nitrite, each c.c. of which is equal to ·0001 milligramme of nitrite, and comparing the colours as in Nessler's test.

Nitrates.—In a porcelain dish 10 c.c. of the water with 1 drop of solution of sodium carbonate are evaporated to dryness. One cubic centimetre of phenoldisulphonic acid is added and thoroughly mixed. Ammonia is added, and distilled water to

make the solution up to 50 c.c. Nitrates, if present, lead to the production of yellow ammonium picrate, and this can be estimated by making colour comparisons with a standard solution of potassium nitrate added to distilled water after going through the same procedure.

5. **Metals.** — Lead is the metal of most importance to determine, but iron, zinc, or copper may be present.

Lead.—Chromate of potassium added to the water in a tube gives a yellow turbidity if this metal is present. With $\frac{1}{10}$ of a grain per gallon this turbidity is seen in half a minute on looking down at a dark surface. With larger amounts of the metal the turbidity appears more rapidly. The amount present is estimated by adding known amounts of a lead salt to tubes of distilled water, and comparing these, after adding the chromate salt, with the water under analysis.

Iron, Zinc, Copper.—To 100 c.c. of the water in a tube a few drops of hydrochloric acid and ferrocyanide of potash are added. A white turbidity indicates zinc, and if this appears within two or three minutes $\frac{1}{10}$ of a grain is present. A blue colour indicates iron, and a reddish-brown colour copper. The quantitative estimation is performed by adding the different metallic salts in definite amounts, as in the test for lead.

REPORT ON A WATER AFTER EXAMINATION.

Unless a water is obviously very impure or contains pathogenic organisms, it is injudicious to condemn it merely from the results of a chemical analysis. The source of the water must be known, the geological features of the gathering-ground, and the conditions under which it was obtained (dry or wet weather). No single factor is sufficient to justify a condemnation. If the conditions are such that contamination may possibly take place, that source of water should be avoided. If the suspended matter be in excessive amount, note if the water becomes clear by subsidence in the reservoir.

Pathogenic Organisms.—The most important part of a water analysis is the bacteriological test. If specific organisms are found, or those belonging to the *B. coli communis* group, the water is contaminated. In other words, if the microbes are undoubtedly of intestinal origin, and discoverable in small amounts of the water, it should be condemned.

Colour.—A water should be almost colourless; slight yellow or green tints may indicate pollution.

Total Residue.—This should be pure white, and should not char when heated, indicating absence of organic matter. The total solids should not exceed 40 parts per 100,000.

Chlorine.—The presence of chlorine by itself in excess is not of importance as it may be due to the presence of saline strata or proximity to the sea. Its association with nitrites, nitrates, or organic matter indicates sewage pollution, however, as does also any rapid variation in the amount of chlorine present. From ·5 to 1·5 parts per 100,000 are present in a good water, the extreme limit being 5 parts.

Hardness.—A water suitable for town purposes may be of 10 degrees, a "hard water" from 10 to 15 degrees, and a "very hard water" above 15 degrees. In boilers the "fur" collects on the inside from precipitation of salts, and is dangerous owing to the risk of explosion. Permanent hardness should not be greater than 2 grains per gallon.

Free Ammonia.—If this is present to any extent it indicates sewage pollution, and especially if the chlorine and sulphates are high, as these are largely present in urine. In pure water it will amount to 0·002 parts per 100,000, and if it exceeds ·005 the water should be rejected.

Albuminoid Ammonia—If it comes off rapidly it indicates animal contamination, but if slowly it may be from harmless vegetable matter, and is then usually associated with almost an entire absence of free ammonia. In pure water 0·005 parts per 100,000 may be present, but if it amounts to 0·01 the water should be suspected.

Oxygen Absorbed.—If this does not exceed 0·1 part per 100,000 the water is of great purity; of medium purity if not exceeding ·15 parts; doubtful if from ·15 to ·2 parts, and impure if above this.

Nitrites and Nitrates.—Unless these are known to come from fossiliferous strata their presence indicates *previous sewage contamination*, as they result from the oxidation of the nitrogen derived from the decomposition of organic material. The presence of nitrite is much more suggestive of sewage pollution than is the presence of nitrate. As little as $\frac{1}{1000}$ part of nitrite in 100,000 of any water is "high," but nitrates may be present to 6 or 7 parts in 100,000. If nitrite be present as a result of metallic reduction the metal can be detected. If

free ammonia, nitrite, and chlorides be in excess it is almost certain that sewage impurity is present; if chlorides are absent, drainage from manured fields may be suspected.

Lead, even in minute amounts, *e.g.* $\frac{1}{10}$ of a grain per gallon, must lead to the rejection of the water, unless means can be taken to prevent the water from acting on it. One need only test for this metal when ammonia or nitrites are present, or in very soft water.

Iron.—If a water contains more than 1·5 parts of iron per 100,000 (=1 grain per gallon) it is unfitted for domestic use.

Examples of Analysis.

	Pure Water.	Usable Water.	Suspicious.	Polluted.
Chlorine	1·0	4·5	7·	10·
Free Ammonia	·002	·005	·005	·025
Albuminoid ,,	·006	·01	·015	·025
Nitrite } Nitrate }	·000002	·125	·220	·280
Oxygen required	0·1	·15	·15	·20

Pollution of Rivers.—The question as to whether a polluted river causes a nuisance may be referred to a medical man for solution. The pollution may be apparent, as shown by the water being frothy or evolving large bubbles of gas, being discoloured, or bad-smelling. A decomposing deposit may be left on the banks at low tide, and this may give off offensive smells. An analysis of the water at various points, above, at, and below the source of pollution, must be made. This must also be done at various seasons of the year. The question for solution is whether the water is rendered unfit for its primary purposes, *i.e.* the maintenance of fish life, and its use for potable purposes. The rights of the "riparian proprietors," or those through whose lands the river runs, must be conserved. If the river is foul or the banks and bottom covered with slimy refuse, or if fish cannot live in the water, these proprietors have a remedy at Common Law.

Relation of Parasitic Diseases to Drinking Water.—The ova of *Tænia solium*, *Tænia mediocanellata*, *Bothriocephalus latus*, *Oxyuris vermicularis*, *Ascaris lumbricoides*, *Trichocephalus*

dispar, *Filaria sanguinis hominis*, *Bilharzia hæmatobia*, and the embryos of *Dracunculus medinensis* may be present, and if swallowed in the water may give rise to their specific symptoms.

Ice is pure or impure according to the water from which it is made. Bacteria are not killed by freezing.

CHAPTER V.

HOUSE SANITATION.

All refuse collected during the day should be removed at once from the vicinity of the dwelling. In towns this is accomplished by scavenging, ashes, kitchen refuse, etc., being collected in covered receptacles, and removed daily. In rural dwellings the refuse is collected in the **Ashpit**, which should be emptied twice each week. It ought to be placed as far from the dwelling-house as possible, and in a position sheltered from winds and sun. The floor should be raised above the level of the ground, and it, as well as the low side walls, must be non-porous. A drain should lead away any liquid which collects on the floor, and rain must be kept out by means of a roof. The space in front should be paved for a considerable distance.

The removal of human excreta, on account of its offensive odour and dangerous character, must be carefully attended to. Unless the removal be by water carriage it is almost impossible to have the excrement deposited within the dwelling. In the country the *privy* is a closet built at some little distance from the house for the purpose of defæcation.

Construction of the Privy or Midden.—It ought to be built of brick or stone, and both floor and walls must be made perfectly impervious by a layer of smooth cement. The floor should be raised a few inches above the ground level, and should slope towards the door. Under the seat a pail of moderate dimensions is placed so that it will require to be emptied at least once a week. It ought to have a lid to close it tightly so that during removal no nuisance will arise. The privy must have a separate entrance apart from the house, from which it must be distant at least 6 feet, and 40 feet from any drinking-water well.

A deodorant may be thrown over the excreta in the shape of fine ashes from the kitchen range, as in *Morell's Ash Closet.*

In the Rochdale System the pails contain some crude sulphuric acid, which fixes the ammonia in the fæces as ammonium sulphate, and so improves the manurial value while lessening the offensive smell. The receptacles are removed each week, and the excreta dried and sold as manure ("poudrette").

In the Goux System the empty pails are lined with any of the following substances—ashes, peat, clay, sawdust, or bracken, with charcoal, gypsum, or ferrous sulphate added. The liquid part of the excreta soaks into the lining, which also falls down and acts as a deodorant. This lessens the manurial value of the contents, while at the same time lessening the capacity of the pails.

Moule's Earth Closet.—In this closet the deodorant action of dry earth is taken advantage of. Good garden loamy soil, which has been thoroughly dried (preferably sun-dried), is placed in a hopper behind the seat. When a handle is pulled, about $1\frac{1}{2}$ lbs. of the earth are thrown over the excreta in the pail, and this is sufficient to prevent any odour arising from a solid evacuation. If urine is also allowed to enter the pail more than double the amount of earth is required. The soil may be dried, and used over and over again in the closet, each time becoming more valuable as a fertiliser. Sand or gravel may also be employed, but a larger amount of these is necessary, as they are not good deodorants.

In Gibson's Closet there is a small urinal in the front part of the seat, so as to lead this liquid to a drain.

The earth closet is very suitable for isolated houses in the country or for villages, but its working is too expensive for towns.

In all these pail, dry, or *conservancy systems* the refuse must be removed very frequently, and clean empty pails left. Such a system is costly to start, and as many workmen are required, the expense of upkeep is also high. On an average the pail system costs 8s. per head per annum, while the water carriage system costs but 4s. Unless the dry system is carefully looked after, there is danger to the public health, and the risk of contaminating wells is always present. With the privy-midden system the incidence of typhoid fever was in one

district 1 in 37, with the pail system it was 1 in 120, while with the water-closet system it was 1 in 560.

Pneumatic Method.—In this method the basin of each closet is connected with a drain which leads the excreta to closed cesspits. The latter are emptied at intervals by means of an indiarubber pipe connected with a large travelling iron cylinder on wheels, from which the air is exhausted by an engine. The method is in common use in continental cities. The closed cesspit acts to a certain extent as a septic tank.

Liernur's Method is used in some very low-lying cities (Amsterdam, St. Petersburg, Prague, etc.) which it is impossible to drain otherwise. The excreta in the basins of the closets is sucked through iron pipes into small tanks in each district which form the centre of a drainage area. These in turn are emptied into a large central reservoir, where the contents are concentrated, and "poudrette" obtained. A partial vacuum is kept up in these tanks by means of powerful suction engines. The tanks are emptied or filled by opening and closing valves. *In the Berlier System* the tanks empty themselves automatically when full.

The disadvantages of these systems are, that a double set of pipes are required, one for the human excreta and another for the slop water. As there is no means of flushing the pipes, disgusting odours escape into the house. The dried material fetches from £6 to £7 per ton.

Latrines are deep trenches dug for the reception of excreta when many men are congregated during short periods, *e.g.* soldiers in camp, or navvies at work. Care must be taken to dig them far enough from the settlement to obviate any nuisance, and to the lee side of prevailing winds. They must be screened by hedges or brushwood, and distant from wells. Each morning a foot of fresh earth must be thrown in, and when filled to within 2 feet of the surface the trench should be closed, and a mound heaped above it to prevent its being reopened.

Since the introduction of water-closets the manurial value of house refuse has become slight, and much difficulty is experienced by municipal authorities in getting rid of it. Farmers do not care to have it, as it is mixed with so much paper, boots, tin cans, etc. It may be "dumped" into disused quarries or gullies, or carried out to the sea, but very often it has to be burnt in **Refuse Destructors.** These are large, sloping furnaces, which,

when first started, are fired with coal. After they have become thoroughly heated the refuse furnishes sufficient carbon to keep up the combustion. To prevent nuisance, the foul-smelling smoke which escapes may be led into the furnace and burned. The ash or "clinker" is used for the making of roads or cement, while the heat may be utilised for the production of steam for driving electric dynamos. There are two kinds of furnaces—(1) slow combustion destructors, or those without forced draught; (2) high temperature or forced draught furnaces. In the latter a steam jet blower allows of the temperature being raised to 2000° F., so entirely consuming the noxious materials, and leading to the formation of a hard, vitrified clinker, while allowing only inodorous gases to escape.

HOUSE DRAINAGE.

Water-closets.—These are by far the most convenient means of getting rid of the excreta. A supply of water is brought into each house, and as it must be removed when foul, it can also be made use of to carry away fæces and urine. It is, at the same time, more economical, as a single set of pipes are alone required to carry away both dirty water from sinks, etc., as well as that from water-closets. The water-closet can also be placed inside the house, whereas the privy must always be outside. There is no danger of the communication of diseases by water-closets if the sanitary arrangements are kept perfect. There are three varieties of water-closets, viz. pan, valve, and hopper closets.

1. *Pan Closet.*—It is an old-fashioned and much used variety, but is in every way insanitary. The lower opening of the pan (*a*) is closed by a movable basin which works in a large container (*b*). The outer surface of the basin where it projects into the container, and the upper part of the latter, become fouled with excrement, and cannot be cleaned, hence foul-smelling gases escape into the house when the closet is open. The contents pass, as a rule, into a large D-trap (*c*), which is also insanitary, and liable to decay.

2. *Valve Closet.*—The "Bramah Closet" may be taken as a good sample. The valve works in a box below the basin, and when closed seals up the outlet of the latter. There is an overflow pipe to the basin which opens into the valve box.

About 2 gallons of water remain in the basin, and this cleans out the valve apparatus very thoroughly each time the closet is used.

Both of the preceding closets require a leaden tray beneath

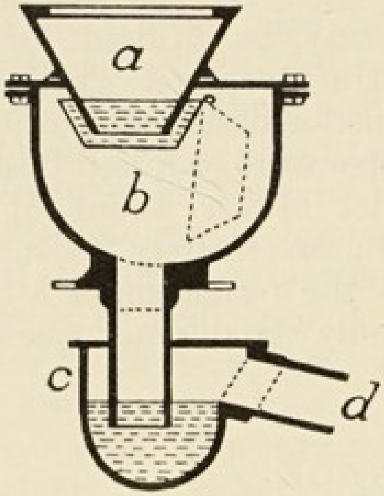


Fig. 25.—Pan closet with insanitary form of D-trap.

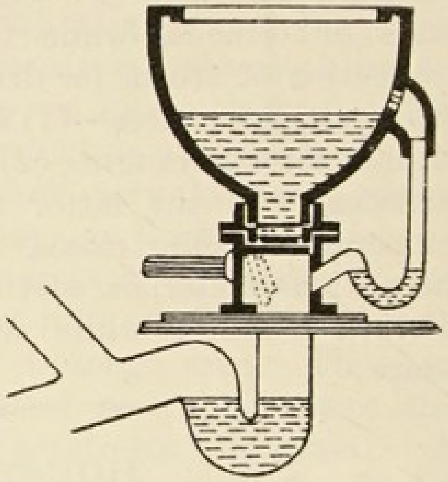


Fig. 26.—Valve closet.

them in case of leakage. This is known as a "safe," and is 3 to 4 inches in depth, and must have an overflow pipe opening to the external air.

3. (*a*) *Long Hopper Closet.*—This consists of a long, tapering

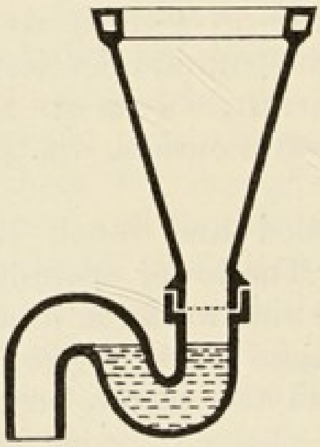


Fig. 27.—Long hopper closet.

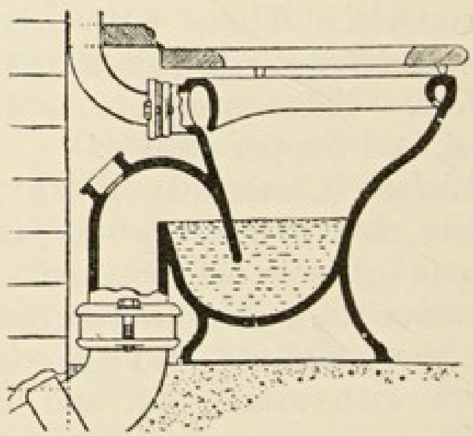


Fig. 28.—Short hopper or "Wash-down" closet.

basin ending in a trap beneath. It requires a large and rapid supply of water to flush it out, but is a cheap and good form of closet as there are no mechanical parts to get out of order.

All of the preceding require to be boxed in with wood, and hence are insanitary as dust and dirt collect beneath the seat.

(*b*) *Short Hopper or "Wash-down" Closet.*

(*c*) "*Wash-out*" *Closet.*—This and the "wash-down" closet are the most popular at the present time. The latter two closets are in pedestal form, and require no boxing in nor provision of "safes," as basin and trap are in one piece. The "wash-out" consists of a shallow basin, retaining a depth of $1\frac{1}{2}$ to 2 inches of water. On the whole the Wash-down Short Hopper Closet is the most satisfactory and sanitary form of closet, and is to be preferred. To act well, the flush of water must be copious and delivered suddenly, so as to wash everything into the soil pipe. The pedestal form of closets may be used as urinals or slop sinks by raising the wooden rim which serves as a seat.

Water-supply for Closets.—A separate cistern must invariably be set apart for the supply of the water-closets, which must on no account be served from the drinking-water cistern. The water should be conveyed to each water-closet by a wide pipe ($1\frac{1}{4}$ inches in diameter at least), and must be delivered suddenly from a height of 6 to 7 feet, so as to clear out the basin thoroughly. It is much to be preferred that each water-closet should have a small cistern for its own supply placed in the same room.

Prevention of Waste of Water by Water-closets.—If 2 gallons of water are sent rapidly and with momentum into a basin it is sufficient to clear it out completely, while 3 gallons furnish an ample flush. In order to prevent undue waste of water various devices are adopted. A compartment may be cut off from the large cistern sufficient to contain 2 gallons. When the closet is used this amount alone escapes suddenly into the basin, while the compartment slowly fills through a small hole in the partition. More frequently, however, directly above each closet, and at a height of 6 to 7 feet, a small cistern is fixed which holds only 2 to 3 gallons. The

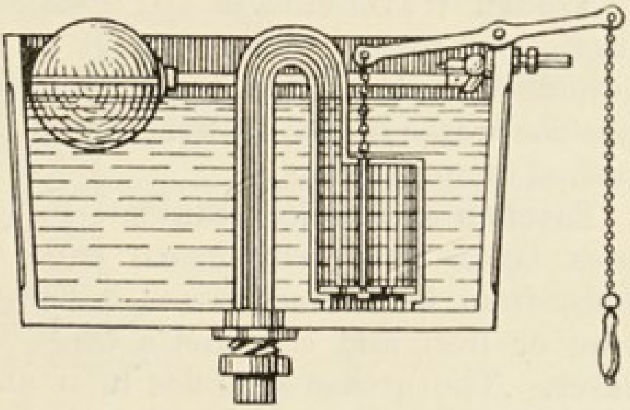


FIG. 29.—Type of cistern generally used for water-closets to prevent waste of water.

delivery pipe to the basin is $1\frac{1}{2}$ to 2 inches in diameter, and so a sudden flush is obtained. When emptied, the cistern slowly fills through a narrow pipe. Under the seat a "waste preventer" may be fixed. In Underhay's, when the handle is pulled up, it draws with it the piston of a suction pump. When left, the piston slowly closes and cuts off the supply of water. Many other forms are on the market.

Traps for Water-closets.—Each water-closet must be cut off from the soil pipe by an efficient trap. This is usually of strong lead, but in the pedestal form it is of porcelain or earthenware and is then part of the closet. The depth of the water-seal must be at least 2 to $3\frac{1}{2}$ inches, and the pipe beyond the trap must be ventilated.

Position of Water-closet.—If possible the closet should be built outside of the main wall and connected with the house by a short lobby. This lobby should have windows on each side to favour cross ventilation, and both lobby and closet should have separate doors. Plenty of air must be admitted to the closet, which should have a window of 6 feet in superficial extent. The walls should be of tile, smooth cement or varnished paint. It may be ventilated by inlet and outlet pipes. If there are two or more closets or bathrooms, the plumbing may be economised by having one directly above the other.

Trough Water-closets are installed for public use in poor districts of towns. They consist of rows of seats over a continuous trough. Each basin should be trapped by dipping into the water in the trough, which ought to be automatically flushed at intervals.

Kitchen or Scullery Sinks.—In large establishments these must be provided with *grease traps* to prevent the fittings or drain from becoming choked. The trap is made of earthenware or iron, and contains a large volume of relatively cold water. The grease solidifies in it and floats to the top, while the dirty water flows away from beneath it.

Waste Waters from baths, wash-hand basins, and sinks must be led through trapped and ventilated waste pipes to a main waste pipe, which should open into a ventilated disconnecting trap before it enters the house drain.

Soil Pipe.—This is the pipe which conveys only the discharges from water-closets and urinals to the drain. It is best when made of strong drawn lead (never "seamed") or iron.

Its diameter should not exceed 4 inches, and it should run vertically.

Position.—It ought to be on the outside of the wall so that if it becomes leaky no harm will result, but it must not be

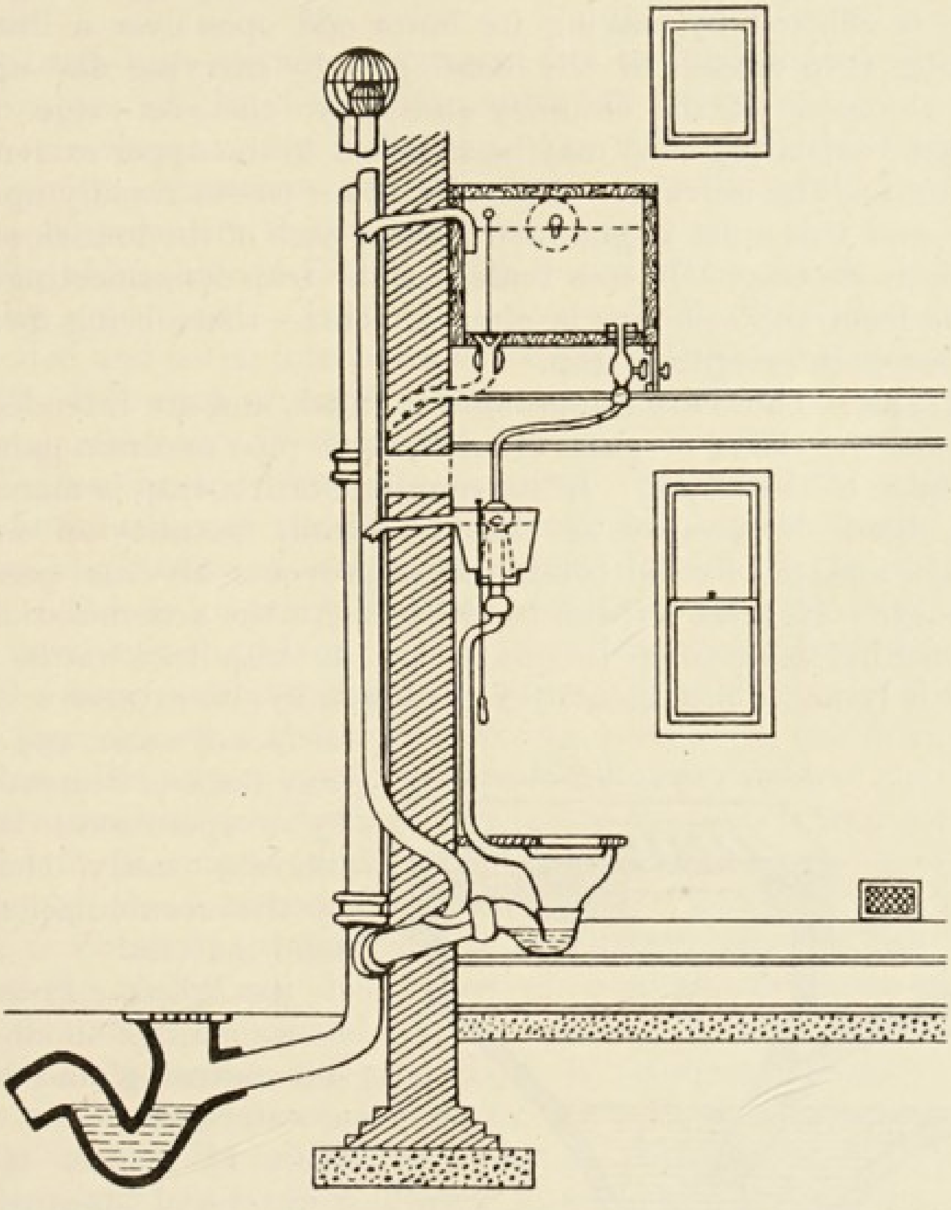


FIG. 30.—To illustrate the proper arrangement of a water-closet; the water-waste preventing cistern; the soil pipe and its ventilation with the intercepting trap.

exposed to the sun's rays. If inside the house, it must be placed in a special space built for it. The soil pipe must not be led under the house if it can be avoided. If it must pass under the dwelling, then it should be bedded in cement, and made to open into disconnecting traps at either side. The

rain-water pipe must never be used as a soil pipe. On account of its own weight, and the weight of the water passing down, it must be securely fastened to joists, and by flanges to the walls.

Ventilation.—A free circulation of air must play through it. This is effected by making its lower end open over a disconnecting trap outside of the house, and by carrying the upper end alongside of the chimney and above the roof-ridge. An upcast ventilating cowl may be attached to the upper extremity to increase the current. A current of air passes rapidly up the pipe, and this must be conducted along each of the branch pipes as far as its trap. In new buildings the trap disconnecting the drain from the soil pipe is often omitted—there being merely the sewer-intercepting trap.

Traps.—These are comparable to doors, and are intended to prevent the reflux of gases from the soil pipe or drain gaining entrance to the house. In its simplest form a trap is merely a pipe bent downwards so that a certain quantity of water always remains in the bend, and so prevents air from passing through. If, however, the bend be slight, the accumulation of gas behind may force the water in the trap backwards, and thus it becomes inefficient. A shallow trap also exposes a large surface of water, and so it may become "unsealed" by evaporation; it is likewise easily choked by the accumulation of solid matters.

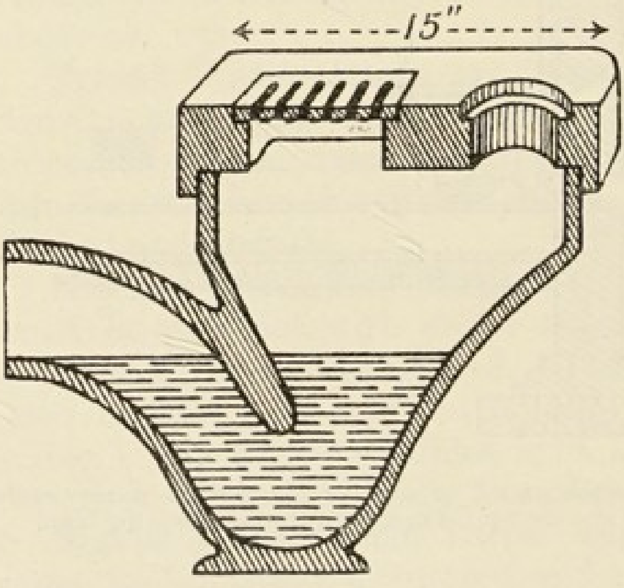


FIG. 31.—Self-cleansing trap with loose top.

An Efficient Trap for house fittings should be self-cleansing and have a water-seal of not less than 1½ inches. (The "water-seal" means the depth of water between the lower end of the roof-bend and the edge of the outflow.) Traps may become unsealed by reason of faulty construction, insufficiency of the dip allowing of too free evaporation, and insufficient ventilation allowing the seal to be forced.

For house fittings (water-closets, sinks, baths, etc.) a strong, solid-drawn lead trap is best, and should be placed on the waste pipe close to the fitting. An inspection-opening in the form of a brass screw plug should be fitted to the lower part of each trap, so that if it becomes choked it may be easily cleaned.

Smooth-bore round pipe traps are easily unsealed by the momentum of the descending water or by syphonage. This may be obviated by enlarging the outflow of the trap or making it somewhat flat in shape (*i.e.* the anti-D-trap). S-shaped traps are known as syphon traps.

The old-fashioned D-trap fitted to pan water-closets is to be wholly condemned. It is very large, and the dip pipe is easily corroded and eaten into holes by the excreta.

The Bell trap or Antill's trap are so easily choked up that they should never be employed in yards, areas, or courts.

Unless the tributary pipes are well ventilated, the water in the house traps of the fittings above, is apt to be sucked out when a quantity of water is poured down a water-closet or sink. This is known as *syphonage* of the trap by suction. In the same way the water in the traps below may be forced out by the *compression* of air in the pipes. The discharge down a soil pipe acts as a water-plug driving everything before it, and sucking the water out of unventilated pipes behind it. The *momentum* with which the water passes through a trap may be sufficient to empty it also. To obviate the emptying of the traps by these means, free access of air must be provided; this is obtained by carrying a ventilating pipe of full bore from the upper and distal part of each trap ("crown of the outgo") to the external air, or making it join an air-shaft which ends in the soil pipe above its highest tributary. In this way a current of air plays through the soil pipe, and along each of its tributaries as far as their traps. The gases of the excreta are thus diluted to such an extent, that even if the traps become unsealed, no harm will result. Rats, however, sometimes eat through leaden pipes in their search for food or water.

Drain Intercepting Traps.—At the lower end of the soil pipe it was formerly usual to place a trap outside of the house. This disconnected the soil pipe entirely from the house drain, while allowing air freely to enter the lower part of the former. These were usually made of stoneware (*e.g.* Mansergh, Hellyer,

etc.). Of late, however, the tendency has been to omit this trap.

Sewer Intercepting Traps.—The direct passage from sewer to house drain is intercepted by means of glazed earthenware traps. These are usually large, and each is placed at the bottom of a ventilated manhole. It is most important to have efficient self-cleansing traps, such as Buchan's, Weaver's, Hellyer's "Drain Sentinel," etc. By such means a thorough ventilation of the drain from the sewer to the soil pipe, as well as the tributaries of the latter, is provided, and in this way reflux of drain or sewer air to the house is prevented.

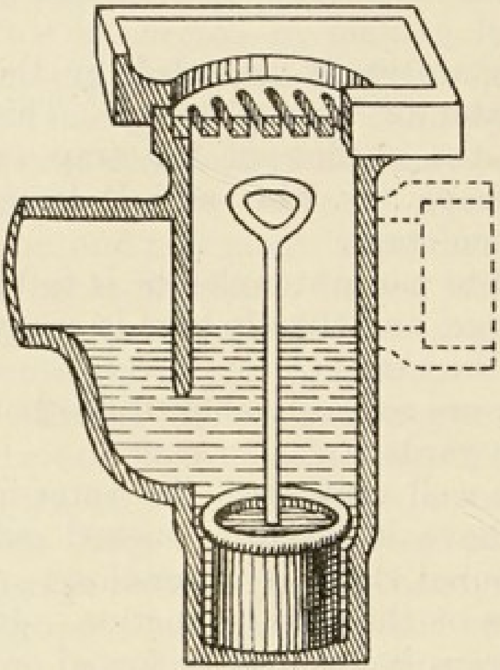


FIG. 32.—Dean's silt gulley with movable receptacle for solid matters.

Gully Traps are placed at the sides of the roadway, and are strongly made of iron. A large cavity is provided for the detention of solid matters, while the rain and muddy water flows off to the sewer.

DRAINAGE.

A drain is the pipe which conveys the waste water and water-closet materials from the soil pipe to the sewer. It is considered to belong to the house, and must be kept in order by the proprietor. In law it is "any drain of and used for the drainage of one building only" (Public Health Act, 1875).

The Object of the drain is to remove immediately from the house foul water, and to prevent the reflux of foul air into the house.

Requirements.—The drain must be absolutely water-tight; the interior must be perfectly smooth to prevent accumulation of filth; all junctions should be made at acute angles, so as to lessen retardation of the flow; it must be laid in straight lines, and have a definite and uniform fall.

Varieties.—Glazed fire-clay pipes are usually employed. They vary from 4 to 18 inches in diameter, and are from 2 to 3 feet in length. Cast-iron pipes, coated internally with a tarry preparation, are, however, to be preferred as the joints can be made more secure.

Joints.—Cement is used to embed the spigot in the faucet end of the clay pipes, but any cement projecting into the lumen must be carefully removed. The ends of some drain pipes are coated with special preparations, and only require to be screwed together to form tight joints. For iron pipes, oakum is beaten in, then lead is run in and hammered tight.

Inspection Openings are merely lids fixed to certain pipes, or one longitudinal half of a pipe may be made removable, so that obstructions in the drain may be got rid of. Such an opening is necessary at intervals when the drain is very flat, where it takes a sudden bend, or where one or more drains are joined together.

Foundation.—At the bottom of the trench a concrete foundation for the drain pipes should be laid, to prevent the joints opening if the soil were washed out from beneath them.

Size.—For an ordinary house a drain pipe of 4 inches in diameter is ample. Large mansions may require 8-inch drains, but they should always be as small as possible, so as to run full, and be self-cleaning.

Fall.—To ensure a proper flow the drain must have a sufficient fall, which must also be uniform. A fall corresponding to ten times the diameter of the pipe is sufficient, *e.g.* for a 4-inch drain the fall would be 1 in 40. If the drain is laid too level it tends to become blocked, and "*flush-tanks*" may be required to keep it clear. These are tanks which accumulate water or sewage, and, when full, automatically discharge it rapidly into the drain, so clearing it out.

A Drain should never be laid under a house if possible. If it must be, then iron pipes should be used, laid in a straight line with disconnecting man-holes at each side of the house.

Man-hole or Disconnecting Access Chamber.—This is simply a small pit lined with brick leading down to the drain, which ought to run in an open pipe across the floor of the chamber. It allows access to the drain on each side. The man-hole is covered with a grating for ventilation.

Disconnection of Drain.—It must be disconnected from the sewer by an efficient ventilated trap (*e.g.* Buchan's Sewer Air

Intercepting Trap). This trap prevents the reflux of sewage gases, while allowing a free current of air to play through the drain and soil pipe. It is usually placed at the bottom of a man-hole disconnecting chamber, immediately before the house

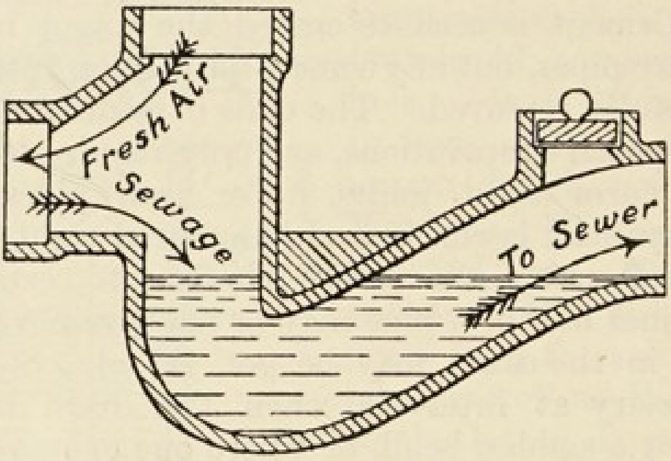


FIG. 33.—Buchan's intercepting trap.

drain quits the private property and enters the public thoroughfare. If the drain is long it must be ventilated at intervals by air shafts passing up to gratings at the surface of the ground, or these may be led up the side of houses so as to prevent nuisance. A proper plan of the drainage system of each house should be made for future reference.

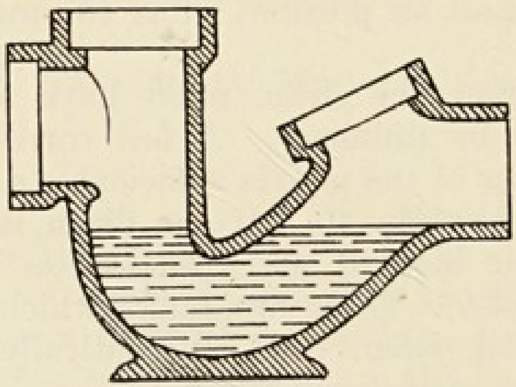


FIG. 34.—Syphon trap for intercepting the drain from the sewer.

Cesspool or Cesspit.—In this country these are almost obsolete, though still in common use on the continent. A cesspool is a pit dug in the ground, and lined by cement or impermeable brick. The drainage enters this, and the gases are prevented from returning to the house by the intervention of a water-trap. These cesspits are cleaned out at intervals by the contents being sucked up into large cylinders through the agency of an exhaust engine. Owing to the risk of leakage from them, cesspools are universally condemned by sanitarians.

INSPECTION OF HOUSE FITTINGS AND DRAINS.

In order to determine that there are no leaks in the plumbing work of a house or in the drains, it is common to test these before the latter are covered in. This may be done in several ways.

Hydraulic Test.—The whole system is filled section by section with water after plugging up the drain, and noting if the water-level in the various appliances has fallen after an interval of two hours. This test is, however, a severe one if the levels are great.

The Smoke Test is commonly employed. The upper end of the ventilating pipe is closed, and strong smelling smoke (*e.g.* that evolved from burning cotton-waste dipped in tar) is pumped into the drain by means of a special bellows (*Eclipse smoke generator*), or a "smoke rocket" is lighted and inserted into the drain, and evolves sulphuretted hydrogen gas. If the doors and windows of the house be kept closed, and the smell be perceived in any room, then there must be a leak in the house fittings, and this must be searched for. Sulphur may be burned at the lower end of the drain, or some highly odorous liquid (peppermint oil, paraffin, creosote, etc.) may be poured down a water-closet for the purpose also of detecting leakages.

The Pneumatic Method is conducted as above, only that air is forced into the drain under pressure. Any leakage is noted by the fall of a float in a manometer attached to the generator. The disadvantage here is that a leaking joint cannot easily be located.

CHAPTER VI.

SEWERS: DISPOSAL OF SEWAGE, ETC.

SEWERS.

These are merely larger pipes for conducting the sewage from several drains. They are the property of the Local Authorities, who have to build and maintain them. Legally the term "sewer" includes every drain, ditch, channel, etc., from more than one house.

Varieties.—They may be made circular in shape, and of earthenware when not exceeding 18 inches in diameter, or of silicated stone, when they may be up to 42 inches in diameter. Concrete may be run round a mould, which is kept in position until it sets. Cast-iron pipes have to be used where it would be impossible to build a brick drain, as in narrow crowded streets, or where the ground is water-logged and cannot be drained, or where the sewer has to be carried through estuaries or quicksands. An iron pipe need only be two-thirds the diameter of an earthenware one, as it can be worked full or under pressure. If, however, the sewer be desired of large dimensions, or if it is subjected to heavy traffic above, then it is advisable to build it of brick.

Built Sewers.—Small sewers (under 3 feet diameter) may be built of one layer of bricks 4½ inch thick. The bricks should be hard and impervious, and should rest on a solid base or invert; they are bedded in hydraulic cement. Larger sewers require to have two thicknesses of brick (9 inches). They must be made absolutely water-tight by a covering of Portland cement outside, and in soft ground they must have the lower part bedded in cement. The subsoil water is conveyed away by drains below or at the sides of each sewer.

Shape of Sewer.—It may be built in circular or egg-shape form.

(1) Circular is cheaper to build and is advisable when the amount of sewage is large, and does not vary greatly in amount (as in the separate system), or where, at most, the minimum flow is only half the maximum.

(2) The egg-shaped sewer is to be preferred if the flow varies much in amount. In dry weather the sewage sinks to the narrower part where the wetted area is smaller, and hence the flow is more rapid owing to diminished friction, or in other words it affords a larger hydraulic mean depth (*i.e.* the sectional area of the current divided by the length of the wetted arc) for small flows, than a circular sewer of the same size. Oval sewers are also stronger, and resist external pressure in every direction.

Size of Sewers.—The size depends upon the estimated maximum discharge, and the available fall. The nature of the area to be drained has to be noted. In the centre of towns the rain which falls has no opportunity of soaking into the ground owing to the paving of streets and courts, and hence it finds its way at once to the sewers. In suburban districts the reverse holds; only after some hours does the volume of sewage increase in the sewers. Each inch of rainfall corresponds to 100 tons per acre; it is usual in towns to make provision for carrying away ½ an inch of rainfall per hour, and ¼ of an inch in suburban districts. The amount of house sewage depends on the amount of water-supply, and were rainfall excluded, it would be easy to calculate the size of sewer necessary for its removal. In determining the size of a sewer the average rainfall has to be calculated, but as storms are frequent the sewer has to be made twice the size that would suffice for ordinary occasions. To obviate making sewers unnecessarily large, *storm-water overflow pipes* are introduced. When the flow in the sewer rises above a certain level, it overflows into these pipes, and is conducted by them into water-courses or into the sea.

The Fall must be sufficient to prevent deposit, but not too great, else the invert will soon be worn out. The velocity must never be below 2 feet nor beyond 4½ feet per second. The larger the sewer the less will the fall require to be; thus, a sewer 10 feet in diameter will only require a fall of 2 feet per mile, while one of 1 foot diameter will require 20 feet. If laid too steeply, the joints will soon give; in such

cases it must be bedded in concrete, or made to discharge into man-holes at intervals, in order to break the force of the flow of sewage. From low levels it may be necessary to raise the sewage up to higher levels. This is done by "pumps" or "ejectors" (Shone's), which act through compression of air.

Dead Ends should be avoided if possible by making one sewer discharge into another. If impossible, the end must be ventilated.

Cleaning of Sewers.—Sewers must be flushed out periodically by means of "flush-tanks," or by damming up the sewage in one section, and suddenly releasing it. This is done by lowering a sluice-gate at a man-hole, and drawing it up quickly when the section behind is nearly full of sewage; the onward rush cleans the sewer for a considerable distance.

Ventilation of Sewers.—To get rid of the gases, which are evolved from sewage, the sewers must be thoroughly ventilated; this is usually done by leading shafts from them to gratings in the roadway. It is found that eighteen to each mile is sufficient to keep the air of sewers perfectly pure. These shafts also act as man-holes, allowing access to the sewers for the purpose of cleaning. In cases, however, where there is no proper fall, at dead ends, at localities where ventilation is insufficient, or from faulty construction, the escaping air is often very offensive.

Various forms of deodorising apparatus may be fitted up in the air-shafts of sewers, for the purpose of destroying these gaseous emanations.

Charcoal in trays is useless, as when wet it is non-absorbing; but a solution of sulphurous acid or (as in Reeve's apparatus) the simultaneous discharge of sulphuric acid and permanganate of potassium solution on to a plate,

$$4KMnO_4 + 6H_2SO_4 = 2K_2SO_4 + 4MnSO_4 + 6H_2O + 5O_2$$

may oxidise the organic vapours and prevent smell. In other cases the fœtid gas is made to pass through a flame, to impinge on a heated iron plate (Keeling's extractor), or to feed gas or oil street lamps (Webb's system). The air-shaft may be carried from the sewer up the side of houses to the level of the chimney-stalk, and aspirating cowls may be affixed also. It has to be remembered, however, that sanitary authorities are responsible for deaths or injury resulting from the escape of sewer gas into adjoining houses.

Outfall of Sewers.—The various main sewers end in a collecting or intercepting sewer, and this, if discharging into the sea, must be carried sufficiently far out, and its end must be turned down so that at the lowest tide its outlet will not be exposed. In other cases a flap-valve is attached which only opens to allow sewage to escape. The position of the outfall must be such that currents, tides, or winds will not carry the sewage back towards the shore. The discharge into tidal estuaries must also be carefully regulated. In the case of large towns it is necessary to carry the outfall sewer several miles away before leading it into the sea.

Separate *v.* Combined Systems.

In the Separate System the drainage from houses is alone conveyed by one set of sewers which, of course, need only be small in size. Another set of drains conducts the subsoil drainage and storm-water into streams or rivers. The great advantage of this is, that the sewage is concentrated and uniform in quality and quantity, and can be used directly for irrigation, etc.; and that the sewers running nearly full are self-cleansing. On the other hand there is the difficulty and expense of keeping up two separate systems. Builders may join house drains to the storm-water sewers or *vice versa*, and after heavy rains these become foul from street and yard washings. The separate system can be used in suburban districts; but in crowded localities the rain coming from yards and roofs is often very foul, and must be treated as sewage.

The Combined System is most usual, however; in it both sewage and storm-water are conveyed by the same sewer. They must be made sufficiently large to carry away the largest amount of storm-water, or some method must be adopted to prevent them running quite full, or else they are liable to burst. The volume of sewage varies greatly, and during rainy seasons it is so dilute that there may be difficulty in disposing of it.

DISPOSAL OF SEWAGE.

Sewage, as it is found in the combined system, is a very dilute solution of organic matter (25 to 40 grains per gallon).

It contains ammonia, potash, phosphoric acid, with many other substances, and is alkaline in reaction. The solid matters usually amount to 2 or 3 lbs. per ton of sewage. It is of great value as a fertilising medium, but the hindrance to its use lies in the immense quantity of water with which it is diluted. There is no great difference in the sewage from non-water-closet and water-closet towns.

By the Rivers Pollution Prevention Act of 1876 it is illegal to pour crude sewage into streams; it must first be purified. In proper purification all the suspended organic matter should be removed, and in the effluent 80 per cent of that in solution should be oxidised into nitrates. The standard of purity of the effluent to be aimed at, should be that only 1·5 parts per 100,000 (= 1 grain per gallon) of oxygen be absorbed at 80° F. in four hours, or that 0·15 part of albuminoid ammonia be present in 100,000.

In seaboard towns the sewage is easily got rid of by pouring it into the sea. In inland towns, however, a great difficulty arises in disposing of it. This is not so great where the separate system is in force, as it can then be disposed of by irrigation or filtration through land. The natural method is to return the sewage to the land from which it originally came, but owing to the great dilution which takes place in the combined system it may not be easy to acquire a sufficient area for the purpose of purifying it.

The Chinese set much store on solid and liquid excreta, and they have proved its value as a manure. The traveller who urinates into a receptable kept for that purpose at a shop or dwelling confers a favour, and the owner of a public latrine in China has almost as lucrative a business as that of a pawn-broker.

Sewage may be purified by (1) allowing the solid matters to settle, (2) chemical treatment, (3) employing the earth to absorb the organic matter, (4) the agency of bacteria.

1. **Tank Storage.**—The sewage may be led to a large tank made of cement or brick, where the solid materials and many bacteria sink to the bottom as a sludge. The effluent may flow into a second tank, where a further precipitation may take place. The effluent may then be treated with chemical agents, or may be used to irrigate the ground. The suspended matter in sewage is, however, very light, and no great benefit is obtained from these settling tanks. More effective results are

got by straining the solid matters out by means of wicker-work or canvas rotating strainers. The deposit or "sludge" has but little value as a manure.

2. **Precipitation or Chemical Purification.**—In this, the addition of some chemical or combination of chemicals causes the formation of insoluble compounds, and these, falling down, carry with them suspended matters as well as a proportion of dissolved organic matter in the sewage. The same reagents are employed as in the purification of water (see page 402). The aim is to obtain an effluent sufficiently pure to pass into streams. The precipitating agents are thoroughly stirred up in the sewage, which is then allowed to flow into a series of large settling tanks.

(*a*) *Lime.*—Milk of lime is stirred into the sewage; from 12 to 16 grains of lime are added to each gallon, according to the hardness present. A much more effective method, however, is to add lime in solution (lime-water). Unfortunately the effluent is alkaline and so readily putrefies. Though the lime method is cheap it seldom purifies sewage sufficiently to allow it to be passed into streams, and, besides, it makes it still more alkaline, more readily putrescible, and more lethal to fish. Clay along with lime is employed in Scott's process. Sewage containing salts of iron and mineral acids is particularly suited for lime purification. The refuse waters from breweries contains much carbonic acid, and lime acts well as a purifying agent upon it.

(*b*) *Alum Process.*—From 5 to 10 grains of sulphate of alumina are used for each gallon. This process would seem to be the most effective. In Anderson s process alum in a crude form is made by acting on clay with sulphuric acid.

(*c*) *Mixtures of Lime and Alum* are employed. Each acts in its own way, and so a more thorough purification is brought about. All the suspended matter, and much of the organic matter is removed. This method is in use in Glasgow.

Sillar's A.B.C. Process was formerly in use, but is now almost abandoned. The reagents as at first recommended were alum, blood, and clay. The blood was soon found to be useless, so was replaced by charcoal. Zinc sulphate is also added.

(*d*) *Salts of Iron.*—Ordinary ferrous sulphate is employed in some towns, from 2 to 5 grains per gallon of sewage being sufficient. Calcium sulphate is formed and protoxide of iron, which fall as precipitates, and the latter being easily oxidised

and deoxidised acts on the organic matter, oxidising it. The sewage of London is clarified by the addition of lime-water and iron sulphate before the effluent is passed into the River Thames. Spence's alumino-ferric blocks are dissolved by suspending them in the flowing sewage; they purify it about 60 per cent. Ferrozone is a mixture of crude alum, ferrous sulphate, and magnetic oxide of iron. The above reactions may be represented by the following:—

$$Al_2(SO_4)_3 + 3Ca(OH)_2 = Al_2(OH)_6 + 3CaSO_4$$
$$FeSO_4 + Ca(OH_2) = Fe(OH)_2 + CaSO_4$$
$$Fe_2(SO_4)_3 + 3Ca(OH)_2 = Fe_2 3(OH)_2 + 3CaSO_4.$$

In all these processes the sludge is of little or no value as a manure, and from London alone some 2,000,000 tons are carried out to the sea annually. In other instances it is dried or dug into the ground, or pressed into cakes by squeezing it in canvas bags, or burnt to form cement (Scott's process).

(*e*) *Magnesium Chloride* is used in Hillé's process along with lime. In the *Amines* process the sewage is sterilised by the addition of volatile amines and ammonia, obtained by the action of lime on herring brine; an inodorless sludge is obtained by this method.

There are many patent methods of purifying sewage, but almost all consist in the use of one or more of the preceding chemical salts.

General Conclusions.—No chemical treatment alone purifies the sewage thoroughly, or even to such an extent as to allow its passage into streams. The more precipitant which is used, the bulkier and less useful is the sludge. The organic matter in sewage is not greatly affected by any of the precipitants, while almost all the suspended matter is removed. Ammonia is most valuable to the farmer, but none of the processes remove any of it from sewage; all, however, remove some phosphoric acid, and this is a good manure. Sewage purified by precipitation is found to be more harmful to fish life than crude sewage, and this is due to the added salts. In most cases the filtrate must be further purified by the land or by passing it over contact beds. A good chemical treatment will remove about one-half the amount of impurity. Much of the sewage of Glasgow is treated chemically, and the effluent having been filtered through coke or sand, is rendered sufficiently pure to pass into the River Clyde.

Purification by Electrolysis (Webster's process).—This method has never gained much success, probably on account of the expense of the process. The sewage is electrolysed as it flows through long troughs, which are fitted with large iron plates. At the positive pole chlorine and oxygen are given off, and these unite to form hypochlorous acid. The latter attacks the organic matter, and also forms hypochlorite of iron. At the negative pole the bases are set free (potash, soda, ammonia, magnesia, etc.), and these again decompose the iron hypochlorite. The hydrated ferrous oxide rises to the surface as a scum, along with bubbles of air, and so clarifies the sewage. The sewage then passes to a tank, where the oxide of iron subsides to the bottom, and still further purifies the sewage. Owing to the disinfectant action of the chlorine, and to the precipitating action, the effluent is remarkably pure.

The Hermite Process consists in electrolysing sea-water, and then passing this into drains or sewers, where it exerts a disinfectant action.

PURIFICATION BY THE LAND.

Almost the whole of the fertilising material in sewage can be removed by making it pass through the soil. The earth acts not merely as a mechanical filter, but owing to the presence of nitrifying organisms the organic matter is broken up, and still further oxidised in the interstices of the ground. It is most applicable when the sewage is not too dilute. When the sewage has filtered through the soil, the filtrate must be carried off by deeply laid drains, and the more or less pure effluent may then be poured into rivers.

Broad Irrigation of Land.—This means the distribution of sewage over a large surface of ordinary agricultural land, having in view a maximum growth of vegetation (consistent with due purification) for the amount of sewage supplied. A suitable area of land must be set aside for the "sewage farm." It ought to have a gentle slope, preferably towards the south. The surface must be made even, and the soil must be of a free, loamy or sandy character, with an open subsoil to favour percolation. The ground must be thoroughly drained at a depth of at least 6 feet from the surface in order to remove subsoil water as well as filtered sewage. If the soil be retentive and clayey, filtration will be slow, and in dry weather the surface

will tend to crack, and so the sewage may escape purification. It, therefore, requires more thorough drainage and breaking up, but clay soils furnish better crops; the surface must be well trenched. The slope of the ground must be gentle; 1 in 150 is sufficient in suitable soils, but if the soil is very porous 1 in 25 may be required to prevent too rapid percolation.

Sewage Carriers.—The sewage is distributed over the farm by means of channels, which run along the slopes about 40 feet apart from each other. These are shallow trenches made of cement, brick or wood. When a certain area of the ground is to be irrigated, a sluice is closed in the carrier traversing the ground, and the sewage then flows uniformly over the surface. The sewage may be run continuously on the ground for twenty-four hours. The flow must be intermitted at intervals, however, or else the ground is apt to become clogged. If the soil is very free, then the filtrate coming from the subsoil drains may be used to irrigate a lower area of the slope, and the effluent may even be treated two or three times in this way or until it is sufficiently pure to pass into streams. Irrigation may be carried out during the entire year, but in very wet weather the ground becomes so saturated that filtration will not take place. The sewage must then be stored in storage tanks, or, if the farm be near the coast, it is allowed to flow into the sea without treatment.

Proportion of Land to Population.—It is usual to allow 1 acre of loamy land to each 100 inhabitants, but if clayey then only to 25 persons. Under ordinary conditions 12,000 tons of sewage may be run over each acre per day. If precipitation has taken place previously, then these figures are relatively 400 and 200 persons.

Crops.—Italian rye grass uses up the most sewage, and hence it is more often grown, as several crops may be obtained during the year. Oziers, mangold wurzel, cabbage, etc., may also be cultivated, but cereals cannot be grown on sewage farms in this country because evaporation is too slow. The maximum growth of vegetation is desired for the amount of sewage given with purification of the effluent.

Broad irrigation has been found useful for inland towns and villages where suitable land can be obtained at a cheap rate, and which does not require expensive treatment. For cities the amount of land necessary is very great. In no case in Great Britain has any profit ever been made from such a farm

when the cost of preliminary preparation is included, even though dairymen are willing to pay a high rent for the grass land. If the sewage has merely flowed over the ground, it may not be purified in the least. It must percolate through the soil in order to be purified.

Downward Intermittent Filtration Through the Soil.—This means the concentration of sewage at short intervals on as small an area as will absorb and cleanse it. As before, a suitable area must be selected, with a proper fall, and a loose marl soil containing lime. It does not require to be as large as in the preceding irrigation farm, but must be thoroughly drained at a depth of 7 feet so that this depth of soil is well aerated. The area of land is divided into three equal parts; one part is saturated with sewage during twelve months, while the other two-thirds are under cultivation. The part which is under sewage concentration is divided again into four parts. On to each of these the sewage is run continuously for six hours, and at the end of this time it may have been flooded to a considerable depth. It is then allowed to rest for eighteen hours, during which time the sewage filters through the soil, and air enters. The ground becomes saturated with organic matter during the year in which sewage is run on to the ground, and consequently during the next two years it yields excellent crops. The earth forms a solid filter fully 6 feet deep, and this is capable of purifying from 40,000 to 120,000 gallons per acre per day. It is usual to allow 1 acre to every 1000 inhabitants. If the sewage has been purified by precipitation, 4000 to 5000 persons are allowed to each acre. The soil acts as a mechanical filter, and as a nitrifying agent, oxidising ammonia into nitrites and nitrates, which unite with the lime in the soil. The oxygen contained in the ground oxidises organic matter, and vegetation uses up these products during growth. It is better to lay the farms out in ridges and furrows. On the latter, plants are grown, while the sewage is led intermittently into the furrows. The sewage may be strained before it is led on to the ground in channels. Downward filtration is a most efficient means of purifying sewage, and more especially if it be treated in the first place by precipitation methods. The effluent is very pure, containing practically only the products of oxidation (*e.g.* nitrites and nitrates) with very little of the organic carbon or nitrogen.

General Considerations.—Where land is expensive, then the

chemical or bacteriological methods are the most suitable; but if cheap, then filtration through soil is still the best, though it may yield little or no profit.

Effects of Sewage Farms on Health.—When in the vicinity of towns, they often lead to litigation, owing to nuisances arising from the offensive smells. During summer or with certain winds these are more apt to be complained of. When towns encroach on such farms it becomes necessary to relinquish this method of sewage disposal, both because of the nuisance, and because the land rises in value on account of new buildings. Epidemics of typhoid fever or dysentery have been ascribed to the proximity of sewage farms. If properly constructed and managed, however, these risks should not occur. It is possible that vegetables grown on sewage farms, and eaten uncooked might induce the development of *Tœnia solium or Ascaris lumbricoides* in man, and in animals fed on sewage-grown grass the ova of certain intestinal parasites might be ingested. In China the sufferers from intestinal parasites are very numerous, and this is undoubtedly due to eating sewage-reared vegetables. It is said that the milk of cows fed on sewage grass has an offensive smell, and does not keep fresh for any length of time.

BACTERIAL TREATMENT OF SEWAGE: BACTERIOLYSIS. BIOLOGICAL PURIFICATION.

Within the last ten years the purification of sewage by taking advantage of the resolving powers of bacteria has made immense advance, and almost all new purifying works are on this system. Ordinary sewage teems with micro-organisms of all kinds, and instead of trying to inhibit them, by this method every encouragement is given for their growth; it makes use of the peptonising and oxidising power of certain bacteria which are present in sewage.

Septic Tank.—The sewage is first conducted to a large settling tank made of brick, and sunk in the ground, and which may be covered or open. It should be 6 to 8 feet in depth. This is known as the *septic tank*, for in it anaërobic organisms flourish. These organisms break down into simpler compounds, and liquefy the solid organic matter in the sewage. The sludge which collects is largely composed of mineral

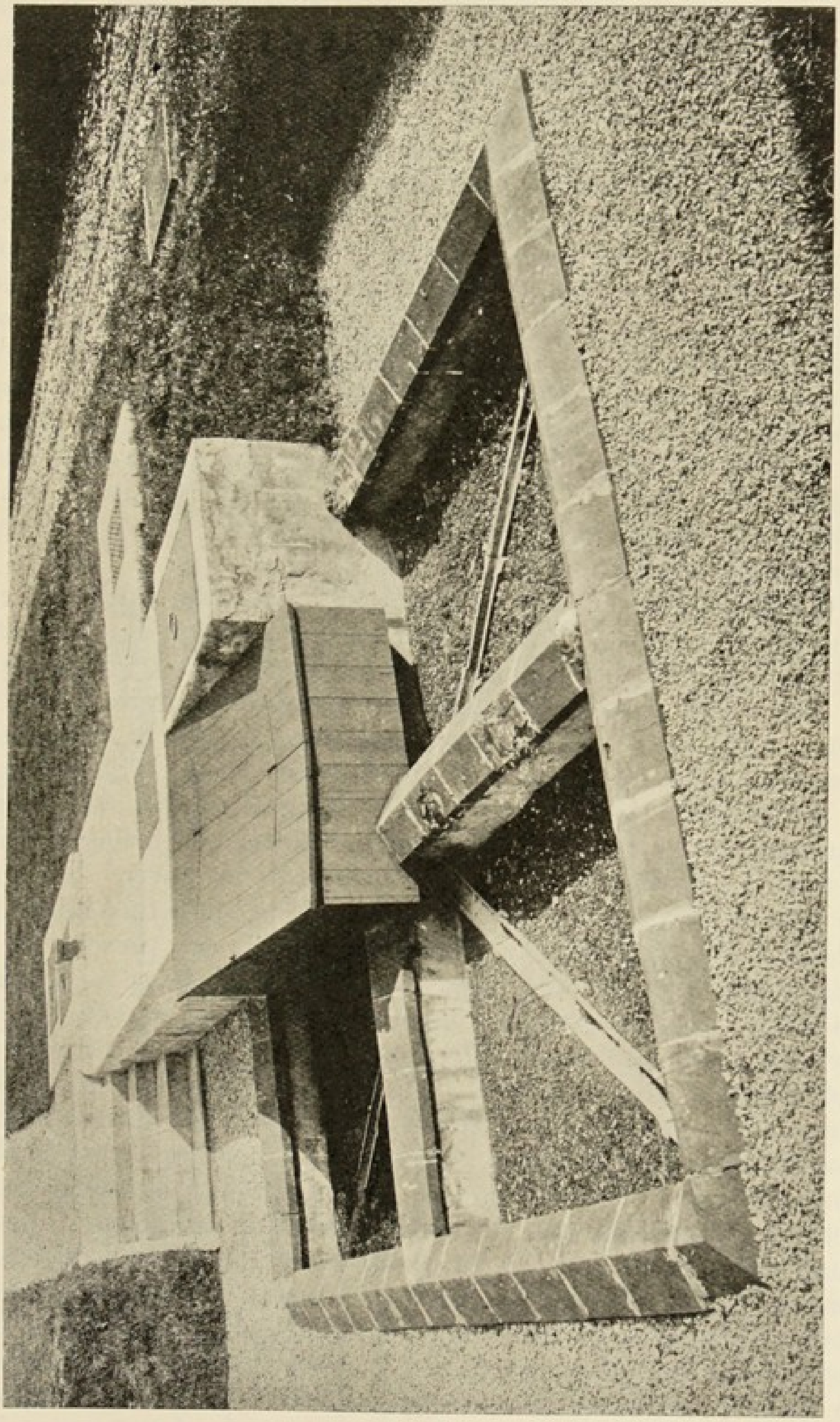


FIG. 35.—Installation showing septic tank and contact beds with sewage carriers.

matter, and is so small in amount that the tank seldom requires to be cleaned out at all. As the result of fermentation a thick scum forms on the top of the sewage, varying from 2 to 12 inches in thickness. During this bacteriolysis the organic matter is resolved into ammonia, carbonic acid, water, nitrite and nitrate, and such gases as carbon monoxide, hydrogen, and marsh gas. In the case of the covered tanks these gases may be led away and used either for heating, or after carburetting, for illuminating purposes. Cellulose in vegetable matters is dissolved by the action of the *Bacillus butyricus*, with the evolution of much marsh gas. The flow through the tank must be very slow, else pathogenic organisms present in sewage are not destroyed; the sewage ought to be allowed to remain in it from twelve to twenty-four hours. The tank is usually a large excavation lined with cement, and rendered impermeable. It is arched over, and the roof is sown with grass.

Contact Beds.—The overflow from the septic tank is then conducted in channels to coke filtering beds. Each of these consists of a cement foundation and walls, and is filled with lumps of coke, coal, gravel, or clinker to a depth of from 4 to 13 feet. Each lump may be from a ½ to 2 inches in diameter. The bed rests on a layer of perforated tiles. The sewage is distributed evenly over each by means of stoneware channels, or by fixed or revolving sprinklers of various forms, so that the sewage merely trickles through the filter. During its passage through the bed the sewage is brought into intimate relation with the aërobic organisms, which are present as a gelatinous layer on the lumps of coke, and thus a further breaking up of the organic matter takes place, *e.g.* ammonia, carbonic acid, sulphuretted hydrogen, water, as well as nitrites and nitrates being formed. As the filtering bed must be aerated, the percolation of sewage must be intermittent in the case of small contact filters, to allow of air getting access to the lumps of coke. To obtain this rest, a series of aerating beds must be provided, and these are used in rotation. Each small one is made to work twice daily; but in the case of large contact filters the sewage may be applied continuously, but slowly, by means of revolving sprinklers. As sand-filters for the purification of water do not act well at first, so neither do these percolating filters work well until they have strained out from the sewage the aërobic organisms. After four weeks

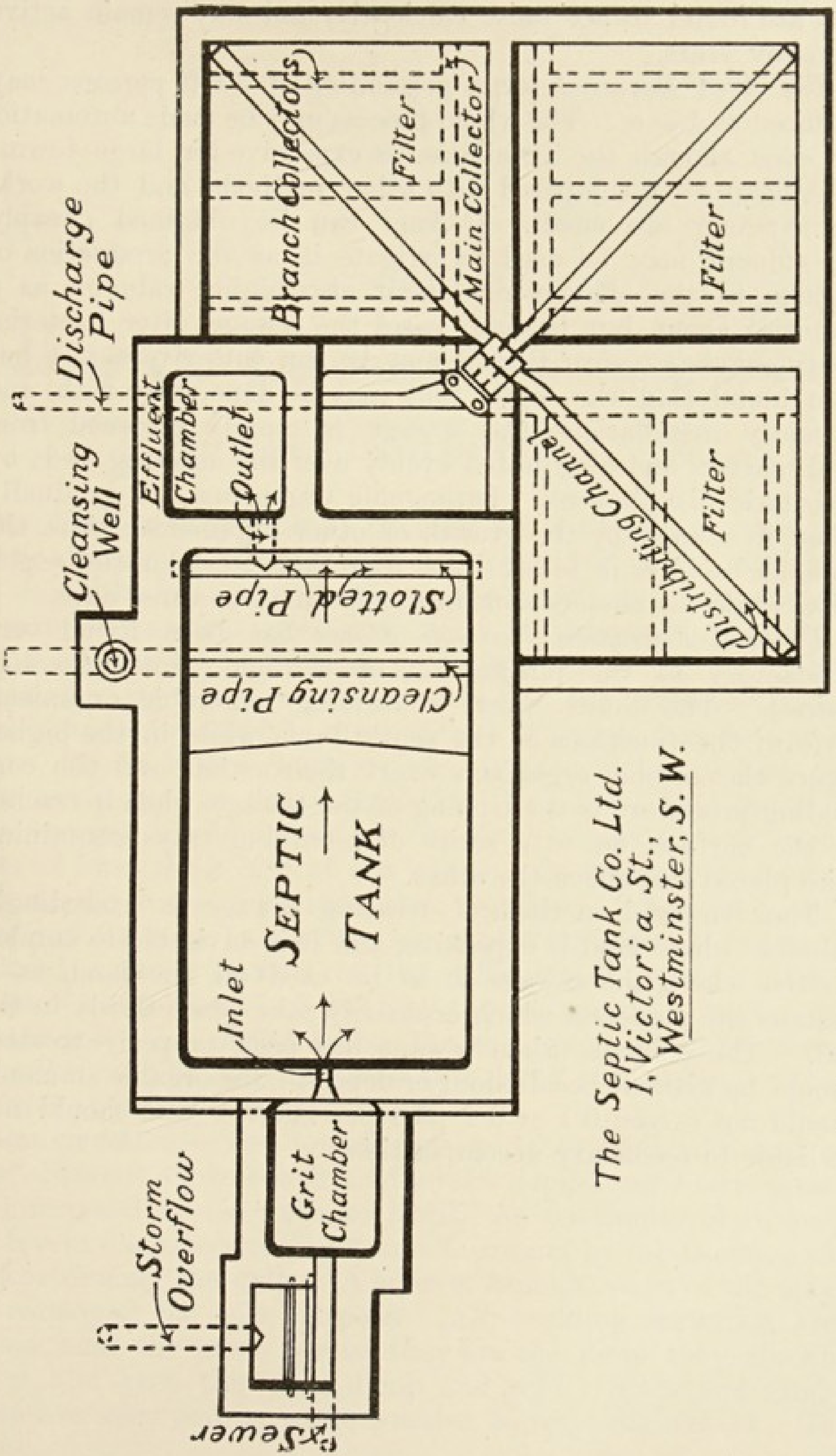


FIG. 36.—Plan of sewage disposal works showing septic tank and filtering beds.

they are found to act most efficiently, and may remain active for many years.

The Area Required for a population of 3000 persons may be stated as 1 acre. The whole process may be made automatic, and even though the installation is expensive for large towns, it is cheap when compared with other methods, and the working expenses are small. If land can be obtained cheaply the effluent may be used to irrigate it, as the production of nitrates in the effluent renders it also highly valuable as a manurial agent, but in many cases the sewage, after bacterial treatment, is so pure that it may be run into rivers. It has been found that the septic tank may be done away with, and in many installations the sewage is merely screened from solid matters and distributed evenly over the aerating beds by automatic distributors. Pathogenic organisms are gradually killed in sewage by the growth of other organisms; thus, the typhoid bacillus is killed by a four days' stay in the septic tank, while the cholera spirillum only survives three days.

Upward Filtration Through Stones has been found very satisfactory in the purification of sewage (*Scott-Moncrieff system*). The lower layers containing anaërobic organisms perform the functions of the septic tank, while in the higher layers the aërobic organisms exert their action, and the concluding procedure is the tipping of the sewage, when it reaches to the surface, on to a series of nitrifying trays containing coke placed one above the other.

The Bacterial method of treating sewage is exceedingly valuable where land is expensive, and it is advisable to employ it even where the sewage is to be used on the land, as it hastens the processes which ordinarily take place slowly in the soil. The effluent, when sewage has been properly treated, should be without fæcal odour or deposit; the organic ammonia should not exceed 0·1 or 0·2 part per 100,000, and should not be liable to secondary decomposition.

CHAPTER VII.

HOUSE AND HOSPITAL CONSTRUCTION, ETC.

HOUSE CONSTRUCTION.

Site.—The dwelling should be built on a slight elevation to favour drainage; there should be free access of air, and the soil should be dry and porous (*e.g.* sand or gravel). The ground beneath and around the house must be thoroughly drained, and a space free from trees or shrubs left around it. The direction of the house should be such that the principal rooms have abundant sunlight; these should, therefore, face east and west. Rooms with a northern exposure are dark and cold, as they never receive direct sunlight. To allow light to the lower rooms, dwellings should be built separate from each other at least the height of the houses. In towns it is better to build the houses high than close together. "Back-to-back" dwellings are most insanitary, so are also houses built in small enclosed squares, because of the difficulty of obtaining free access of air to them. A dwelling should never be built over "made soil," *i.e.* carted refuse thrown down; if imperative, the soil should be cemented over to a depth of 6 inches, or the house may be built on open arches.

Construction.—The foundations must be well laid, and a short distance above the ground-level a *damp-proof course* must be interposed in the walls to break the continuity of it, and so prevent dampness arising from the ground by capillarity, and thus saturating the walls. A layer of asphalt, slate, or tile may be employed for this purpose. All building materials are porous, and the more porous they are the more they absorb water, and keep the walls damp and cold. Brick and sandstone are very porous, while granite is very slightly so. To

prevent complete saturation, the wall may be made with air spaces in its thickness; thus, instead of building a wall with a double layer of bricks placed close together, the two thicknesses should be separated by an interval of 2 to 3 inches. The house is also made much warmer by such a wall, as the air space makes it relatively non-conducting. The least thickness of a dwelling-house wall should be 9 inches. Joists for the floor should not be embedded in the walls, but should be supported on projecting stone or fire-clay slabs.

The Roof must be made impervious to water by proper slating or tiling. It should not, however, be impervious to air as it forms an excellent ventilating structure.

The Floors of ordinary dwelling-houses in this country should be made of hard wood boards (*e.g.* oak) closely jointed together ("tongued"). When polished they are easily kept clean, rubbing with a damp and then with a dry towel being sufficient. The ground floor should be raised 2 feet above the level of the soil, and the latter should be covered with a continuous layer of asphalt. A free current of air should play under the floor, being admitted by perforated bricks or gratings on each side. Cement, stone, or tile floors are too cold for this climate, and the numerous jointings in brick or tile floors favour the accumulation of dirt.

Lining of Walls.—This is usually of plaster, which being fixed to laths, forms another air space in the walls, and the rooms consequently are made warmer. The wall may be papered; in bedrooms or bathrooms washable ("sanitary") papers are preferable. In public rooms the surface may be painted or varnished, but when so, additional means of ventilation must be provided, as these walls are rendered impermeable by such treatment.

Windows.—These should be carried up nearly to the ceiling so as to allow of the escape of foul air when the upper sash is drawn down. The sides ought to be splayed out to allow easy access of light to the room, and the proportion of window surface should be at least 1 square foot to each 100 cubic feet of air space in the room. Double windows are useful in noisy localities, as they deaden the sound while allowing of ventilation. Every room should have a window of ample size opening to the fresh air. Rooms with "borrowed light" should never be used for living or sleeping in, as they are usually insufficiently ventilated as well as badly lighted. The height of

the room should be 10 feet, as draughts are less felt, and ventilation is easier than in a room with a low ceiling.

The Hall or Staircase should be ventilated, and lighted by a cupola.

Basement.—To keep the dwelling dry, a basement should be provided, but it ought to be employed only for cellars and wash-house. In old houses the kitchen and servants' accommodation are, however, situated in the basement. To make these conditions as good as possible, the area must be paved with cement, and well drained. A bed of asphalt should be placed on the ground under the house, and the floor of the basement should be raised above the level of the soil, and ventilated underneath. The ground around should be sloped away to allow the entrance of light into the rooms.

The Dampness of a room may be roughly estimated by exposing in it a known weight of freshly burned lime for twenty-four hours. If when doors and windows are closed it increases more than 1 per cent in weight, the room must be considered damp.

Stables should never have dwelling-houses built above them. The stable floor should be cemented and well drained, so that the soil may not become polluted. Ridge ventilation, with a ground-level opening for fresh air at the head of each stall, is necessary. If a dwelling is placed above the stable, the floor must be made of impermeable material.

Schools, Lecture Halls, etc.—To each pupil from 15 to 20 superficial feet of floor space should be given, with 200 to 250 cubic feet; from 750 to 1000 cubic feet of fresh air should be provided per head per hour.

CONSTRUCTION OF GENERAL HOSPITALS.

The usual rules of house construction must be followed.

Administrative Block.—This should be built larger than is necessary at the time, in view of the probable extension of the hospital. In it the staff are housed, and the kitchen and dispensary are accommodated. It should not be above two stories in height.

Wards.—The long axis of each ward should run in a direction from north to south, and they should be separated from each other by a distance not less than twice their height. It is best to have only one, or two stories at most, as, if more,

the space between the blocks requires to be very great. The wards should be built on the *pavilion* system; that is, building them on either side of a central covered passage. All the wards should communicate with the administrative block by means of covered ways. Each ward should be about 30 feet in width, and 12 to 15 feet in height, giving 100 square feet of floor space to each patient, and a cubic space of 2000 to 3000 feet. The windows should be opposite to each other, and should furnish 1 square foot of surface to each 70 cubic feet of ward space.

The Walls should be of impermeable material (Parian cement, or white-washed, varnished, or painted plaster). All corners should be rounded, and no ledges left to collect dust or to hinder its easy removal.

Water-closets and Bathrooms are best when placed in separate small rooms at the far end of each ward. They must be cut off by lobbies, and freely ventilated and warmed independently of the ward.

The Nurses' Room should be at the near end of the ward, and have an observation window looking into the latter.

Ventilation is best carried out naturally by cross windows, as well as by inlets for fresh air under each bed. Tobin's tubes are also good, but mechanical means may be found necessary.

Warming ought to be by open fires of the hot-air type as well as by hot water or steam pipes. Operating theatres, the post-mortem room, mortuary, etc., must also be provided.

Observation Ward.—This must be entirely separated from the general hospital, and is for all intents an infectious diseases hospital, and should be administered as such.

INFECTIOUS DISEASES, ISOLATION, OR FEVER HOSPITALS.

These must be built and regulated in the same way as ordinary hospitals. The cubic space to each bed must be much greater, however—2500 to 3000 in severe cases (typhus or small-pox); the floor space 150 to 200 feet, and the windows 1 square foot to 40 cubic feet of air space. Ventilation must also be much freer, and in many fever hospitals the patients are treated practically in the fresh air. There ought not to be more than twenty beds per acre as a maximum. The hospital

should be of such a size as to provide at least one bed per 1000 of the population. All soiled linen must be at once placed

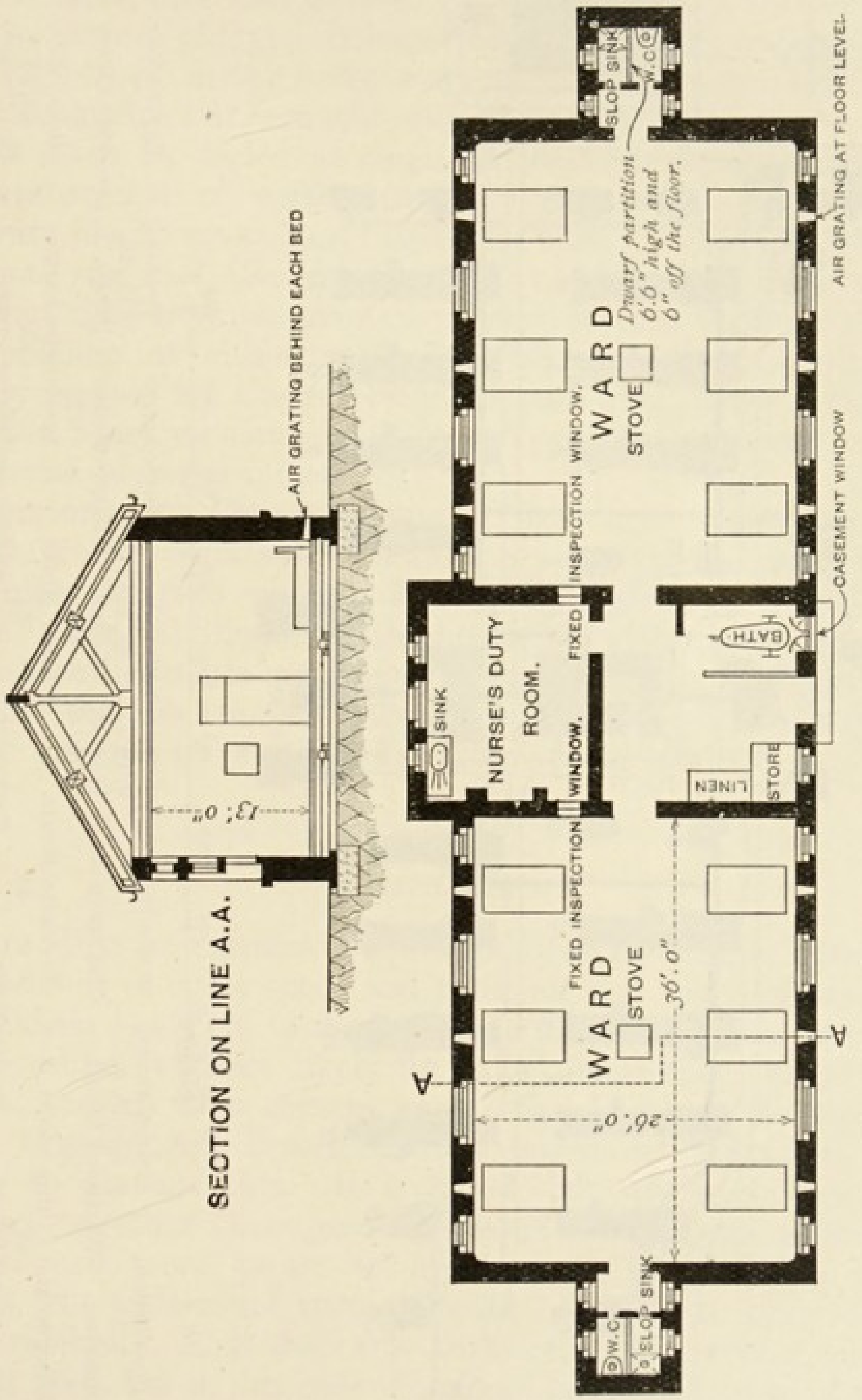
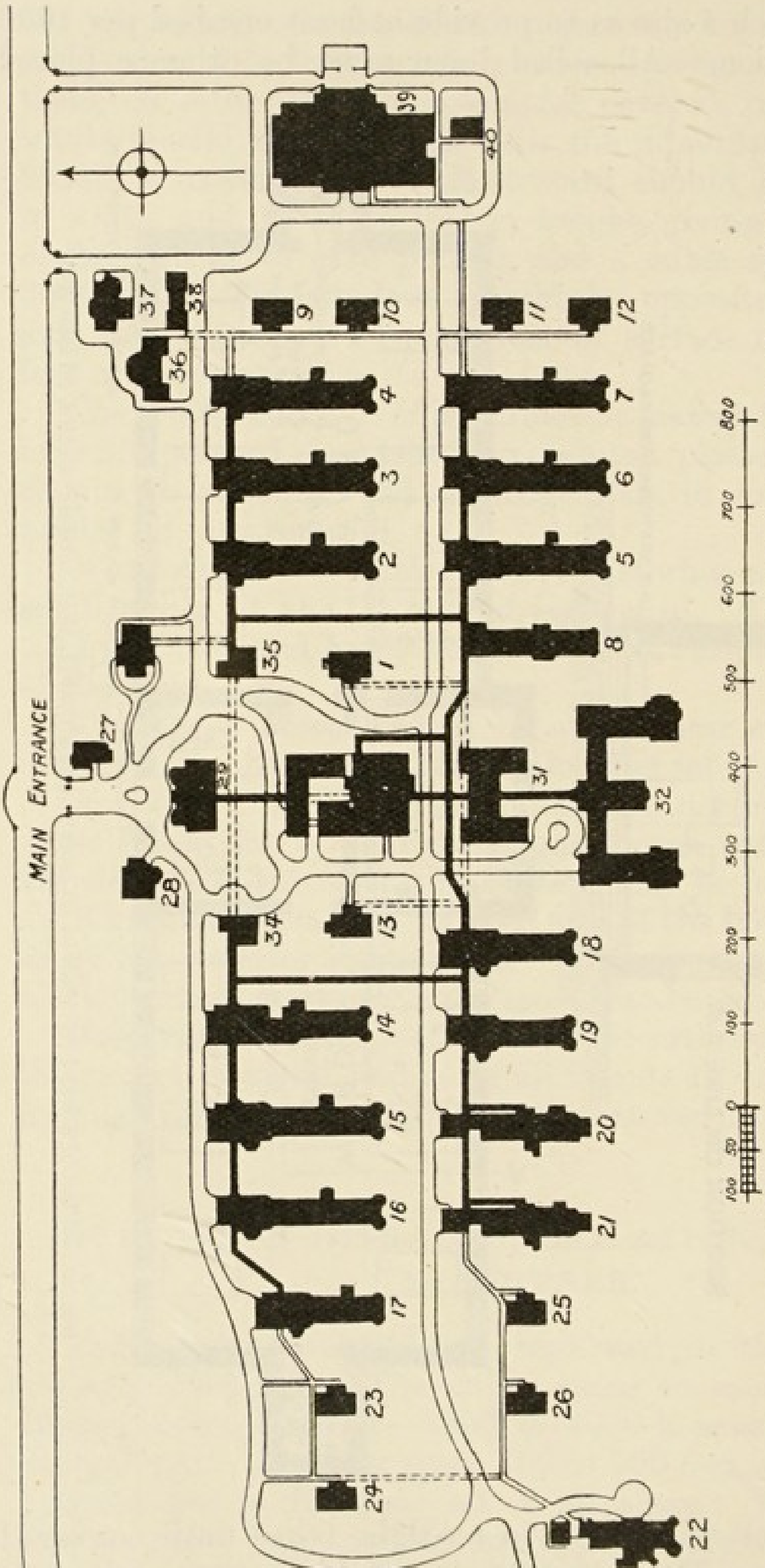


FIG. 37.—Plan of a ward pavilion in an isolation hospital (L.G.B. model), section on line A A.

in a disinfectant solution or in air-tight boxes until conveyed to the laundry. The water-closets should have an automatic disinfectant flush, or, what is better, the excreta should be



Observation. 1, 13. Scarlet Fever. 2, 3, 4, 5, 6, 7. Convalescent. 8. Isolation. 9, 10, 11, 12, 23, 24, 25, 26. Diphtheria. 14. Typhoid. 15, 16. Erysipelas. 17.
Measles. 18, 19. Whooping Cough. 20. Chicken-pox. 21. Typhus. 22. Lodge. 27. Superintendent's House. 28. General Offices. 29.
Kitchen and Dining-rooms. 30. Servants' Home. 31. Nurses' Home. 32. Scarlet Discharge. 33. Reception. 34, 35.
Educational Block. 36. Mortuary. 37. Workshop. 38. Laundry and Boiler-house. 39. Disinfector. 40.

Fig. 38.—Plan of the isolation hospital at Colinton Mains, Edinburgh.

received into a disinfectant, mixed with sawdust, and burned. The bodies of those who have died from small-pox or typhus are infective, and hence must be washed with a disinfectant, and the orifices plugged with corrosive wool. The corpse should then be placed in the coffin and surrounded with sawdust or other substance impregnated with some disinfectant; the coffin should then be sealed at once. A disinfecting apparatus, an incinerator, and an ambulance station must also be provided. Separate blocks must be set aside for each infectious disease.

Small-pox and Cholera Hospitals need only be very small, but should have ample ground around, so that in the event of an epidemic of either occurring, temporary wards may be rapidly erected for the reception of patients. They must not be built near populous localities or public institutions, owing to the risk of aerial infection.

Sanatoria for Consumptives.—These are usually situated in salubrious situations where the air is pure, and preferably close to pine woods. The private grounds should be ample. The pavilions should be small with many windows so that the patients may be treated almost in the open air. Movable shelters are also provided, so that they can always be turned towards the sun or away from strong winds.

SCHOOLS.

Care must be exercised to prevent overcrowding of scholars, as deficiency of cubic space and fresh air tell more injuriously on children than on adults. In the Public Schools of cities overcrowding is more likely to take place than in private schools, though to a certain extent the Local Authority, the Local Government Board, or the Board of Education take means to prevent this. It is found that where children are crowded together their general health suffers, and infectious diseases are more prone to break out. In planning large schools, the individual rooms should be made to open on to a central hall. It is desirable to have all the rooms on the ground floor, but in any case the school ought not to be of more than two floors, and the corridors must be wide and well lighted.

School-room.—An oblong shaped room is desirable with windows on one of the long sides; no single room should ever

be made to contain more than 100 pupils. For olders scholars a *minimum* allowance of 10 square feet of floor space, and 100 cubic feet of air space for every pupil must be allowed in each class-room, and only a slightly lower amount for young scholars. The desks should be proportioned to the height of the children, and the seats have backs, and be placed at right angles to the window wall. To each child an allowance of 18 to 20 inches of desk or form space should be given, and the desk sloped at an angle of 15°. Illumination must be ample or else the acuity of vision of the pupils is liable to become affected. Light ought to come from the left side of the pupil, so as to prevent the shadow of the hand falling on the writing-paper. The heating of school-rooms is best effected by means of hot water pipes and open fires carefully guarded. Separate urinals and closets must be provided for boys and girls—one closet to every fifteen girls or twenty-five boys. All children attending school should be frequently examined by the Medical Officer of the School, in order to detect any defects of vision, hearing, "over-pressure," epilepsy, mental deficiency, etc.

HYGIENE OF THE PERSON.

Exercise.—When an individual takes exercise or does work, the hearts' action becomes more energetic and rapid ; respiration is deeper and more rapid ; the skin becomes reddened from the dilatation of the capillaries, and the sweat glands become active. Watery vapour is given off in larger amount, and so is carbonic acid gas. The urine is diminished in amount, and the nitrogen eliminated is slightly increased. Over exertion tends to strain the heart muscle, and if severe and lasting, cardiac dilatation is brought about. Long continued strain leads to hypertrophy of the heart, and especially of the left ventricle, often associated with aortic incompetence or aneurism. Athletes or "strong men" seldom live to old age.

Work Done is usually expressed in terms of pounds or tons lifted 1 foot. An ordinary day's work for an adult man is equivalent to 300 tons lifted 1 foot, and this is comparable to a man walking 16 miles in five hours. It is computed that a man walking at the rate of 3 miles per hour on a level surface does work equivalent to raising his own weight $\frac{1}{20}$ of the distance he has walked. The standard diet yields 4000 foot

tons of available energy, but about 3500 foot tons of this are required for the maintainance of the bodily functions and heat production, leaving only 300 to 500 foot tons which forms an ordinary day's work for an adult.

Clothing.—Attention must be given both to the nature of the clothing, and to the mode of its application to the body. Woollen articles should be worn next the skin ; because of their non-conducting quality and absorbent nature they keep the body warm and dry. The more porous the materials, the warmer they are, owing to the amount of air which they contain, and which acts as a non-conducting medium. Clothing ought never be made to fit tightly on the body, but should be loose, so as not to impede the free motion of the trunk or limbs, or to hinder transpiration. The evils of tight-lacing are too obvious to require consideration.

CHAPTER VIII.

DISINFECTION, INFECTION, ETC.

DISINFECTION.

A Disinfectant is a substance which is capable of killing by its poisonous action pathogenic organisms. In other words, it is a germicide. An *antiseptic* merely arrests the growth of organisms; thus, a very dilute solution of a disinfectant may be an antiseptic. A *deodorant* only removes or masks odours; thus, dry charcoal absorbs noxious gases; some disinfectants are also deodorants.

Requisites in a Disinfectant.—A good disinfectant should (1) be strongly germicidal, and this power should not be lost by contact with organic matter, (2) mix with water in all proportions, (3) be non-poisonous and non-corrosive to skin or metals, (4) have a penetrating power and deodorant action, (5) be inexpensive.

Conditions Necessary for Disinfection.—(1) The disinfectant must be present in sufficient amount. (2) It must be allowed to act for a sufficient time; generally, the longer the exposure the more thorough the disinfection. (3) It acts best at a certain ("optimum") temperature.

Estimation of the Strength of a Disinfectant.—The strength of a disinfectant may be determined in various ways, *e.g.* (*a*) chemically, as the estimation of the amount of chlorine in a sample of bleaching powder. This is of little importance, however, from the germicidal point of view.

(*b*) For practical purposes a determination of its lethal effects on cultures of certain organisms is alone required. Thus, a certain definite quantity of anthrax virus may be exposed to definite amounts of a disinfectant present in varying percentages

of distilled water or other medium, and for constant times. A later examination after incubation will show what percentages have killed the organisms, what have modified the growth, what have merely arrested growth, and what have had no effect on it. If the same proceeding is carried out with other disinfectants, and with a culture of exactly the same age, it allows of an arrangement of the disinfectants in order as regards their germicidal powers. Threads may be dipped in various cultures, and exposed to the action of a disinfectant; it is then seen how far the further growth and reproduction of these organisms have been affected. One ought always to control these experiments with pure carbolic acid in similar percentage dilutions, the *Bacillus typhosus* being taken as the standard germ. A comparison between these tests allows us to express them in the form of a ratio known as the "*carbolic coefficient*" ("Rideal-Walker coefficient"). It is very necessary, however, to test all disinfectants as they would be used in ordinary work, *e.g.* with ordinary fæces or urine, and not with watery dilutions of specific organisms. Milk is an excellent organic diluent for this purpose. No single disinfectant is equally lethal to all organisms. Some disinfectants are much more lethal to certain organisms than are others, and hence are to be preferred in particular cases.

Disinfection.—In thorough disinfection the organisms present everywhere in a room should be killed. The infectivity of the excretions must likewise be destroyed (sputum, fæces, etc.), and the spread of the disease by infected persons must be prevented. It is the aim in medical and surgical practice to destroy the organisms *in situ*, or to neutralise their toxins as they are elaborated in the body. Though this is the ideal, it is seldom attained in actual practice.

METHODS OF DISINFECTION.

Light and exposure to free air are the most useful forms of disinfection which exist.

Sunlight is a powerful germicide; thus, the typhoid bacillus is killed by a six hours exposure to sunlight.

Dry Heat.—When organisms are raised to a high temperature they are killed. It is more difficult to destroy them by dry heat than by moist heat, because with the former they

tend to form spores, and these are more resistant to heat than ordinary bacilli. For example, the spores of anthrax are only killed by an exposure to dry heat for four hours at a temperature of 212° F., while they succumb in one minute if boiled in water. Besides this, dry heat penetrates with difficulty into articles of clothing, bedclothes, pillows, mattresses, etc., owing to their non-conducting character. The outside of these may be charred while the temperature in the interior may only be slightly raised. Mere overdrying of certain fabrics causes them to become very brittle and easily torn. Many stains are also fixed permanently by dry heat.

Moist Heat.—Practically all contagia are killed by exposure to boiling water or its steam for five minutes. Steam also penetrates bundles of clothing or bedding with great ease, owing to the formation of a partial vacuum, caused by the condensation of the steam in the cold articles. A great deal of latent heat is also evolved during the condensation, and thus the articles are rapidly heated throughout. The penetration of heat may be still furthered by first exhausting the air already in the article, and then admitting steam under pressure and in a current. Within ten minutes of exposing a pillow to steam at a temperature of 240° F. and 10 lb. pressure, the interior was found to have reached 234° F.

The Disadvantages of moist heat are, that woollen articles become yellow, and often shrink greatly owing to "felting." This is due to the fact that the natural fat (suint) is soluble in boiling water, and the fibres of wool then adhere closely. Many stains are also permanently fixed at the temperature of boiling water (urine, blood, fæces). The colours in dyed articles may also "run." Moist heat or steam is most effectual for woollen materials (carpets, rugs), hair and feather mattresses, etc.

Apparatus for Disinfecting by Steam.

The apparatus should be placed between two isolated rooms. The infected articles are introduced on one side, and removed when disinfected through the opposite door of the apparatus, and into the uninfected room. There ought to be no risk of infected articles being mixed with disinfected. Two entirely separate groups of individuals should deal with the infected, and disinfected materials.

Steam Disinfectors.—In general principle, the steam disinfector consists of a strong iron cylinder composed of double walls of boiler plate. A double-jacketed door at either end is made to close tightly on a rubber collar by means of screws. The articles to be disinfected are introduced on wooden trays, or, if large, run in on a trolley. High pressure steam is first introduced into the jacket so as to heat up the walls and the interior, and subsequently it is directed into the interior as dry saturated steam. The steam must be absolutely free from atmospheric air. Pressure safety valves are connected both with the jacket and with

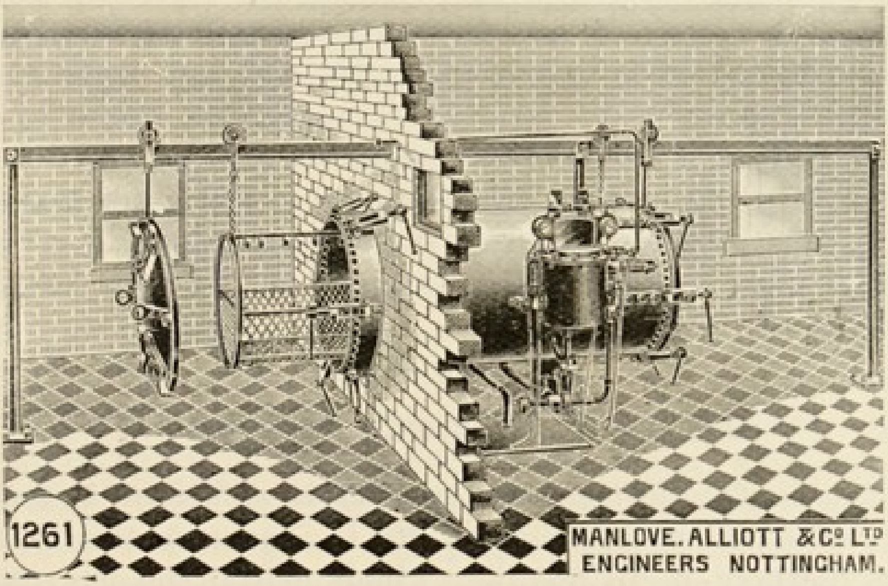


Fig. 39.—Steam disinfector showing the apparatus opening into the "infected" and "disinfected room" by separate doors.

the interior, and a temperature index is also affixed. A pressure of 20 lbs. per square inch is found most suitable to favour penetration; the steam should pass in a current through the apparatus so as to drive the contained air out of articles, and hence an exhaust tube should be provided. The production of a vacuum in the interior also favours penetration, by withdrawing the air in the interstices of large heavy goods. If the steam is superheated or dried it is not nearly so powerful in its germicidal action, and approximates more to dry hot air in its activity. The articles are left in the disinfector for about twenty minutes; at the end of this time, steam is cut off from the interior while it is continued in the jacket, and in this way the articles are dried before removal. Washington Lyon's,

the Equifex, or Goddard's Steam Disinfectors are built on this principle; these all require more or less skilled supervision. Low pressure steam is slow in penetrating articles, and condensation in them may be troublesome.

For Cottage Hospitals such disinfectors as *Thresh's* are safer and more suitable, and afford perfect disinfection. In it the jacket contains a solution of calcium chloride, which boils at a temperature of 220° F., and is heated by means of a furnace beneath the apparatus. The steam is introduced at ordinary atmospheric pressure, but, passing in a "current," it is said to penetrate bulky materials even more quickly than steam under pressure. The articles, before removal, are dried by passing a current of hot air through them after disinfection. In *Reck's* machine the jacket is done away with, and low pressure steam is delivered regularly. In *Meyer's* apparatus steam is generated by boiling water at the bottom of the jacket, the steam escaping into the interior by apertures in the inner casing.

It is unnecessary to describe *Hot Air Disinfectors*, as they are never introduced into new hospitals, and at best their disinfection is insufficient.

Gaseous Disinfection: Fumigation.

If the disinfectant gas be evolved in sufficient amount and under suitable circumstances, it is perhaps the best and easiest method of disinfection which exists, the gas reaching every part of the room without attention. If, on the other hand, any part is omitted in using a disinfectant spray, the room has not been thoroughly disinfected. The latter method depends entirely for its efficiency on the care of the workman, whereas the former depends on the diffusion of gases, which is independent of human agency. On the other hand, it must be recognised that none of the gases penetrate into fabrics for any depth. It is, therefore, necessary that clothing, etc., should be spread out, and thick articles (*e.g.* mattresses) disinfected by steam.

Disinfection of a Room after a Case of Infectious Disease.—Certain precautions must be taken: thus, all outlets must be carefully stopped up, the chinks of windows papered over, the chimney damper closed or otherwise sealed; in short, the room must be made as air-tight as possible. Moisture favours the action of disinfectant gases, hence pails of hot water should be

placed in the room, and everything arranged so as to be readily accessible to the fumes ; drawers and presses opened, their contents spread out, bed-clothes hung over lines, and everything well moistened. Even after this the mattress and pillows must be sent to the steam disinfector for sterilisation. The door of the room must be tightly closed and sealed from the outside, and the room left under the action of the gas for as long as possible, certainly not less than six hours. At the end of this time doors and windows should be opened, care being taken not to inhale the fumes or allow them to irritate the eyes, and when thoroughly ventilated it may then be entered. All articles which can be washed are then to be placed in a disinfectant solution or boiled. The walls and ceiling ought to be scraped, and repapered or whitewashed. All woodwork, painted work, or floors must be washed with a disinfectant solution, *e.g.* corrosive sublimate solution 1 : 2000. The Local Authorities usually take in hand the disinfection of rooms after cases of infectious disease, as well as the disinfection of bedding.

Formic Aldehyde.—This is the most powerful germicidal gas which is in common use at present. It may be made by passing heated methylic alcohol over red-hot asbestos, when CH_3OH becames CHOH, or formic aldehyde. This gas easily dissolves in water, and furnishes "formalin," which is a 40 per cent solution of the gas. When more gas is passed in, or when formalin is heated, a white powder falls to the bottom, and this when dried is moulded into tablets, and known as *paraform*. Formic aldehyde is most easily obtained by heating these tablets in presence of watery vapour, and various lamps have been devised for the purpose (Alformant, Bengues). If the paraform is moulded on to or incorporated with a block of carbon it volatilises when the latter burns ("Konoform Formaldehyde Fumigator"), and so the use of lamps may be done away with. It is a powerful deodorant as well as disinfectant. At least ten paraform tablets (60 grammes) should be used for every 1000 cubic feet, or 1 grain for each cubic foot. This gas does not tarnish metals nor bleach coloured fabrics, but is very irritating to the eyes and lungs. The smell may easily be removed by sprinkling ammonia about. It has to be remembered that it is not a penetrating gas, but only a surface disinfectant. It acts most energetically in dry atmospheres—contrary to most of the disinfectant gases.

Sulphurous Acid (SO_2) is a heavy gas, and may be evolved by burning sulphur in basins placed on slates over tubs of hot water. If placed on shovels or tins, the burning sulphur easily eats away the metal, and might set fire to the room. Cylinders of liquefied sulphurous acid are very convenient, as are also "sulphur candles." In a large apartment the sulphur should be burned at elevated positions in different parts of the room. The air must be kept very moist and articles damped. At least 2 lbs. of sulphur should be burned for every 1000 cubic feet, and if the room is not very tightly closed 3 lbs. is necessary. The endeavour should be to get 2 per cent of the gas in the room; 1 lb. of sulphur gives 11 cubic feet of sulphurous acid = 1·1 per cent. In America 4 per cent is required for disinfection. Disinfection by sulphur is effectual for ordinary infection, but it cannot be relied on for such diseases as small-pox, anthrax, or cholera. The smell is very persistent, and thus it is an excellent medium for the destruction of mosquitoes and vermin.

Chlorine.—This is most easily evolved from bleaching powder by the addition of hydrochloric acid. About 2 lbs. of the powder with 1 lb. of strong acid should be employed for each 1000 cubic feet. The basins should be placed on elevations, as the gas is heavy and slow in diffusing. It is desirable to have 1 per cent present in the air of the room to be disinfected.

Coloured fabrics may be bleached, and metallic substances are corroded by the two preceding gases, but the latter may be protected by oiling. Bromine, iodine, and nitrous fumes are seldom used now. At best, gaseous disinfectants takes only one part in the process of disinfection, thorough washing and free exposure to air and light being the most important factors in the process.

Liquid Disinfectants.

Care must be exercised in their use, lest the volume of the fluid to which they are added may not reduce their percentage strength below that at which they are germicides. An excess of disinfectant should always be used. Those which are miscible with ordinary soaps are to be preferred, as both disinfection and cleaning can be performed at the same time.

Carbolic Acid or Phenol, $C_6H_5(OH)$, is the best known, though not perhaps the most powerful, of these agents. For

disinfecting purposes the crude form is to be preferred, but it has to be kept in mind that the very light or very heavy tar oils have little germicidal power; besides, the latter are very sparingly soluble in water. Cresol and cresylic acids form a large part of crude carbolic acid, and they are more powerful germicides than the pure acid itself. Carbolic acid must be used as a 5 per cent solution. It is a more penetrating disinfectant than corrosive sublimate, as it is not precipitated by contact with albuminous substances.

So-called Carbolic Powders or Soaps are not to be relied on as germicides; they are, however, deodorants.

Lysol contains 50 per cent of cresols with a potash soap. It is used as a 2 per cent solution, and is a powerful disinfectant.

Izal is of much the same composition, and is about four times as powerful a disinfectant as phenol. It is, besides, non-poisonous, and is employed in a 5 per cent solution.

Cyllin does not contain phenol, cresylic acid, or cresol, and yet has a strong bactericidal power.

Creolin, Bacillol, Saprol, Solutol, Sanitas-Okol, etc., are combinations having cresol as their active basis, and possessing the merit of non-toxicity.

Lysoform is a liquid formaldehyde potash soap, and is non-poisonous while strongly germicidal.

Mercuric Chloride; Corrosive Sublimate; $HgCl_2$.—This acts as a germicide in a strength of 1 in 1000, and as an antiseptic when 1 in 5000; while it is lethal to spores when 1 in 500. It must be used in excess, as much of it is precipitated by organic matter as an albuminate; this may be prevented by adding hydrochloric acid or common salt to the solution. The Local Government Board recommends the following mixture as a disinfectant spray, or for washing infected houses, byres, etc.:—Corrosive sublimate, $\frac{1}{2}$ an ounce; Hydrochloric acid, 1 ounce; water, 3 gallons, and anilin blue to colour it. In surgical use its action is uncertain, and hence carbolic acid is to be preferred.

Mercuric Iodide is even more powerful and less poisonous than the perchloride. It must be dissolved in a weak solution of potassium iodide.

Chloride of Lime (2 ounces to 1 gallon of water) acts in virtue of the hypochlorous acid which it evolves. *Chloros* contains 10 per cent of available chlorine.

Sulphate of Zinc; Chloride of Zinc (Burnett's Disinfecting

Fluid contains from 50 to 70 per cent).—These are used in from 2 to 5 per cent solutions, and are strongly germicidal.

Ferrous Sulphate and Copper Sulphate are not much employed now, as their disinfecting power is slight. They act as deodorants by absorbing sulphuretted hydrogen gas; 1 lb. must be added to 1 gallon of water.

Permanganate of Potash, $KMnO_4$ (Condy's Fluid), is not very powerful, merely acting as an oxidiser.

Peroxide of Hydrogen is very active even in a solution of 1 in 1000, but its expense limits its use to surgical practice. In 1 per cent solution it kills most pathogenic organisms within five minutes.

Sanitas is also an oxidising agent containing camphoric acids and some peroxide of hydrogen.

Formalin forms an excellent disinfectant for urine, fæces, and sputum, in the proportion of 10 drachms to a quart of water. In 1 per cent solution it is a powerful germicide.

Sprays.—The more powerful disinfectants may be employed in various forms of apparatus which generate a fine spray. This is directed on walls from below upwards, then on the ceiling, and lastly on the floor and furniture. Thus, corrosive sublimate, 1 to 1000; formalin, 1 to 50 of water; chlorinated lime, 2 ounces to a gallon, etc., are so used. Disinfection by sprays is rapid, and, when done by a conscientious workman, very effectual; 2 gallons of solution must be used for every 1000 square feet of surface. It also necessitates a thorough washing and drying up of the furniture, floor, etc., and this is an essential part of thorough disinfection.

Slaked Lime is a valuable and cheap disinfectant, and is used for whitewashing the walls of yards, prisons, etc.

Antiseptics.—Examples of such are:—weak solutions of disinfectants, essential oils (cloves, cinnamon), alkaloids (quinine), alcohol, salicylic acid, etc.

Disinfection of Excreta.—The fæces in cases of enteric fever or cholera should be received into a strong disinfectant solution, as corrosive sublimate 1 : 1000, and after having been broken up by stirring, must be tightly covered up, and left for two hours before being thrown down the water-closet. In isolation hospitals the fæces and urine from infective patients may be received into close iron vessels and sterilised by steam introduced at the bottom, or sawdust may be mixed with the excreta, and the whole incinerated.

INFECTION.

Infection means the introduction into the body of a pathogenic organism which is capable of multiplying within it. Infectious diseases, if acute, are known as *zymotic diseases*. Those which are accompanied by a rash are known as *exanthemata*.

Modes of Infection.

(1) *Inhalation.*—This is the most frequent mode of ingress of organisms, *e.g.* small-pox, typhus, measles, pertussis, etc. Infected clothing retains the virulence of the contagion for long, and susceptible individuals may readily acquire infection from these (*fomites*) by inhalation.

(2) *Inoculation*, as in vaccinia, anthrax, glanders, rabies, tetanus, septicæmia, syphilis, etc.

(3) *Ingestion* into the stomach or bowels.—The water- or milk-borne diseases are examples, typhoid, scarlatina, cholera, tabes mesenterica, diphtheria. Tuberculous flesh may convey the disease. The fingers soiled with excretions (cholera, enteric), may directly convey infection to the mouth, and so to the alimentary tract.

(4) *Absorption* through mucous membranes, *e.g.* venereal diseases, contagious ophthalmia, glanders, diphtheria, etc.

(5) *Insects.*—Flies may convey infection from the excreta of infected patients to food which is being eaten, or directly from the sick to the healthy. Micro-organisms may be conveyed by their feet or in their excretions; cholera bacilli live at least four days in the intestinal canal of flies. Typhoid, cholera, plague, tuberculosis, ophthalmia, leprosy, etc., may be communicated in this way. Biting insects may harbour specific organisms, and transmit these to human beings in the act of blood-sucking (mosquitoes in malaria, fleas or bugs in plague, tsetse fly in sleeping sickness, etc.).

The terms *infectious and contagious* are now almost synonymous, only a very few diseases being directly due to contact (gonorrhœa, syphilis, glanders, etc.).

Nature of Contagia.—It is almost certain that each infectious disease is due to a particular organism, and, indeed, most of these organisms have been isolated. The infection is given off from the diseased in various ways; measles is spread

by the breath, and by the nasal and bronchial secretions; small-pox, glanders, or syphilis are spread from the discharges, and exhalations from the skin convey it, as in typhus.

Distribution.—Most infectious diseases are world-wide in their incidence (*pandemic*). A few are localised, and do not spread to any extent from certain foci (*endemic*). At intervals a widespread increase of one disease takes place, or it becomes *epidemic.* Isolated cases of infectious disease are known as *sporadic* cases.

Seasonal Activity.—At certain periods of the year some of the zymotic diseases take on an increased activity. The meteorological conditions at these seasons seem to suit the micro-organisms better, they then grow actively and the diseases become more general. In other cases this increase may be due to the assembling of peoples from distances, as in pilgrimages or fairs, or to a lesser degree to the meeting of children at school after holidays.

Severity of Attack.—Some epidemics are associated with a much higher mortality than others. The early cases in an epidemic are often the severest. Frequent recurrences of one disease usually tend to become milder in form with each attack.

Predisposition to infectious disease may be due to:—

(1) Age; children, as a rule, are more susceptible; enteric fever is an exception, however, young adults being most prone to attack.

(2) Sex; though both are equally liable to contract disease, the male mortality is higher than the female.

(3) Family; certain families are much more liable than others to contract disease.

(4) Condition of health; debility, fatigue, anxiety, etc., render individuals more liable to infection.

Incubation Period.—This corresponds to the interval which elapses between the time of exposure to infection, and the "invasion" or manifestation of the symptoms. It is fairly constant in each disease, and is important to remember, in order that those who have been exposed to infection ("contacts") may be isolated for the proper time. Occasionally the incubation period may be remarkably shortened (as in milk-borne scarlet fever). In other cases the incubation period may appear to be very long; the latter may be due to "deferred infection," where the clothing may have become infected, and at a later period may transmit the disease to the wearer.

Short Incubations.—Erysipelas, 1 to 2 days; septicæmia, 1 to 2 days; influenza, 1 to 3 days; diphtheria, 1 to 4 days; scarlatina, 2 to 5 days.

Long Incubations.—Measles, 10 to 12 days; small-pox, 10 to 15 days.

Variable Incubations.—Cholera, 1 to 4 days; pertussis, 7 to 12 days; typhus, 7 to 16 days; enteric fever, 12 to 20 days; mumps, 14 to 24 days.

IMMUNITY.

Non-susceptibility to a given disease may be natural or acquired, and is known as "immunity." In every one there is a greater or less power of *natural resistance* to disease, and this is probably due to the leucocytes in the blood acting as phagocytes or as manufacturers of microbicidal substances. When an individual becomes infected, these alexins neutralise the toxic products of the micro-organisms, while the phagocytes endeavour to destroy the organisms themselves. If these processes succeed, the infection is destroyed, and the person remains well; if they do not succeed, the disease manifests itself.

Acquired Immunity may be Attained.—(1) By a previous attack of the infective disease, as small-pox, a specific immunity having been conferred. As long as the blood serum contains these antibodies in sufficient amount, the individual is immune.

(2) Inoculation may also confer an artificial immunity, as in vaccination.

(3) The injection of antitoxins, and (4) the injection of attenuated toxins themselves, may confer a more or less permanent immunity.

Artificial or Isopathic Immunisation: Protective Inoculation.

(1) *Active Immunity* is conferred by giving injections of attenuated organisms or of their toxins. A small dose is given at first, but this is gradually increased, and in time a high degree of immunity is conferred, and persists for long. A hyperleucocytosis is desired (and is obtained by the injections) so that the organisms introduced by infection may be killed. The serum in the blood of the patient is an antimicrobial one. Antirabic inoculation is an example of this immunisation.

(2) *Passive Immunity* is obtained by injecting the serum of an animal previously immunised. This serum already contains the antibodies necessary to neutralise the toxins of the organisms present in the infected individual. It does not stimulate hyperleucocytosis, and hence the immunity conferred does not last long. The sooner the injections are commenced the greater is the benefit. This forms the basis of the antitoxic treatment (*e.g.* diphtheria).

Therapeutic Agents of Bacterial Origin.

The therapeutic agents of bacterial origin are of two classes —(*a*) Vaccines and (*b*) Sera. The *vaccine* may be derived directly from a culture of the particular organism, or the latter, grown at a higher temperature than its optimum, or by some other treatment, is attenuated, and then used as a vaccine. Therapeutic *sera* are derived from the blood of animals which have been immunised either by the injection of bacilli or their toxins. In the preparation of these, the quantity injected into the animal (usually a horse) is at first very small, but is gradually increased until an amount sufficient to kill many hundreds of unprepared horses may be injected without producing ill effects. The blood of such a horse is then received into sterile vessels; after coagulation, the serum is removed and used as the antitoxic serum. It may be dried, and forms yellow scales very suitable for use in the tropics; the serum is, however, more generally used in this country. It requires six to nine months before a horse is thoroughly immunised to the toxins of diphtheria. About a gallon of blood may be removed from a prepared horse each month. Pains in the joints or rashes (erythema, scarlatiniform eruptions, urticaria, etc.) may result from injections of antitoxins in the human being.

It is impossible in a brief space to give an adequate description of the infectious diseases, but the facts which from a Public Health point of view have to be remembered are —(1) The seasonal activity. (2) Incidence as regards age and sex. (3) The mortality. (4) The incubation period. (5) Early means of diagnosis. (6) Modes of infection. (7) Period of isolation. (8) Treatment.

CHAPTER IX.

INFECTIOUS DISEASES.

Scarlet Fever: Scarlatina.—*Seasonal Activity*: maximum is in October; minimum from March to May: epidemics generally arise every five years, though sporadic cases are constantly present.

Incidence.—Infants are seldom attacked, but it is essentially a disease of childhood, 85 per cent of cases occurring in children under ten years of age; the maximum number is met with during the fifth year of life. The younger the child, the more severe is the disease, and hence the importance of protecting children from being attacked; adults likewise take it in a severe form.

Case Mortality, or Proportion of Deaths to Patients.—On an average this is 4 to 8 per cent of those attacked; in some epidemics it is much lower, while in others it is far higher. The mortality amongst males is greater than amongst females, though females are attacked in a greater proportion. Scarlet fever is at present a much milder disease than it was formerly.

Incubation.—It is almost certain that four days is the average period of incubation. Exceptionally it may be twenty-four hours or may extend to seven days.

An Early Diagnosis should be made by observing the condition of the tongue and the throat. During epidemics, those patients who merely suffer from sore throat with little or no rash, spread the disease through not being recognised as cases of scarlatina.

Modes of Infection.—(1) By the air. Most probably the streptococcus described by Klein and Kürth is the specific organism. This is given off chiefly in the discharges from the nose, mouth, and throat, and mainly from the period of in-

vasion to the height of the eruption. The infection gradually lessens in intensity, though it may persist for six to eight weeks, and may be propagated by the desquamating scales of the skin, the infection being thus carried by the *air*. The later peeling of the skin is probably non-infective. The virus retains its power for long when dry; hence infected clothing may communicate the disease many months afterwards (*fomites*). Scarlatina may also be communicated by pet animals, insects, or flies, and even from the bodies of those dead from the disease.

(2) Food may likewise become contaminated, and especially milk. The latter may become infected through the milkers, or those distributing milk, suffering from scarlatinal sore throat, or desquamating epithelium may fall directly into the milk from their hands and arms.

Relation Between Scarlet Fever and Disease in Cows.—It is said that cows are subject to a disease resembling scarlatina, and that, when suffering from this, a vesicular eruption on the udder is noticed (Hendon Cow Disease, so called because Dr. Klein first investigated an outbreak at Hendon). The milk from such affected cows is said to produce scarlatina in children. This has not been confirmed, however, by later observers.

Isolation.—The patient must be isolated as long as there is any discharge from the nose, mouth, eyes, or ears (otorrhœa being a common sequela of scarlatina) and until desquamation has ceased, as these may be infective. As a rule the period of detention is seven weeks from the commencement of the illness. If the case has been very severe, probably a detention of from eight to ten weeks may be necessary. Contacts should be quarantined for one week.

"*Return Cases.*"—A child who has had scarlatina may be discharged from the isolation hospital after the usual period. Soon after its return home, one or more members of the same family develop the disease. They have probably caught the infection from the first child, who may still be suffering from a naso-pharyngeal or ear discharge, or it may have been allowed to play with children acutely ill just before its discharge, and hence may convey active germs to its home. Convalescent patients should be kept strictly apart from acute cases in the hospital, and on return home the child ought not to be allowed to play with its companions for a week. The attendants may develop merely a sore throat, and yet this may be a latent form

of scarlatina, and from it a true infection may be given to susceptible individuals.

Rules for the Isolation of Patients Suffering from Infective Diseases.—Where the patient is one of a young family, or if the house is in a crowded tenement, it is necessary to remove the case to an isolation hospital. Even amongst the well-to-do classes hospital treatment is advisable owing to the disturbance a case of infectious disease causes in a household; thus, the rest of the children must be kept from school, those at work must live out of the house, etc. When, however, removal is refused, a room ought to be prepared as distant from the ordinary living rooms as possible. It should be stripped of everything (curtains, draperies, carpet) but the bare necessaries. A set of utensils for cooking, and dishes for the use of patient and nurse, ought to be kept in the room. A nurse must attend to the invalid, and should not mix with the other members of the family; she should wear an easily sterilisable cotton or linen dress. A sheet wet with a disinfectant should be hung outside the door, merely as a protection when the door is opened. Abundance of fresh air should be admitted to the sick-room, both during the day and night. All discharges must be disinfected at once; those from eyes, nose, throat, or ears being received on rags and burnt. Urine and fæces must be kept in contact with a disinfectant for 2 hours before being thrown down the water-closet. A mild antiseptic ointment may be rubbed over the body to prevent the desquamating skin from being blown about, and an antiseptic gargle should be used. During convalescence, disinfectant baths may be given, and desquamation promoted. The infected clothing should at once be placed and left in a disinfectant solution for two hours before being removed from the room for boiling (corrosive sublimate, 1 : 2000; chloride of zinc, 1 : 25; izal, 4 ounces to 1 gallon of water, etc.). The throats of those who have been in contact may be sprayed with an iodised water gargle or other antiseptic.

Pasteurisation of Milk.—Where there is a likelihood of the milk having conveyed the disease, it may be partially sterilised (Pasteurised) before use, by putting the milk in a closed vessel (bottle or tin), and placing this in a pot of cold water. The latter is then raised to boiling-point and kept boiling for twenty minutes, after which the milk must be rapidly and thoroughly cooled. The milk is raised to a tempera-

ture of 140° to 180° F., which is sufficient to destroy the lactic acid bacilli as well as most of the pathogenic organisms. This method does not produce those physical changes in milk which sterilisation does. Sterilised milk is apt to produce rickets in children fed for long periods on it.

Milk-borne Epidemics.—Such diseases as scarlatina, diphtheria, and enteric fever are propagated by contaminated milk, and an inquiry shows the following characteristics:—

(1) The cases follow the distribution of milk from the cart.

(2) The better classes suffer to a greater extent than the poorer, owing to the greater consumption of milk by them.

(3) Those who drink the largest quantity of milk in the family suffer most, as they absorb a larger amount of the poison.

(4) The incubation period in such epidemics is as a rule shortened.

(5) The onset of the epidemic is sudden, and when the supply of milk is cut off it declines rapidly. In an ordinary epidemic the commencement is gradual, and so is the decline.

Measles; Morbilli.—This is a pandemic disease.

Seasonal Activity.—There are two maxima, viz. June and December; the minimum is from August to October.

Incidence.—It is a child's disease, affecting chiefly those from two to five years of age.

Mortality.—This is greatest during the second year; above 90 per cent of the deaths take place during the first five years of life. The male mortality is also greater than the female. On an average the case mortality is 3 to 4 per cent. Measles itself is not a dangerous disease, but it is attended by many and dangerous complications.

Incubation is usually ten or eleven days; but it may in exceptional cases be four to fourteen days.

Early Diagnosis may be assisted by finding Koplik's bright red spots with central bluish-white points on the buccal and labial mucous membrane, and by the persistence of a short dry cough.

Modes of Infection are chiefly from the breath, and in the secretions from the eyes and nose, both preceding and during the eruptive period. Fomites rarely spread the disease.

Period of Isolation is usually three weeks from the period of invasion. Contacts must not be allowed to return to school for fourteen days.

Treatment.—It is almost impossible to stamp out the disease, owing to children going about during the early or coryza-like period when it is most infective. This disease and whooping-cough furnish the most common reason for closing schools, especially in country districts. Owing to the expense incurred in notifying cases of measles, and the hopelessness of preventing epidemics by isolation, it is a disease seldom included in the Compulsory Notification Act by Local Authorities.

German Measles ; Rubeola ; Rubella ; Rötheln ; Roseola.—A disease of spring or early summer, which chiefly affects adolescents and young adults of both sexes. The incubation period varies from twelve to eighteen days, and the patient must be isolated three weeks from the period of invasion. It is a remarkably infectious disease, but is associated with a very low mortality.

"Fourth Disease" has to be distinguished from rubella and scarlet fever. Its incubation period is from nine to twenty-one days, and the patient continues to be infectious for twenty-one days.

Whooping - cough ; Pertussis.—*Seasonal Activity.*—Maximum, March to April ; minimum, September to October.

Incidence is mainly amongst children during their first two years of life, and is most fatal to females.

Mortality.—It accounts for 2 per cent of the total deaths. The younger the child the greater the danger ; fully 75 per cent of the deaths from pertussis occur in children under two years of age. The case mortality is usually 4 to 5 per cent.

The Incubation is usually seven to fourteen days.

Isolation should be kept up until all spasmodic cough has gone, *i.e.* six to eight weeks. Contacts or suspects should be quarantined for fourteen days.

Modes of Infection.—Besides direct infection through the breath from one patient to another, it may be carried through the air for several yards, as across a street, and, as it is highly infectious, its incidence is great amongst children. It is often associated with epidemics of measles, which precede, accompany, or follow whooping-cough. The infection is often carried by clothing (fomites).

Small-pox ; Variola.—This disease is endemic in India, China, Egypt, and in many Eastern countries, but may

become epidemic. The last great epidemic, in 1871-2, caused 42,000 deaths in England alone.

Seasonal Activity.—This is greatest during the first half of the year.

Incidence.—Children are particularly susceptible. Previous to the introduction of vaccination, 90 per cent of small-pox deaths occurred in children under five years of age. At every age, however, those unprotected by vaccination are prone to take the disease. By reason of infant vaccination, the disease is now one which chiefly attacks adults. Dark races are more susceptible than white people.

Case Mortality.—This varies with the variety; thus, in discrete small-pox it is, among the vaccinated 5·2 per cent, and among the unvaccinated 35·4 per cent, while in the confluent or hæmorrhagic form almost all those unprotected by vaccination succumb. The younger the patients, the higher is the mortality ; the mortality among males is greater than in females.

Incubation Period is almost invariably twelve days; exceptionally it may be nine or fifteen days.

Early Diagnosis is most important. The disease is infective from its earliest manifestation, hence unrecognised and ambulant cases spread the disease widely. Severe pain in the back and headache, together with the presence of hard papules in the skin of the forehead in a fevered patient, ought to arouse suspicion.

Mode of Infection.—Usually this takes place directly through the breath (nose, mouth, throat) of the patient during the early period, and from the skin during the suppurative stage (after the eighth day). It is readily spread through infected clothing, and so frequently in rags, that Orders prohibiting their importation from infected ports are issued from time to time by the Local Government Board. Many affirm that the infection is also carried through the air for considerable distances, basing their assertion on the fact that infection has spread in many cases for a distance of fully half a mile around small-pox hospitals. In many of these cases, however, the influence of personal intercourse has had much more to do with the spread of the disease than aerial convection, and in many hospitals laxity regarding isolation has been great. A dead body may also spread the disease.

Period of Isolation.—The patient must be isolated until all

the scabs have fallen off. This usually takes place in a month or six weeks.

Treatment.—The patient must be treated as a specially infective fever patient. Free access of air must be constantly maintained, and a rigid isolation carried out. Even amongst the well-to-do classes, small-pox patients are better to be treated in the isolation hospital than at home. During convalescence, disinfectant baths should be given each day.

Small-pox Hospitals.—A small permanent hospital should be maintained, about a mile distant from any dwellings, and protected from prevailing winds. There should be ample space around it, so that in the event of the disease spreading, extra temporary wards may be quickly erected.

Prevention of an Outbreak.—Every suspicious case must be at once isolated and vaccinated. All infected clothing and bedding should be burnt, and the rooms thoroughly disinfected. Amongst the poorer classes, an empty house or tenement must be made ready for the reception of all those who have lived among or have been much in contact with undiagnosed cases of small-pox during the preceding fortnight. This is called the "Reception House." All of these "contacts" must be vaccinated or revaccinated at once, and kept in quarantine for seventeen days, being visited and examined medically each day to see if in any of them small-pox develops. Those who are so quarantined must be maintained at the expense of the Local Authority, and the usual wage must be paid to operatives who have been compelled to cease their work. A certain number may be allowed out to work each day, being only required to sleep in the reception house, and to be under daily observation.

Vaccination in Relation to Small-pox.—Inoculation of small-pox has been practised for centuries in China, and the custom still prevails in many parts of that empire of grinding the small-pox scabs into powder, and blowing this up the nostrils of those to be inoculated. In 1721 Lady Mary Montagu introduced into England from Turkey, the practice of inoculating lymph from the vesicles of mild cases of small-pox into healthy individuals, so that small-pox might be produced in them in as slight a form as possible. Towards the end of the eighteenth century this inoculation became very common, and was attended with excellent results, both in England and Scotland. It was termed "variolation," and produced of course

the infectious form of the disease. The mortality from variolation on an average amounted from 2 to 3 per cent, as contrasted with 25 to 30 per cent from small-pox.

It was well known to the farmers and dairymaids in Dorsetshire and the neighbouring counties, that the disease in cows known as "cow-pox" (a vesicular eruption on the teats and udder) was easily contracted whilst they were milking, and that it produced on their hands and arms a vesicular eruption which prevented them from taking small-pox afterwards.

Edward Jenner, having learnt this fact, inoculated a boy with the lymph from a case of cow-pox, and found that, six weeks later, he had protected him from taking small-pox by inoculation. This discovery of the protective value of vaccination was made in 1796. It very rapidly became widely practised, and with marvellous results as regards both the incidence of, and mortality from small-pox. During the eighteenth century small-pox caused, of the total mortality, 9 per cent. From 1801 to 1850, when vaccination was practised though not compulsory, this fell to 3·8. From 1851 to 1880, when vaccination was compulsory, the figure was 1·4, and since then it has steadily diminished.

A much larger proportion of confluent and hæmorrhagic cases occur amongst the unvaccinated than amongst the vaccinated. As regards mortality, in an unvaccinated community fully 50 per cent of those attacked die; while in a vaccinated one it is under 5 per cent.

Vaccination confers almost complete (but not absolute) immunity against small-pox for some five or six years. This protective period is not so prolonged during childhood as it is during adult life. Seven years may be taken as the limit of protection, and, therefore, *revaccination* is necessary, and should be performed at the age of ten to fourteen years. In countries where revaccination is compulsory (*e.g.* Germany) small-pox is almost non-existent, and the same is seen in the members of our own Army, Navy, or Civil Services, who on entering, are compelled to submit to vaccination. Though the protective power of vaccination dies out in time, its *modifying* power remains, and so, even when a vaccinated individual contracts small-pox (it may be long afterwards), the disease is much milder, of shorter duration, and leaves little disfigurement. Vaccination to be efficient in affording protection must be thorough. Four insertions ought to be made, and the total

vesicular area ought to cover at least half a square inch. Glycerinated calf lymph, or lymph purified by chloroform vapour, should alone be employed. The incubation period of vaccinia is much shorter than that of variola, and consequently vaccination performed even five or six days after exposure to the infection of small-pox may confer immunity, or, at least, may greatly modify and lessen the intensity of the disease.

Vaccination Acts.—1840, First English Act; this prohibited inoculation of small-pox, and recommended vaccination. 1853, Compulsory Vaccination Act; every child had to be vaccinated before it reached the age of three months. Acts of 1867, 1887 amended and superseded these; that of 1898 extended the age to six months, and made provision for domiciliary vaccination, and conscientious objection. In Scotland, the Vaccination Act of 1863, as well as the Public Health Act of 1897, and the Vaccination Act of 1907, control the practice, the latter also permitting conscientious objection. In Ireland, the Act of 1863, and the Public Health Act of 1878 deal with vaccination.

Chicken-pox; **Varicella** is a highly contagious disease chiefly affecting children, and having a very low mortality. It closely resembles modified or very mild cases of small-pox, and is transmitted in the same manner. Epidemics of chicken-pox and small-pox are often coincident. The incubation period is fourteen days, and the child should be isolated four weeks or until all scabs have disappeared. Contacts should be quarantined for eighteen days. Care must be taken not to mistake a mild case of small-pox for this disease.

Typhus Fever; **Petechial Fever**; **Dirt or Jail Fever.**—This was formerly one of the commonest diseases, Russia and Ireland being its chosen seats. The last great epidemic in Europe was in 1846-7; it is a disease now seldom met with in this country.

Seasonal Activity.—During the cold months of the year it is most prevalent, owing to the poorer classes crowding together and closing the means of ventilation in their rooms. Want of food is a great predisposing cause.

Incidence.—It chiefly affects adults of both sexes, though the male mortality is much higher (most cases occur between the ages of ten and fifteen years).

Case Mortality varies from 10 to 16 per cent, and is higher in adults than in children.

Incubation is usually twelve days.

Diagnosis must be made to distinguish it from influenza.

Modes of Infection.—The infection is carried in the breath or by the exhalation from the skin, and travels through the air for several yards. The contagion is, however, soon destroyed by air and light, though it remains in unaired clothing or in old houses for long. It is closely associated with dirt, want, and overcrowding, hence its frequency in prisons in former times. The infection from the dead body is even more intense than from the living.

Period of Isolation.—Patients must be isolated five weeks from the onset of the disease. Contacts should be quarantined for at least two weeks.

Prevention.—In the poorer parts of towns, insanitary and overcrowded tenements should be destroyed, and open spaces formed. When an epidemic arises, house to house medical inspection must be made to discover cases, and to inquire into overcrowding. The patients should be treated with abundance of fresh air, and the discharges thoroughly disinfected.

Relapsing Fever, Bilious or Famine Fever, is a highly infectious disease, having a close relation to typhus fever; epidemics of the two diseases often occur together. Overcrowding and famine seem to be its chief causes, hence it has appeared as rare epidemics in Ireland and Scotland.

Mode of Infection is through the air of the patient's room, and by means of infected articles of clothing or bedding. Biting insects may also convey the disease. The *Spirillum Obermeierii* is the specific organism, and gives rise to fever, recurring after a week of apyrexia. The absolute diagnosis is made by discovering the spirillum in the blood. The mortality from this disease is low.

Diphtheria.—Though much more common in towns, it is also found in sparsely populated districts. The virulence of the disease increases with the length of time the epidemic lasts. Cases at the beginning may only be recognised as "sore throat," but the intensity increases with succeeding cases. It is markedly endemic in its incidence.

Seasonal Activity.—In the cold damp months (November to January) the greatest number of cases occur, though even

in dry seasons the disease may be prevalent. Epidemics never appear in rainy years.

Incidence.—It is a disease which affects children of both sexes equally; two-thirds of all the cases occur in children under ten years of age. Certain families show a marked predisposition to diphtheria.

Mortality.—This is greatest during the fourth year of life, and the disease is more fatal to females than to males. The case mortality with the antitoxin treatment is now 10 to 12 per cent, as contrasted with 30 per cent before its introduction.

Incubation is usually two to three days.

Early Diagnosis.—The appearance of the throat is characteristic, but a cover-glass film showing the Klebs-Loeffler bacillus from a swab, or a culture on coagulated blood serum gives an absolute diagnosis. Care has to be taken to distinguish this organism from Hofmann's bacillus. Diphtheria is often associated with epidemics of scarlet fever or measles. When the diphtheritic organism is associated with the *Streptococcus pyogenes* the case is, as a rule, very virulent and less amenable to antitoxic serum.

Modes of Infection.—The contagion is carried in the breath (kissing), or by the projection from the throat or nose of particles of the membrane; by infected utensils, handkerchiefs, towels, toys, books, etc. The infection persists long in infected articles. Milk has often carried the disease, either because of the cow suffering from diphtheria ("chapped teats," leading to broncho-pneumonia), or from milk becoming contaminated by the milkers. School infection is a frequent mode, one undiagnosed case infecting many healthy scholars, and necessitating perhaps the closing of the school. It may be contracted (rarely) from pet animals, or from horses and fowls ("gapes"). No great importance is now placed on its production through drain or sewer air.

Isolation.—Some patients retain the infection for long after obvious symptoms have ceased. As long as there is any nasal or bronchial discharge the case is suspicious, and microscopic examination of these should be made at intervals. The shortest period of isolation should be four weeks.

Treatment.—The patient must be most thoroughly isolated; antiseptic applications should be made to the throat and nose. Injections of antitoxic serum in large doses (2000 units) must be given at once; if the case is very severe, 4000

units, with repetition of the dose in four hours if necessary; intravenous injection is to be preferred in bad cases, as many hours are thereby saved. Those who have been exposed to infection, and the attendants, should also have a prophylactic injection (500 units), which protects them fully for three weeks. This antitoxic serum is obtained from the blood of a horse which has been rendered immune to diphtheria by repeated and increasing doses of the diphtheria toxin.

Mumps; Parotitis Epidemica.—This is a pandemic disease, extremely and directly infectious to young people; it is common during the cold damp months of the year.

Incubation period is two to three weeks; the patient must be isolated for three or four weeks, while contacts ought to be quarantined for four weeks.

Influenza is an intensely infectious pandemic disease, spreading over wide areas with great rapidity. It is induced by the invasion of Pfeiffer's bacillus. The contagion is carried in the air, by contact, or by clothing. It seems to have no relation to season or climate. The *incubation* period is two days.

Tuberculosis.—This causes one-tenth of the total mortality in England and one-seventh in Scotland. Though the deaths from all forms of tuberculosis have decreased greatly during the past fifty years (and specially is this true regarding phthisis), there has not been a corresponding reduction in the mortality of children from tuberculous affections; in fact there has been an increase.

Season has little relation to this disease, owing to the chronic character of its manifestations.

Incidence.—Tuberculous meningitis chiefly affects children during their second or third years of life; while tabes mesenterica is most often found during the third to the fifth years. Tuberculous ulceration of the bowels occurs from the twelfth to the eighteenth years, and phthisis pulmonalis selects individuals ranging from fifteen to thirty-five years as its most frequent prey.

Death Rate.—Phthisis causes a death rate of 1·5 per 1000, while other tuberculous diseases give rise to a death rate of 0·7 per 1000 of the population.

Occupation has a marked relation to tuberculosis, and especially in the form of phthisis. Those who work in close, hot, badly-ventilated rooms, and especially if the occupation

be dusty, are prone to the disease. Absence of sunlight favours the disease, as also working in constrained positions which hinder the free entrance of air into the lungs. The dwellers in overcrowded rooms, who are badly fed, are very liable to phthisis. The greater the "room density," the greater the incidence of this disease, or, in other words, the more marked the poverty, the more prevalent is tuberculosis. Damp conditions of the soil or house also favour the disease; whereas dry, well-drained localities are not subject to its ravages. Where phthisis was formerly common in damp localities, it has almost disappeared through thorough drainage. Heredity has also a marked relation in causing a lessened power of resistance to tuberculosis.

Contagion.—This is communicated by inhalation, in food, or by inoculation.

(1) The first is by far the most frequent cause; healthy people living constantly with the phthisical, and under similar social conditions, easily fall victims. The sputum becomes dried, and the organisms being carried into the air are inhaled by the healthy and induce the disease. Though tubercle bacilli are not exhaled by phthisical patients during ordinary respiration, they are expelled when the individual coughs, sneezes, or expectorates. In a recent instance, a daughter gave the infection to 7 of her immediate relatives within three months, all of them having been perfectly healthy until her return home.

(2) When the flesh of tuberculous animals is eaten in the raw or under-cooked condition, it may originate the disease in those who partake of it; this is specially true of diseased internal organs; the milk from tuberculous cows is specially prone to transmit the disease to infants and young children. From 20 to 40 per cent of all cows kept in cow-sheds are tuberculous, and though the udder may not be the seat of disease, the milk from such cows only too often contains tubercle bacilli. The percentage of milk samples which contain tubercle bacilli varies from 56 (Cambridge) to 3·7 (Manchester). A dose of *tuberculin* (dead tubercle bacilli with their toxins) injected into cattle, indicates by a febrile reaction taking place, that they are tuberculous. It has been almost certainly proved that there are no essential differences between bovine and human tuberculosis, and that the organisms of the one produce almost similar diseases in the other, though this is denied by Dr. Koch. Tuberculin inoculated into the skin

of a tuberculous person produces redness and œdema after forty-eight hours, with the formation of a papule which disappears within a week. One per cent solution of dried tuberculin may be instilled into the eye, when an inflammatory reaction and a fibrinous exudate forms on the conjunctiva of tuberculous patients. This reaction of Calmette lasts only from twenty-four to thirty-six hours, and both it and the subcutaneous inoculation of tuberculin give no results with non-tuberculous individuals.

(3) Inoculation may take place in surgeons while performing operations, or in washerwomen when washing infected clothing.

Prevention.—Isolation in sanatoria is desirable. If this cannot be carried out, then the patient must be kept in one room, the windows of which must be kept constantly open to admit abundance of light and air. The sputum or other discharges must be disinfected at once. Cyllin is an excellent disinfectant for the sputum, and pocket sterilisable spittoons should be used. No other person should sleep in the same room with a consumptive patient. Milk must be obtained from perfectly healthy cows fed in the open, otherwise it should be Pasteurised or treated (as by peroxide of hydrogen) so as to lessen the chance of its infecting young children. This may be done on a large scale by municipalities, and the milk sold in sealed bottles for the use of infants. Care should be taken to prevent the sale of tuberculous flesh (pigs, cattle, fowls), no matter how localised the disease may be. The Royal Commission on Tuberculosis recommends that if the disease be very localised, the affected parts are alone to be destroyed, and the rest may be passed for consumption. Attention must be paid to the mode of life of those affected, with reference to the prevention of over-crowding, insanitary conditions of the houses, back-to-back dwellings, absence of sunlight, etc. As regards operatives, careful inquiries should be made into the mode of heating, ventilation, and dustiness of factories or workshops, and means must be taken to improve these if necessary, schools and institutions for the young being especially attended to. Damp ground has an indirect relation in lowering the health of the dwellers, causing catarrhs and predisposing to phthisis, and therefore thorough drainage must be carried out. Rooms which have been occupied by consumptive patients for long should be disinfected in the usual manner. The notification of all cases

of tuberculosis, with a view to the elucidation of the cause, and for the purpose of preventing the spread, is most desirable, and has been made compulsory by many Local Authorities.

Enteric or Typhoid Fever is caused by a motile flagellated bacillus, described first by Eberth.

Seasonal Activity.—On account of its activity during the autumn (September to November) it has been called "autumnal fever."

Incidence.—Young adults are most subject to the disease, and especially when they are resident in warm climates. Males are more often attacked than females, but the case mortality is greater among the latter.

Case Mortality is, on the average, 15 per cent.

Incubation is usually fourteen days, though it may extend to three weeks.

Early Diagnosis.—It must be remembered that in cold climates diarrhœa is very often absent in enteric fever, while it is perhaps the most prominent feature in warm climates. Widal's agglutination test affords strong confirmation if positive. Mild cases are often not recognised, and the dejecta from such may contaminate wells, and give rise to widespread epidemics.

Modes of Infection.—Though it may be communicated through the *air* to attendants, yet by far the most frequent mode is by *water* contaminated with sewage containing the specific organism. This may result from leakage from privies, drains, or sewers, gaining entrance to wells, or by the level of the subsoil water rising to the level of polluted soil. Enteric, like cholera, is a "water-borne disease."

Drain or Sewer Air, if it carries with it the typhoid bacillus, may infect water in the cistern, or if it finds its way into bedrooms may produce the disease, but the air of drains or sewers *per se* can only lower the vitality and predispose to the actual disease.

Shellfish (oysters, mussels, etc.) are often stored in sewage-polluted water at the mouths of rivers for the purpose of fattening. Eberth's bacillus lives for several weeks in such molluscs, which may communicate the disease to those who partake of them.

Vegetables grown on sewage farms may carry infection. Water-cress has conveyed the organism from polluted water.

Milk or Ice-cream transmits in many cases enteric fever to those partaking of them. As a rule, milk becomes contaminated by being kept near human excreta, or through the

use of polluted water for washing the dishes, or added for purposes of fraud. The milk from cows suffering from a disease allied to enterica may, it is said, produce the disease in human beings.

Direct Infection may take place from hands dirtied with typhoid excretions (urine or fæces) being conveyed to the mouth, or from soiled clothing.

Insects (flies, etc.) may carry the organism from typhoid excreta directly to the food which is being eaten. Infected dust may also convey infection.

Fomites, in the shape of soiled bedding or clothing which has become dry, may readily transmit the disease.

In brief, the methods of transmission are from "drains, dairies, drinking-water, dust of dried dejecta, and also from the filthy feet of fæcal-feeding flies."

Isolation.—So long as the stools contain the specific organism the patient is infective; this may continue for months or even years. The bacilli remain active in the gall-bladder, it may be for years; a dairymaid spread the disease for six years after her supposed recovery.

Prevention.—The patient must be isolated, and all the discharges disinfected as they are produced. (The urine and fæces should be thoroughly stirred up, and kept in contact with a 2 per cent solution of corrosive sublimate for two hours, before being passed into the drain. Care must be taken to disinfect the soiled linen, and to cleanse thoroughly drains and sewers. Wright's immunisation by injections of dead cultures of Eberth's bacillus has been found of value in tropical countries. If constantly present in one district, the water-supply should be carefully investigated, and changed if necessary. It has been proved that in towns making use of the pail system of privy, typhoid fever is more prevalent than where water carriage is employed. This is probably due to infection of the soil or to the agency of flies.

Pettenkofer's Ground-water Theory.—Many years ago Pettenkofer enunciated the theory, that epidemics of typhoid and cholera were related to the rise and subsequent sudden fall in the level of the ground water in warm soils impregnated with animal impurities, as well as with the specific organisms of these diseases. This sudden fall left the organism on or near the surface of the ground, and in a state of activity. This is not now believed in to any extent, but of course there is always

the risk of the contamination of surface wells by the *rising* into them of polluted subsoil water.

Epidemic Enteritis ; Epidemic Diarrhœa ; British Cholera ; Summer Diarrhœa.—This mainly affects the young and aged in towns, and especially in the densely populated areas of these.

Seasonal Activity.—This is greatest during the warmest months of the year, viz. July to September.

Incidence.—Infants and young children succumb readily to this disease, which very frequently attacks bottle-fed babies.

Mortality.—It is the most fatal of all zymotic diseases to children. About one-fifth of the total infant mortality is due to diarrhœa. The greatest number die at the age of from three to nine months. In old age it also proves very fatal.

Modes of Infection.—Probably several organisms are concerned in producing this disease, though the *Bacillus enteritidis sporogenes* is the most likely. The infection is introduced in the food, and is almost always carried by flies. The drier and warmer the year the more numerous are the flies, and hence the increase in epidemic diarrhœa. Conversely, in wet cold summers there are fewer flies and less diarrhœa. In towns where the water carriage of sewage is employed there is much less diarrhœa than in towns which use the dry system. Where scavenging is well carried out, epidemics of diarrhœa are rare. Porous damp soils favour epidemic enteritis. Food which is irritating to the gastro-intestinal canal (*e.g.* sour milk) may predispose to this affection ; breast-fed babies are much less liable to contract diarrhœa. Overcrowding has no appreciable effect on the disease, but the dirtier the house the greater the prevalence owing to the home infection of food, and especially of milk. The conclusions of Ballard as to the temperature and character of the soil, its relative dampness and richness in organic matter, as influencing epidemic enteritis, have now only a historic interest.

Treatment consists in bestowing great care on the food, and preventing its infection ; insisting on cleanliness of the house, and of the person ; milk and other easily putrescible food should be Pasteurised or sterilised, and the feeding-bottles must be kept clean and sweet.

Asiatic Cholera.—*Seasonal Activity* is greatest during the warmest months. It is endemic in certain parts of India and elsewhere in Asia, but may become pandemic, spreading along

the lines of communication. It usually lessens in severity with cold weather.

Incidence.—It occurs chiefly in low-lying districts, and amongst the dirtiest of the inhabitants. Dark races are much more liable to attack than white races.

Mortality.—The death rate is often 50 per cent of those attacked, and is greatest among males. During the last epidemic (1866) in England, the mortality was 672 per million of the population.

Incubation varies from thirty-six to seventy-two hours.

Diagnosis is best made by recognising the comma-like spirillum of Koch in the dejecta.

Modes of Infection.—The spirillum obtained from the intestinal discharge grows in polluted water, and also lives in damp soil, and may thus infect water-supplies. Infected water is the most usual mode in spreading cholera. This has been demonstrated repeatedly in towns where, in the district supplied by a contaminated water, the cases have been numerous, while even in families living in the same locality but with a different and pure water-supply, there were few or no cases. Flies also spread the disease by infecting articles of food, and the contagion may even be propagated through the air to a limited extent. The organism can grow and multiply in milk, and may gain entrance to it from polluted water. Infected clothing, if damp, retains the infection for long, and hence washerwomen are more prone to cholera than the general population. The organism is easily killed by drying.

Prevention.—Yards, streets, etc., must be kept clean; and care must be taken that the water-supply is perfectly pure; if in doubt, the water should be boiled. Damp ground should be drained, and care taken to prevent pollution of the soil by dejecta. Soiled linen must be thoroughly disinfected while bedding should be burnt. The excreta should be cremated during the illness, and for at least ten days subsequent to apparent recovery, as they may be the source of further infection. Damp rags have often carried infection. The attendants must exercise great cleanliness, as direct infection from the hands is common. Haffkine's preventive inoculation of attenuated living cholera bacilli has given fairly good results. When epidemics of cholera are present or even threatened, the Local Government Board issues *Special Directions* for the guidance of Port Sanitary Authorities, or *General Cholera Orders* to all Local

Authorities or masters of vessels, for preventing the spread of the disease. *Orders Prohibiting the Importation of Rags* from infected ports are also made. Any vessel which has had or has a case of cholera on board must fly a yellow flag when within 3 miles of the coast. Another Order prohibits the landing of filthy and unwholesome aliens.

Epidemic Cerebro-spinal Meningitis; Spotted Fever.—*Incidence.*—It chiefly affects children, and especially amongst the poor, ill-fed, or overcrowded.

Mortality is very high, 40 to 60 per cent dying from the disease, while those who recover are often the subjects of grave nerve lesions, blindness, deafness, idiocy, etc.

Diagnosis is made by examining the cerebro-spinal fluid obtained by lumbar puncture, and detecting the intracellular diplococcus of Weichselbaum, which is also present in the nasal mucous membrane. It must be distinguished from the *Micrococcus catarrhalis.*

Transmission is directly through the air from the diseased, by the nasal discharge, or by fomites.

Anthrax.—This is a disease which affects the herbivora, and may from them be communicated to man. The spores of the organism occur very often in dried hides (wool or hair) from Persia, Turkey, Russia, China, etc. It is extremely difficult to get rid of the infection in certain farms, and in many districts of France the Algerian sheep has had to be introduced, as it was impossible to protect ordinary sheep from the endemic infection.

Modes of Infection.—(1) Inoculation of the skin through a scratch may give rise to "*malignant pustule.*" This may remain local, and recovery take place, or the bacilli may spread through the lymphatics of the body, giving rise to pneumonia or hæmorrhagic enteritis, and death may ensue in from four to five days. The pustule finds its most common site on the neck, face, or head.

(2) The dried spores may be carried in fleeces or hides from infected animals, and, being inhaled by workmen, cause the rapidly fatal Bradford *wool-sorter's disease or splenic fever.* This is characterised by high fever, and rapid death from pulmonary congestion or inflammation.

(3) The insufficiently cooked flesh of anthrax animals may allow the bacilli to gain entrance through the alimentary tract. The ingestion of spores on grass is the usual method of infection amongst the herbivora.

(4) The bites or stings of infected insects sometimes convey the contagion.

Post-mortem Appearances.—The blood is thick and tar-like and contains the characteristic bacilli; the spleen is greatly enlarged and softened; the internal organs generally are intensely congested; extravasations of blood are seen in all the organs of the body, as well as in the subcutaneous tissue.

Prevention.—The bodies of animals dead from, or killed in consequence of this disease should not be opened, but cremated entire in destructors or buried deeply in a place remote from habitations, grazing ground, or water-supplies. The stalls or stables must be thoroughly disinfected. The disposal of the body and disinfection should be carried out by the Local Authority. Affected animals must be killed at once, as their discharges teem with spore-bearing bacilli, and these infect the grass, and so spread the disease amongst sheep or cattle pasturing thereon. *Anthrax Orders* are issued by the Local Government Board, giving instructions to farmers in affected areas. In factories where hides are treated, dust (containing spores) must be prevented from passing into the room by means of extraction fans. It is better, however, to treat the hides with a liquid disinfectant; where this is impossible, disinfection with formaldehyde may suffice. Disinfection by heat destroys the wool, and is only applicable to horse-hair; it is also very unsatisfactory, as heat penetrates with great difficulty into tightly-packed bales. Electrolysis has been employed to aid germicides in their action on infected wool. The operatives should take great care that there are no abrasions on their hands, and gloves must be worn; they should change their clothing before going home, and not eat without first washing their hands. The malignant pustule must be excised at once.

Those Liable to the Disease are shepherds, farmers, farriers, slaughterers, veterinary surgeons; tanners, fellmongers, wool and hair workers; rag-pickers, etc. Workers in wool and horse-hair are those most frequently affected.

Glanders.—This is a disease common to horses, mules, and donkeys, and is communicated from them to man. A sterile culture of the glanders bacilli (mallein) injected into affected animals reveals the disease by a rise in their temperature, and by a large swelling at the seat of inoculation.

Incubation in man varies from three to eight days. The disease is called **Glanders** when it affects the nose and internal

organs, and **Farcy** when it appears as a cutaneous disease. The mortality varies from 50 per cent in the latter to 100 per cent in the former variety.

The Contagion is conveyed (1) Directly in the nasal discharges or from ulcers, and (2) Indirectly from infected harness, blankets, etc. The bacilli may gain entrance through a scratch, bite, or even through the intact skin, as well as by inhalation, as happens to those engaged in the manufacture of horse-hair mattresses.

Prevention.—Infected animals must be slaughtered and their bodies buried deeply in quicklime. In affected localities every horse should be carefully inspected, and tested by the injection of mallein. Public drinking-troughs ought to be closed, and infected stables thoroughly disinfected and white-washed.

Malaria.—This is caused by the growth and multiplication of a protozoan in the red corpuscles of man. Its reproductive cycle varies from twenty-four to seventy-two hours, so giving rise to the different types of malaria (quotidian, tertian, quartan, etc.). Though the disease is essentially a tropical one, it may be found wherever the ground is damp and where stagnant pools abound, affording facilities for the reproduction of the mosquito or gnat.

Incubation Periods vary with the type of the fever; in the tertian it is from six to twelve days, and in the quartan eleven to fifteen days.

Modes of Infection.—In the female anopheles (mosquito) the flagellated form of the plasmodium is present, and from these insects it passes into the marshy pools in which the larvæ live. The latter in turn become infected and transmit the disease to the fully-developed mosquito. The minute flagellate forms then pass into the proboscis of the insect, and are conveyed into the blood of the human being when bitten by the mosquito.

Prevention lies in stamping out mosquitoes. This is most easily accomplished by destroying their breeding-places. Damp marshy ground should be thoroughly drained. If this cannot be done, the larvæ should be destroyed by pouring paraffin on the surface (a very little suffices) of the pools. This prevents the larvæ and pupæ from obtaining air, and so causes their death. Empty drains are favourite localities for breeding, and may be disinfected by sulphurous acid. Such remedial measures are often beyond possibility, however. Inhabited

houses must then be made impregnable to mosquitoes by having the windows guarded with fine wire gauze, and with double doors of the same material. Habitations ought not to be erected near marshy water, but on elevations, and protected by a belt of trees from marshy ground. Individuals should not leave the house after sundown or in the early morning, and may immunise themselves by taking quinine, 2 to 5 grains daily. They should sleep in the upper stories of houses to avoid infection, as the mosquito does not fly high. The face and hands may be smeared with some oily substance (essential oils, paraffin, etc.) distasteful to the fly. Fumigation by burning pyrethrum or tobacco proves an excellent disinfectant for mosquitoes.

Plague; Pestis.—The "Black Death" or "Pestilence" of the Middle Ages. The disease is more or less constantly present in certain cities of India and Persia, but may take on an epidemic form. It is associated with dirt, overcrowding, and bad sanitation. Rats are even more easily affected by plague than are human beings, and they usually initiate the epidemic. The specific organism is a thick short bacillus which shows bipolar staining.

Seasonal Activity is greatest during the cold months.

Incidence is mostly among adults.

Mortality varies from 70 to 100 per cent of those attacked.

Incubation is from three to five days.

Modes of Infection.—Fleas, lice, and bugs are probably the chief cause of the spread of this disease from animal to animal or from them to man. The fleas of rats do actually bite men, and each flea may ingest 5000 plague bacilli. While biting, the flea passes its excrement on to the skin and during the subsequent scratching, the bacilli gain entrance through the cutis. Inhalation of dust containing the organism may give rise to the pneumonic form, and fomites in clothing may also spread the disease.

Isolation must continue for six weeks.

Prevention.—Cleanliness of the person and of the dwelling. The extirpation of rats has done much to lessen the disease. This can be done by feeding them with Danysz bacilli, which infects them with a deadly disease not communicable to other animals or man. Haffkine's protective inoculation with plague bacilli killed by heat is very successful in diminishing the virulence of plague. Yersin's anti-plague serum is serum

from horses immunised against the plague bacillus. As a prophylactic, 20 c.c. of the serum should be injected, and as a curative 20 to 40 c.c. A house-to-house visitation for the purpose of discovering cases of the disease is most important, with immediate isolation of those infected. "Contacts" should be quarantined for a full week.

Yellow Fever.—This is a tropical disease, endemic in certain parts (Mexico, West Indies, etc.). It never spreads when the temperature is below 68° F. Warmth and humidity favour its increase, and it is specially prevalent in the dirty parts of towns. Yellow fever often breaks out in old, damp, badly-ventilated ships lying in tropical ports.

Incidence.—White races are much more susceptible than dark races.

Incubation varies from two to fourteen days.

Mode of Infection.—Mosquitoes of the Stegomyia variety convey the disease to human beings in their bite, even twelve days after they themselves have been infected.

Preventive measures are very similar to those for malaria.

Acute Contagious Ophthalmia in schools and institutions for the young, is due to different patients using the same towel or sponge. The diseases transmitted may either be :—(1) *Simple muco-purulent conjunctivitis*, caused by several organisms (pyogenic cocci, diplococci, B. coli communis, etc.), and easily cured by 2 per cent solutions of nitrate of silver; (2) *Purulent gonorrhœal ophthalmia*, which gives rise to a much more intense inflammation. It is known as *Ophthalmia neonatorum* in infants, and is best treated by antiseptic lotions (corrosive sublimate, 1 : 5000). In persons over twenty years of age it is a grave trouble. (3) *Acute granular ophthalmia or Trachoma*, characterised by sago-grain-like granulations on the conjunctiva. This is also an intensely infectious disease, and often leads to the deportation of alien immigrants. The treatment of all should be on similar grounds. Each patient should be compelled to keep separate toilet requisites for himself—sponges, towels, etc.

It is unnecessary to refer to other infective diseases, as erysipelas, croupous pneumonia, dysentery, leprosy, actinomycosis, tetanus, rabies, Malta fever, venereal diseases, or to the so-called tropical diseases, as dengue, beri-beri, kala azar, etc., as these have more an ordinary medical interest than a Public Health one.

Inquiry into Epidemics.—In determining the origin of epidemic diseases it is necessary for the Medical Officer of Health or his assistants to make a house-to-house visitation, noting the name, age, and occupation of each patient, the length of his residence in the particular house, and the duration of his illness. The condition of the house as regards water-supply, sanitation, cleanliness, etc., must be investigated, and whether there have lately been cases of suspicious illness in it. A careful inquiry into the milk supply, both as regards its place of origin and distribution, is of great importance.

Every Sanitary Authority must, in order to prevent the spread of infectious disease, make provision for (1) Notification of such by the medical attendants; (2) Isolation Hospitals for the reception of infectious cases; and (3) Disinfection apparatus.

Notification of Infectious Diseases.—*By the Infectious Diseases Notification Act of* 1889 the medical attendant is compelled to report to the Medical Officer of Health of the district within twenty-four hours every case of notifiable infectious diseases which he has seen. For each certificate sent a fee of 2s. 6d. is paid to the medical attendant if a private patient, and 1s. if in public institutions. In some towns the householder must also notify (dual notification). The penalty for default is a fine not exceeding 40s. It is optional on Local Authorities in England to adopt this Act, but it is compulsory in Scotland (Public Health (Scotland) Act 1897).

Diseases under the Notification Act.

Small-pox.	Membranous Croup.	Typhus Fever.	Continued Fever.
Cholera.	Erysipelas.	Enteric Fever.	Puerperal Fever.
Diphtheria.	Scarlet Fever.	Relapsing Fever.	

The Local Authority, with the sanction of the Local Government Board, may add, temporarily or permanently, any other infectious diseases which they think right, *e.g.* phthisis, plague, epidemic cerebro-spinal meningitis, etc. Early notification gives the Medical Officer of Health great control in stamping out any infectious disease at its commencement. It allows him to note the location of each case by plotting them out on a map, and a visit to each house may reveal one common origin; thus, the milk supplied to each of the affected households may have been obtained from a single dairy. This narrows the inquiry down to this dairy, or to the farm from which the milk originally came. It allows also of early removal of patients to isolation hospitals.

It is seldom that compulsory powers are required in the removal of cases to isolation hospitals, though, if the patient or his guardians refuse, a Justice or Magistrate may, on the certificate of a medical practitioner, order his removal, if the sanitary conditions are such that the disease is likely to be spread by his remaining where he is.

If cases of highly infectious disease are kept at home, then the remainder of the children must be taken from school; certain occupations carried on at home must be discontinued, *e.g.* dressmaking, tailoring, washing, or any process dealing with food, and more especially with milk.

Infectious Disease in Schools.

When infectious disease has broken out in a school it may be necessary to exclude only those who are suspected of being infected or who come from infected houses. If widespread, however, it may be necessary to have the school closed at the instance of the Local Authority. This is especially necessary in the case of country schools, to which scholars come from widely separated localities. Epidemics of measles or whooping-cough most frequently lead to closing of schools. This is a drastic measure, and should only be enforced when absolutely necessary. It is more useful in rural districts than in towns, because the children may infect one another when at play in the streets.

PERIODS OF EXCLUSION ADVISED BY THE ASSOCIATION OF THE MEDICAL OFFICERS OF SCHOOLS.

	Eruption.		Quarantine required after last exposure to infection.	Earliest date of return to school after attack.
	Appears.	Fades.		
Small-pox . .	3rd to 4th day	10th day	18 days	When all scabs off.
Chicken-pox .	1st to 3rd day	4th day	18 ,,	When all scabs off.
Scarlatina . .	2nd day	5th day	14 ,,	6 weeks if desquamation and sore throat gone.
Diphtheria .	. .	. .	12 ,,	3 weeks (exceptions).
Measles . .	4th day	5th to 7th day	16 ,,	3 weeks if desquamation and cough ceased.
German Measles	2nd to 4th day	4th to 7th day	16 ,,	2 to 3 weeks.
Mumps . .	. .	. .	24 ,,	4 weeks if swelling gone.
Enterica . .	8th to 9th day	21st day	3 weeks	4 weeks.
Typhus . .	5th day	14th day	3 ,,	4 weeks.
Pertussis . .	. .	. .	3 ,,	6 weeks (earlier if cough gone).
Plague . .	. .	.	3 ,,	3 weeks.

Tabular Review of Infectious Diseases.

Disease.	Age.	Season.	Incubation.	Isolation.	Quarantine.	Mortality.	Death Rate.	Mode of Infection.
Scarlet Fever, Scarlatina	1 to 10 years	Maximum Oct., minimum April	1 to 7, but usually 4 days	6 weeks on average, if discharges from nose, ears, throat, etc., have ceased	7 days	8 per cent on average, highest in males and in early childhood	·17 per 1000	Direct infection; through air, fomites, milk, insects.
Measles, Morbilli .	1 to 5 years	Two maxima June and Dec.; minimum August to Oct.	10 to 11 days	3 weeks	14 to 18 days	3 to 4 per cent, very high in early life and higher in males	·3 per 1000	Direct infection; fomites.
German Measles, Rötheln Rubella, Rubeola	15 to 30 years	March to June	12 to 18 days	10 days	16 to 18 days	Nil	Nil	Direct infection; fomites.
Whooping-cough .	1 to 8 years, mainly during 1st and 2nd years	Maximum March to April; minimum Sept. to Oct.	7 to 14 days	6 to 8 weeks	14 days	4 to 5 per cent	·2 per 1000	Direct infection; through air, fomites.
Small-pox, Variola .	Childhood if not vaccinated; young adults when protective effects of primary vaccination have ceased.	Maximum Dec. to May	12 days	4 to 6 weeks, if all scabs off	14 to 17 days	5 per cent in vaccinated, 35·4 per cent in unvaccinated	·01 per 1000	Direct infection; fomites (rags), air.
Chicken-pox, Varicella, Crystal-	8 to 10 years	Spring and autumn	10 to 14 days	4 weeks, if all scabs are off	18 days	Nil	Nil	Direct infection; fomites, air.

Petechial Fever, Jail Fever			days			[illegible] per cent	[illegible] per 1000	Direct infection; fomites, air, insects.
Relapsing Fever, Famine Fever	Any age	Cold months	10 to 14 days	6 weeks	14 days	5 to 10 per cent	Nil	As above.
Diphtheria . .	1 to 10 years	Maximum Nov. to Jan.	2 to 8 days	4 to 5 weeks, or until nose and throat secretions are free from Loeffler's bacilli	8 days	10 to 12 per cent with antitoxin treatment, 30 per cent without it	·2 per 1000	Direct infection; air; milk; pet animals; infected utensils, handkerchiefs or towels ("school infection").
Mumps, Parotitis epidemica	Young adults	September to April	2 to 3 weeks	3 to 4 weeks	4 weeks	Nil	Nil	Direct infection.
Enteric or Typhoid Fever	Young adults	Maximum Sept. to Nov. minimum May to June	8 to 14 days	2 months, or as long as the stools contain Eberth's bacilli	Not employed	15 per cent	·15 per 1000	Contaminated milk, food, and water; through air; by flies; direct infection by dirty hands, towels, etc.
Epidemic Diarrhœa, Summer Diarrhœa	Infants and the aged	July to September	12 to 36 hours	..	..	..	·5 to 1 per 1000	Chiefly milk infected by dust, flies, etc., as in dirty houses; foul water; over-ripe fruit.
Asiatic Cholera .	Any	Warm months	1 to 3 days	till recovery	10 to 12 days	50 per cent	..	Infected water; flies, fomites, food, air; dirty hands or towels.
Bubonic Plague, Pestis	Any	Cold months	3 to 5 days	6 to 8 weeks	8 to 12 days	50 to 90 per cent	..	Fleas, lice, bugs; inhalation of germs in dust; fomites.
Erysipelas . .	All ages	Spring	1 to 4 days	3 to 4 weeks	..	4 to 6 per cent	·05 to ·08 per 1000	Direct infection; air; fomites.

Quarantine formerly meant the enforced detention and isolation of an infected ship for a specified time. Originally this was forty (*quarante*) days, but later the period was varied so as to be proportionate to the incubation of the special disease which had broken out on the ship. Such means of protecting our own country from infectious diseases has proved so unsatisfactory that it has been entirely given up. It has been replaced by a strict medical examination of those on board, the removal to hospital of the sick, the registration of the addresses of those allowed on shore, and the disinfection of the vessel. In many other countries it is still, however, in force.

Parasitic Diseases.—A consideration of these really belongs to the domain of medicine, and though many are communicated to man through affected meat or impure water, it would be out of place to discuss them here. It may suffice merely to mention **Trichinosis**, a disease common to many countries and due to eating raw or under-cooked pork containing the encysted *Trichina spiralis.* Diseases caused by the different varieties of the *Filaria sanguinis hominis* are observed in tropical countries.

Ankylostomiasis ("miners' anæmia"), or the disease caused by the nematode *Ankylostomum duodenale* and leading to extreme anæmia, is observed among miners both in this country and abroad ("tunnel worm"), as well as among natives of hot climates. The parasite lives in damp localities in mines or tunnels, and the ova are swallowed in water or conveyed to the mouth by dirty hands, or they may enter by abrasions of the skin.

CHAPTER X.

VITAL STATISTICS.

In many ways the statistics of a locality are of the greatest value from a public health point of view. The medical officer of each district must know what the population of his district is, so that he may be able to calculate the birth or death rate. He is thus enabled to observe whether these are on the increase or decline. If the mortality from certain diseases be unduly high, he must endeavour to take means to lessen this. The basis on which the whole fabric of vital statistics rests is the Census and the Returns of the Registration of Births, Marriages, and Deaths.

THE CENSUS.

This is an enumeration of the people which in Great Britain and America is taken every tenth year. To make it as accurate as possible, the whole populace is enumerated at midnight on one particular day at the end of the first quarter of each tenth year. A census return was first made in England in 1801. The enumeration of all who are travelling, as well as vagrants, is taken at the same time. There was a permanent population in 1901 of 6869 in canal boats and 12,574 in caravans, tents, or those living in the open air. Of course, with every precaution, many errors creep in, and it is impossible to know how many people are temporarily out of the country. The sources of error in census-taking are,—intentional frauds or negligence on the part of the enumerators; ignorance or mis-statements on the part of those filling up the schedules; absence of usual residents, etc. Falsification of age is very common, and is seen by

the increased number of girls of ages ten to fifteen who attain to twenty to twenty-five years at the next census, while really there should be a diminution owing to deaths and emigration. For statistical purposes it would be better to have a census made every five years (as is done in France, Germany, New Zealand, etc.), but the expense is considered too great by our Government. In the census return, the name, age, sex, rank, condition as to marriage, relation to the head of family, profession or occupation, birth-place, languages spoken, ability to read and write, and presence of bodily deformities (blindness, deafness, or dumbness), imbecility or lunacy, have to be recorded; and the number of rooms, with their occupants, in tenements.

Population.—Every tenth year the census affords precise information as to the number of inhabitants of each county, registration district, sub-district, or urban district, together with the numbers of each sex, their age and occupation (age and sex distribution). In England and Wales the population on 1st April 1901 was 32,678,213. Of these, 15,799,189 were males and 16,879,024 were females. Allowing 1 square yard for each individual, the whole population would cover fully 10 square miles.

Estimation of the Population.—Even without a census, a rough approximation might be made:—

(1) By multiplying the number of inhabited houses by the average number in each family, as deduced from the last census. As each house is rated for taxation, the first figure is easily obtained, and the number in each family in Great Britain is on the average about 5·2. The number per family is, however, lessening from year to year.

(2) It might be calculated from the birth-rate (it being assumed that it remains constant) by the following formula:—

$$\frac{\text{Number of births in the year} \times 1000}{\text{Birth-rate per 1000 in last census year}} = \text{Population.}$$

Suppose the births numbered 10,200, and the birth-rate were 30,

$$\frac{10{,}200 \times 1000}{30} = 340{,}000 \text{ of a Population.}$$

(3) By assuming that the rate of increase is the same as during the preceding intercensal period. This is by no means

accurate, as the population grows in geometrical and not in arithmetical progression. It may be compared to the accumulation of money at compound interest.

As an Example of the Method of Calculation, the following may be taken. The population of Edinburgh at the end of December 1907 might be calculated roughly in the following manner:—

The population by the census of 1901 was .	316,837
" " " 1891 was .	261,225
The increase in ten years being . . .	55,612
and the increase in each year . . .	5,561
As six years had elapsed since the census of 1901, this means the addition of 5561 × 6, or	33,366
And as nine months had elapsed since April 1st = $\frac{3}{4}$ of 5561 = ...	4,170
	316,837
The population at the end of December 1907 would therefore be	354,373

Such a calculation is most erroneous, however, as it does not take into account the increasing numbers who each year attain the age of marriage.

(4) If complete records of births, deaths, emigration and immigration were kept, the population could easily be estimated after a primary enumeration. This is impracticable, however, in most cases, though adopted in New Zealand.

Interdecennial Increase.—In order that the Registrar General may each week, month, or year furnish the birth or death rate, he must be able to estimate what the population is at any period between two census enumerations. This can be done somewhat accurately if the rate of increase or decrease of the population remains fairly uniform. The data required being:—

(*a*) The decennial increase or decrease during the preceding ten years.

(*b*) The excess of births over deaths during the years under examination. This is termed the *natural increase* of the population, or *increment of life.*

(*c*) Any causes of emigration or immigration.

In practice, the Registrar General estimates the population at any one time by assuming that the same rate of increase will continue as it did during the preceding intercensal period. It is outside of the province of this work, however, to enter into a detailed explanation of this more fully, suffice it to say that the calculation is made by the use of logarithms. It is the most correct method, though it cannot take account of alterations in the population due to emigration or immigration. On an average, the births in England and Wales exceed the deaths by nearly 360,000; this being the "natural increment" each year. The assumption that the rate of increase which prevailed during the preceding interdecennial period is still being kept up is often found to be incorrect when the next census returns are issued. The 1891 census showed that the estimated population of Liverpool was 20 per cent in excess of the reality, while Newcastle was 11 per cent below the actual. These erroneous calculations vitiated the birth and death rates, the latter appearing to be very low in Liverpool, while in reality it had been high, and the reverse obtaining in the case of Newcastle. In towns the rate of increase is very liable to interruption owing to the closing of public works, demolition of overcrowded and insanitary tenements, etc.

As showing the fallacy of determining the population by the increment only, that of England and Wales in 1891 was estimated to be 29,603,913, while the actual census showed it to be only 29,002,525, the difference being largely due to the excess of emigration over immigration. An excessively high or low birth or death rate should draw attention to a probable error in the estimation of the populaton.

Migration of the populace is only determined by the census. There is a general movement towards towns and cities by young adults of both sexes. The opening of new works may attract many people to rural districts, etc., and such cannot be taken into account in the usual statistical estimations. This method of calculating populations by assuming a uniform rate of increase, can only be trustworthy when applied to the entire population of a country, where any irregularities in one locality may be counterbalanced by those of other localities.

Population Constitution.—This constitution shows the relative proportion of males and females, and of persons of different age periods; it is supposed to hold good until the

next census, when new figures are obtained. The census of 1901 showed that 106·9 females existed to every 100 males in England and Wales.

BIRTH-RATE.

This is expressed as so many to every 1000 persons living. By the Registration of Births (English) Act of 1870, every child's birth must be registered within forty-two days by either parent, guardian, or any witness of the birth, and within twenty-one days in Scotland. The Notification of Births Act of 1907 further makes it incumbent on the father, or upon any person in attendance on the mother (the medical attendant is included) who has been present in the house at the time of, or within six hours after the birth, to give notice in writing to the Medical Officer of Health, and this notification must be sent within thirty-six hours after the birth has taken place. The Act applies to any child born alive or dead after the seventh month of pregnancy. Illegitimate children are registered in the mother's name unless the father acknowledges the paternity. The bodies of still-born children cannot be buried without a certificate from a medical practitioner or other qualified informer. Births at sea are recorded by the Registrar General of Shipping.

The Crude Birth-rate is the relation of the number of births in the year to the population estimated at the *middle* of that year. (This is known as the *mean population.*) It is calculated by multiplying the number of births by 1000, and dividing this by the mean population. It would be much more correct to calculate the rate in comparison to the number of child-bearing women in the community. The birth-rate varies from 25 to 40 per 1000. Within comparatively recent years it has fallen greatly in England and Wales; thus, in 1876 it was 36·3, whereas in 1903 it had fallen to 28·4 and in 1906 to 27·2. This may be due to the parents, and especially to women, marrying at older ages than formerly, and also to the voluntary desire to prevent conception. In all countries this fall in the birth-rate is noticeable.

The birth-rate is higher in towns than in rural districts by reason of the higher marriage-rate, the earlier age at which the women contract marriage, and the high rate of infant mortality. A period of prosperity usually leads to an increase

in the birth-rate from the greater number of marriages which then take place. The more commercial the town, the higher is the birth-rate. A high birth-rate usually raises the death-rate, unless this high birth-rate is maintained during several years, when it will have increased the number of individuals of a healthy age.

Illegitimate Births form a proportion of the total births; formerly this was about 4 per cent, but it is steadily decreasing (London 3·7 per cent, Shropshire 7·2, Cumberland 6·9). It would be more accurate to express the illegitimate births per 1000 of unmarried women of child-bearing age.

The greater number of births take place during the first half of the year, the maximum number occurring in June, and the minimum in February and March. The male births exceed the female in the proportion of nearly 104 to 100. The earlier the age at which the parents marry, the greater is the number of their family. In England the average number which constitutes a family is about 5, while in France it is 3·2. A much larger proportion of marriages are unfruitful among the upper than among the poorer classes, and the number of children born to them is also much smaller. To each 1000 married women 235 children are born annually, and 8 to each 1000 unmarried women.

MARRIAGE-RATE.

This varies from 14 to 16 per 1000 of those living. It also has decreased within the last sixty years, being in England 15·6 per 1000 in 1906, while the mean age at marriage is likewise steadily rising; in 1900 the average age of males at marriage was 28·4 years and females 26·2 years. Prosperity increases the marriage-rate, and also lowers the age at which the contracting parties marry. The rate is higher in towns than in the country, because of the larger proportion of young adults of both sexes in the former; in London in 1900 it was 17·6. This rate is calculated per 1000 of the population, by dividing the number of marriages in the year by the population, *e.g.* :—

$$\frac{\text{Number of marriages in the year}}{\text{Total Population}} \times 1000 = \text{Marriage Rate.}$$

It would be better to express the proportion as among those of

both sexes of marriageable age, because when distributed over children and old people, it may appear to be a very low marriage-rate. The average number of births to each marriage is about 4·2 in England and 4·4 in Scotland.

DEATH-RATE.

Certification of Death.—Each death must be registered within five days of its occurrence in England (eight days in Scotland), by the nearest relative present at the death or during the last illness of the deceased, or in default of these by any witness of the death or occupier of the house, or by any relative living nearest to the deceased. (Registration of Deaths Act, 1874 (England); Scotland, 1854, with Amending Act 1860.) The Registrar enters each death on a separate page of the Mortality Ledger, with particulars as to name, age, sex, occupation, cause of death, etc.

Medical Certification of Death.—No certificate of death should ever be granted by a medical man without a previous inspection of the dead body. It is most essential that the practitioner should fill in the causes of death in the certificate with care. Mistakes are most often made in regard to the "Primary" and "Secondary" causes of death. Thus "ascites" is a secondary cause to, it may be, malignant disease of the liver, and phthisis is primary, it may be, to heart failure, etc. Neglect on the part of a medical man to transmit a death certificate within seven days may render him liable to a penalty of £2.

Calculation of the "General" or "Crude" Death-rate.—This is done in the same way as the birth-rate, and is expressed in terms per 1000 of the population per year, known or calculated to the *middle* of the year. If the deaths amounted to 8256, and the population at the middle of the year were 512,641, then

$$\frac{8256 \times 1000}{512{,}641} = 16{\cdot}2 \text{ Deaths per 1000 per annum.}$$

A more correct method is given by the use of logarithms. The proportion of deaths taken as unity, to the whole population, may also be stated thus, $\frac{1000}{16{\cdot}2} = 61{\cdot}7$, or 1 death in 61·7. The deaths of strangers occurring in the locality should be

deducted, while those of natives who die out of the district must be added, so as to secure more accurate results. This is especially necessary where there are large hospitals or asylums, or in rural districts to which invalids resort. The Registrar General supplies "corrections" applicable to the chief towns of England. Wherever the proportion of females to males is high, the death-rate is lowered, owing to the low rate of mortality among females. The death-rate in England and Wales varies from 15 to 20 per 1000 of the population, being 15·4 in 1906.

Death-rate per Month or Quarter.—The number of days in the period must be calculated. The theoretical daily population is obtained by dividing the actual population by 365·24. If this figure be multiplied by the number of days in the period required, the theoretical population for that time is obtained. The rest of the calculation is as before.

Example.—A population is 324,876 and the deaths during February of one year were 530,

$$\therefore \frac{324{,}876}{365{\cdot}24} = 889, \text{ or Theoretical Daily Population,}$$

and this $\times 28 = 24{,}892$ is the population for February. The death-rate for the month would, therefore, be

$$\frac{530 \times 1000}{24{,}892} = 21{\cdot}2, \text{ or Death-rate per 1000 per annum.}$$

The method of calculation for a quarter is performed in the same way. The number of deaths in England and Wales during the two years 1900 and 1901 was 1,139,415, or 1561 daily, 65 hourly, or rather more than 1 per minute.

Mortality per Week.—This may be done exactly in the same way, obtaining the theoretical weekly population by dividing by 52·177, or, more briefly, by multiplying the number of deaths in the week by the number of weeks in the year and dividing by the population.

Example.—Number of deaths in one week 132, and population 324,876, then

$$\frac{132 \times 52{\cdot}177}{324{,}876} \times 1000 = 21{\cdot}2 \text{ Annual Mortality.}$$

Calculations based on these short periods are very unreliable,

however, as it is very unlikely that the weekly rate will remain the same during the year. The birth-rate per quarter, month, or week may be calculated in the same way.

Average Mortality.—This has undergone a progressive diminution since attention has been paid to sanitation. Thus, in England and Wales, previous to 1875, it amounted to 22 per 1000. In 1881 it was 19·3, and in 1903, 15·4. Other contributing factors, however, are the diminishing birth-rate which favours a low death-rate, and the excess of the female population, among whom the death-rate is low.

The total mortality of a whole country does not indicate the true state of matters, because the death-rate of very healthy areas detracts from the high death-rate of unhealthy districts. So marked is this in Scotland, that for Registration purposes it is divided up into Insular and Mainland Rural Districts and Towns: (*a*) eight principal towns with populations above 25,000, (*b*) large towns of from 10,000 to 25,000, and (*c*) small towns with from 2000 to 10,000 inhabitants. In large cities (London, Glasgow) the death-rate may vary from 18 to 21 per 1000; in small towns it varies from 15 to 18, and in rural districts 10 to 16 per 1000 on an average.

Correction for Age and Sex Distribution.—The age distribution of the populace is determined by each census, and the rate of increase at each age period is assumed to remain constant during the intercensal period. Owing to the fact that there is a far larger proportion of young adults of both sexes aggregated in towns, and drawn from rural districts, a correct comparison would not be given by contrasting the mortality of towns with country districts, where there is a greater preponderance of children and old people. The same holds good where many females are aggregated together, owing to the lower mortality amongst them. The proportion of females to males is in towns always greater, and becomes increasingly greater as age advances. Thus, in the age group 55 to 65, women are 20 per cent in excess of men in towns, and only 5 per cent in the country, and in the 65 to 75 age period, this has increased to 33, while in the country the female excess is only 7 per cent. The Registrar General supplies "factors" for all large towns, which are used to multiply the local mortality, and so to neutralise this inequality. These factors are calculated on the age and sex distribution, as displayed in the last census. These factors raise or lower the death-rate

to what it would be if the age and sex distribution locally, were the same as in the country generally, and so furnish the "*corrected death-rate*." A Local Standard Death-rate is calculated for each town or district by means of a comparison between it and the country generally. The factor is obtained by taking the annual recorded death-rate (at all ages) for England and Wales for the previous decennium (the "standard death-rate"), and dividing this by the local standard death-rate.

Example.—The annual death-rate for England during the decennium 1891-1900 was 18·194 per 1000; the standard death-rate for London in 1904 was 17·31,

$$\therefore \frac{18{\cdot}194}{17{\cdot}31} = 1{\cdot}0511, \text{ or the London factor for 1899.}$$

The recorded death-rate in London for 1904 was 16·63, but when corrected or multiplied by the factor, it gives the "corrected death-rate" of 17·48.

The death-rate of all large towns is increased by these factors, because the large number of healthy young adults in towns favours a low death-rate; while the factors reduce the death-rate in country districts, which, when uncorrected, are overstated. A very low death-rate in cities (15 per 1000) should excite suspicion that the population is much overestimated.

The Recorded Death-rate is the death-rate minus the deaths of stranger inmates in public institutions in the locality.

Comparative Mortality Figure represents the Corrected death-rate in each town compared with the Recorded death-rate at all ages in England and Wales taken as 1000. This figure is obtained by multiplying the Corrected local death-rate by 1000, and dividing by the death-rate for the whole country for the year in question. Thus, London has a comparative mortality figure of 1077 instead of 1000, while Hastings is only 779 (the factor being 0·9616). It affords a useful means of comparing the mortalities of different localities.

Zymotic Death-rate.—This means the proportion of deaths from the seven chief Zymotic diseases. It is expressed in terms per 1000 of the population living. The Zymotic diseases are small-pox, measles, scarlet fever (typhus, simple and continued fever, enteric), diphtheria, whooping-cough and diarrhœa. This death-rate may also be expressed as a proportion of the total deaths, or as a proportion of deaths to the numbers attacked.

It varies from 2·34 to 2·6 per 1000 of the population, but has shown of late years a steady fall.

Proportion of Deaths from Certain Diseases to the Total Deaths.—If the total deaths were 1524, and those from tuberculous diseases were 201, then

$$1524 : 1000 :: 201 : x = 131,$$

or out of every 1000 deaths 131 are due to these diseases. In the same way the death-rate for each of the important diseases may be calculated.

Cause of Death.—The Registrar General's Returns are very instructive, as showing how certain diseases have undergone a great diminution during recent decades, while others have increased greatly. Thus, such diseases as phthisis, small-pox, and diphtheria cause a much less mortality than they did thirty years ago, while cancer, nervous diseases, insanity, diabetes, etc., are seen to have a greatly increased death-rate. Suicide was committed only 74 times in each 1,000,000 of the population twenty years ago, while it had risen to 99 in the year 1904. As regards Lunacy, in 1869 there were little over 53,000 patients in asylums, while in 1907 there were almost 124,000. Ten years ago but 1 person was insane to every 314 sane persons; the proportion is now 1 to 282. In thirty-eight years, while the population has increased by 57 per cent, the insane community has increased by 131 per cent. While cases of mania are diminishing in numbers, those of melancholia are increasing.

Male and Female Death-rate.—Except between the ages of ten and twenty-five years the death-rate is uniformly higher in males than in females. Thus, in 1903 the male death-rate was 16·5, while the female was 14·4. This is due to the more hazardous occupations of males, and to their more strenuous life generally, together with their habits of life not being as strict as those of females.

Occupation as it Affects Mortality.—The returns show most clearly what are healthy and what unhealthy occupations. The calculation is made thus:

$$\frac{\text{Deaths from any special occupation} \times 1000}{\text{Total Deaths}} = \begin{matrix}\text{Occupational} \\ \text{Mortality.}\end{matrix}$$

The occupational mortality may be further divided up into age periods, so as to show the influence of occupation at different

ages. Thus, the comparative mortality figures among males aged from twenty-five to sixty-five years was in the case of

Clergy	533	Drapers	1014
Agriculturists	602	Plumbers	1120
Teachers	604	Lead miners	1310
Grocers	664	Glass manufacturers	1487
Lawyers	821	Cutlers	1516
Fishermen	845	Inn-keepers	1642
Coal miners	925	Lead workers	1783
Medical men	966	File makers	1810

Age as it Affects Mortality.—The Registrar General divides all ages into twelve groups. It is well known that the rate of mortality during early life is very high. It declines, however, from birth to puberty, then increases very slowly until adult age, when the rate increases more and more rapidly. The rate between ten to fifteen years is lowest of all. The mortality per 1000 of children under five years of age is more than ten times that of individuals between five and twenty-five.

DEATHS TO 1000 LIVING AT EACH OF TWELVE GROUPS OF AGES.

	All Ages.	0–	5–	10–	15–	20–	25–	35–	45–	55–	65–	75–	85+
Males	19·5	60·4	3·8	2·2	3·6	5·3	7·1	12·3	20·0	37·2	69·8	152·6	300·3
Females	17·3	50·7	3·9	2·3	3·3	4·3	6·1	10·0	15·4	29·8	61·5	142·6	272·0

The death-rate in these age groups may be expressed as (1) per-centage of the total deaths, or better, (2) as the ratio per 1000 of those living at that age group of each sex.

The Age Distribution is most important in determining the healthiness of a locality. A locality with a large infant or aged population will show a high rate of mortality, while in reality it may be very healthy, the death-rate at the extremes of life being, however, naturally high. The presence of an institution for youths will materially lessen the apparent death-rate in a certain locality.

Relation of Age to Disease.—This has a most important relationship; certain ages are more prone to certain diseases, *e.g.* whooping-cough and small-pox during infancy, measles

during the second year, typhoid during adolescence, phthisis from fifteen to thirty, cancer after the age of forty, and so on.

Infantile Mortality.—This is measured by the proportion of deaths of infants under one year, to the *births registered during the year*, the mortality being expressed as a proportion per 1000 births in the same year (*not as per* 1000 *of the population*).

Example.—242 deaths of infants under one year; 1802 births registered, then

$$1802 : 1000 :: 242 : x = 134{\cdot}2 \text{ Infantile Mortality.}$$

The rate varies from 130 to 180 per 1000 births, the former in rural and the latter in urban districts. The mortality is highest amongst infants immediately after birth, and again at the time of weaning (sixth or seventh months). It is higher in manufacturing towns than in the country, owing to overcrowding, intemperance, early marriage, spread of disease, unsuitability of food, use of artificial foods, employment of the mothers in mills or factories, etc. By the Factories Act women are not allowed to return to work in factories until one month after the birth of a child. In Preston (Lancashire) in 1896 the infant mortality was 262; while in London it was only 159. The insurance of infants so as to get *Funeral money* (£5 if they die before five years of age, or £10 if between five and ten years) is a great incentive to child murder, or at least to gross carelessness in rearing them. The rate of infantile mortality has undoubtedly increased of late years. The first children of young parents (under twenty) are, as a rule, weakly, and often succumb. The conditions which lead to infantile deaths apart from the above, are prematurity, congenital defects, hereditary diseases, overlaying, etc. The mortality among illegitimate children is much greater than among the legitimate.

Death-rates of Children Under Five Years of Age are similarly expressed, *i.e.* the proportion of deaths per 1000 children of that age period.

Density of the Population in Relation to the Death-rate.—Other things being equal, as a rule the greater the density of a population the higher is the death-rate. This is due to the higher marriage-rate in towns, and the earlier age of the contracting parties. This consequently increases the birth-rate

as well as the mortality, because of the high rate of the latter during infancy. Infectious diseases spread readily in dense populations, owing to insanitary conditions, want of air, water, light, and food. Intemperance and profligacy are also much more common in cities than in country districts. As showing the influence of density on the rate of infantile mortality in the decade 1891 to 1900, the principal town districts of Scotland had an infantile mortality of 147; the large town districts, 134; mainland rural districts, 95; insular rural districts, 76. The death-rate in towns has undergone a much greater decline than it has in country districts, pointing to the fact that hygienic improvements have exercised a greater benefit there than in rural districts.

The Density or Specific Population is stated as per square mile for country districts, or per square acre for towns. In 1901 the average density was in England 558 per square mile, or 1·1 acre to each person. It varies from 750 persons per acre in certain parts of London to 250 in Glasgow. Density seems to have little effect on the mortality until it reaches above 400 per square mile. In very dense localities it may be stated as "room density." Overcrowding is guarded against, by municipalities licensing each of the rooms in poor localities for a certain fixed number of people. In spite of this, 10 to 12 persons may often be found living together in a single small apartment. It is the "room density" which has the greatest effect in raising the death-rate, and especially is this true in reference to phthisis. In the St. Giles' Ward of the City of Edinburgh the density per acre in 1904 was 105·4, and the death-rate 18·92; while Newington Ward with 21·3 of density, had a death-rate of 11·93.

Season in Relation to Mortality.—The very cold or the very hot months of the year are associated with the highest mortality. The largest number of deaths occurs during the first quarter of the year, and the last quarter accounts for the next greatest number. The third quarter has the lowest death-rate. Respiratory diseases are more frequent during the cold months, whilst diarrhœal diseases accompany hot weather. The relation of the infectious diseases to season has already been dealt with. A cool wet summer greatly lessens the zymotic death-rate.

Evidence of the Health of a Community as shown by vital statistics is mainly seen by (1) the corrected death-rate; (2)

the infantile mortality; (3) the zymotic death-rate; (4) the mortality from phthisis; (5) the expectation of life.

Sick-rate or Morbidity.—An accurate estimation of the amount of sickness present in a community would be of immense value from an economic point of view. Unfortunately, however, no very reliable statistics are available. The Medical Officer of Health of each district can determine to a certain extent the amount of infectious disease present, from the number of cases notified. From the number of deaths due to certain infectious (but non-notifiable) diseases, an approximation to the number of cases under treatment may be arrived at. This, however, is very unreliable, as the mortality from certain diseases varies greatly in different epidemics. A general idea of the amount of sickness may also be obtained from the returns of hospitals, dispensaries, sick benefit societies, etc., or from the army, navy, or civil services. District and workhouse medical officers must furnish the Medical Officer of Health with returns of sickness and deaths amongst paupers. At best, however, only a rough and somewhat general calculation of the sick-rate can be arrived at. It has been computed that, from the age of fifteen to sixty-five, each individual suffers from sickness on an average from one and a half to two weeks each year, and that two years of sickness are suffered to each death which takes place. After the age of sixty, the liability to sickness is so great, that, as a rule, individuals above this age are not accepted by sick benefit societies.

Infirmities of various kinds are noted in the census returns. Thus, 1 person in every 1285 is blind, 1 in 2140 is deaf, 1 in 245 is insane, as shown by the census of 1901.

DURATION OF LIFE.

Mean Age at Death.—This is a simple average, obtained by adding together the ages of those who have died, and dividing this by the number of deaths.

$$\frac{\text{Sum of ages at death}}{\text{Number of deaths}} = \text{Mean age at Death.}$$

It corresponds to the *expectation of life at birth*, or to the mean life-time in a stationary population. This mean age is about forty-four years in the case of males; in females it is about forty-seven years. It is really of little value, however, as the

high rate of infant mortality lessens greatly the general mean life-time. A high birth-rate, consequently, is usually associated with a low mean age at death. Any epidemic which increases the infantile mortality will unduly reduce the mean age at death. It may be calculated by *Farr's Formula* :—

If D = death-rate per 1000 and B = birth-rate per 1000,

then $$\frac{2000}{3D} + \frac{1000}{3B} = \text{Expectation of Life at Birth.}$$

Probable Duration of Life (*Equation of Life*, *vie probable*) signifies the age at which half of any number of children born will have died, so that they have equal chances of their dying before and after that age. By the census return 1881-90, this was fifty-one to fifty-two years.

The following is a summary of part of the *English Life Table* :—

Age.	Survivors at each age out of 1,000,000 born.	Expectation of life.
1	841,417	48·1
2	790,201	50·1
5	734,068	50·9
10	708,990	47·6
30	630,038	32·1
50	476,980	18·9
70	222,056	8·3
80	77,354	4·8
90	8,015	2·7
100	82	1·6

Expectation of Life : Mean Future or Mean After Life-time.—The average number of years which a person at any age may presumably be expected to live is called his "expectation of life." These numbers are ascertained from a Life Table, which shows the sum of the number of years which a supposed 1,000,000 of people live. If the sum of these years be divided by the number living at any given age, this will give the expectation of life for that age. It is greatest at the age of four years, when the child has passed the dangerous and often fatal diseases of infancy. Altogether the mean future life-time is greater among females than among males. When a population is fairly stationary, the mean duration (expectation of

life) is high. The higher the expectation, the greater is the health of the community. Thus, in Scotland the expectation of life at birth was in 1870, 41·65 years, whereas in 1891-1900 it was 46·01, and at the age of five it was 49·96 and 53·03 respectively. The expectation of life at any age is deduced from a Life Table, or in its absence it may be calculated approximately by Willich's formula; if a represent the age at any period between twenty-five and seventy-five years of age, then $\frac{2(80-a)}{3}$ = expectation of life. Thus, at the age of sixty-five the expectation of life would be, by this formula, $\frac{2}{3}(80-65)$ = ten years. By the English Life Table this is found to be 10·3 for males and 11·2 for females.

Life Tables show how many out of an imaginary population of 1,000,000 born at one time will survive at the end of each year, until none are left. A Life Table is made from the census returns of two periods showing the age and sex distribution, and from the returns of deaths during the decennial period. Thus, at the end of the first year only 839,000 males will be alive, at the end of the second year 751,500, and so on until at the eightieth year only 80,000 remain, and at the end of the century but 30 survive. It shows the probabilities of life and death at each age, and in each sex. The method of construction of a Life Table is too complicated, however, for discussion in this work. Life Tables are prepared for national or local areas, or for assured or healthy lives. (The Life Tables of Dr. Farr, Dr. Ogle, Dr. Tatham, Healthy Males Life-table of the Institute of Actuaries, etc., are those best known.)

CHAPTER XI.

DIETETICS. FOOD. MEAT INSPECTION. ETC.

PRINCIPLES OF DIETETICS.

For healthy existence each individual requires as food a daily supply of water, nitrogenous matters, carbohydrates, fats, organic acids, and mineral matters, in order to maintain the functions, to repair waste, and to keep up the heat of the body.

1. *Water.*—Four to five pints of water are consumed by each adult per day. This may not be taken as such, but much is contained in beverages, soups, fruit, etc. Many vegetables and fruits contain as much as 90 per cent of water.

2. *Nitrogenous Materials.*—These exist as animal or vegetable albumins, and do not differ in their nutritive value. The ease of digestibility, however, varies greatly, and hence the full nutritive value may not be obtained from every proteid; thus, the flesh of the lobster or the kernels of nuts are indigestible. Generally, however, animal proteid is more rapidly digested than vegetable, and is more useful in debility or fevers. Although animal food is more stimulating and assimilable, yet perfect health can be maintained on a strictly vegetarian diet, and it is a mistake to believe that increased muscular effort requires an increase in animal proteid food; many athletes are vegetable feeders. As nitrogen is constantly being excreted in the urine (urea, uric acid, etc.), this loss must be supplied by nitrogenous food. If excessive amounts of nitrogenous food be taken for some time, ill-health, plethora, languor, and a febrile condition ensues, with excessive excretion of urea and uric acid. These conditions are probably due to alkaloidal bodies (leucomaines) formed during digestion, which may give rise to a gouty state, or to disease of the kidneys

and liver. A deficiency of nitrogenous food, on the other hand, leads to anæmia, debility, and loss of resisting power.

Extractives have only stimulating but no nutritive properties; thus, beef-tea is valuable in acute illness, but not for continual use as a food.

3. *Carbohydrates.*—This large group consists of the sugars and starches, and forms the great source of animal heat and energy; it constitutes the real food of the muscles, being oxidised into carbonic acid and water. An excess of carbohydrates or fats, leads to the production of adipose tissue in the body.

4. *Fats* are necessary to perfect health, and may be employed, to a certain extent, to replace the carbohydrates. They are in digestion split up ultimately into carbonic acid and water, and so supply energy and heat. In cold countries fats are largely partaken of as heat-producers, as they require the greatest amount of oxidation.

5. *Mineral Matters and Vegetable Acids* are absolutely necessary. They are usually obtained in vegetables, fruits, and flesh. Boiling dissolves out much of the natural salts, and in practice this is partly replaced by the addition of common salt. The cereals (wheat, oats, barley) contain large amounts of phosphates, while carbonates of the alkalies are obtained from fruits by the splitting up of such salts as malates, citrates, tartrates, etc. Iron is a necessary constituent of the hæmoglobin, and must be obtained in food.

FOOD.

Digestibility of Foods.—Foods vary greatly in their digestibility or in the completeness of their digestion; hence a food which is not so rich in nitrogenous matter may afford more nourishment, owing to the ease with which it is digested, than one rich in proteids, which is not so digestible. Hardly any article of diet undergoes complete digestion and absorption in the alimentary canal. A certain amount of residue is necessary in order to stimulate peristaltic action of the intestines; it is consequently impossible to live in health on food extracts or concentrated articles.

Estimation of the Amount of Food Digested.—This is usually done by analysing (1) the food before it is taken, and (2)

the excreta. The difference between these estimations corresponds to the amount which has been absorbed. By such an examination, articles of food may be arranged in order as a Table of Digestibility; thus, sugar is digested to the extent of 100 per cent; rice, 96; white bread, 95; roast meat, 94; potatoes, 90·6; peas, beans, 52·4; gelatine, 50, etc.

Construction of Dietaries.

Standard Diet.—For a person weighing 150 lbs. the standard diet in this country during ordinary work is:—

Proteids	4·5 oz. = 125	grammes	containing	315 grains of Nitrogen.
Fats	3·5 oz. = 100	,,	,,	4800 grains of Carbon.
Carbohydrates	14 oz. = 400	,,	,,	
Salts	1 oz. = 28	,,	,,	460 grains.
	23 oz. = 653 grammes.			

The above are supposed to be dry or water-free foods, if moist this would correspond to 50 ounces. Women require slightly less than men (0·9 standard diet), and children under ten years of age are allowed one-half of a woman's allowance.

For Hard Work more food must be consumed; such as 6 ounces of proteids, 4½ ounces fats, 18 ounces of carbohydrates, and 1½ ounces salts. It has lately been proved that perfect health can be maintained on from one-third to one-half of the amount of proteid allowed in the standard diet; but whether this would suffice for a long-continued period is doubtful. The poorer working classes exist in health on a daily consumption of from 50 to 80 grammes of proteid.

The Energy Value of the food may be expressed as the heat produced during its combustion. The standard of this measure is the *heat unit or Calorie*; 1 Calorie being equal to the amount of heat required to raise 1 kilogramme of water 1° C. It has been found that during digestion 1 gramme of proteid yields 4·1 Calories, 1 gramme of fat 9·3, and 1 gramme of carbohydrate 4·1. The functional work of the body requires about 2800 Calories daily, and about 230 Calories in addition is a fair day's work for an adult. The standard diet affords 3067 Calories, but perfect health can be maintained on 2700 or 2800 Calories.

COMPARISON OF DIETS (GRAMMES).

	Proteids.	Fats.	Carbohydrates.	Calories.
British Soldier . .	113	38	482	2793
Japanese Soldier . .	96	20	450	2380
Edinburgh Student in Residency . . .	143	138	511	3979
Member of Poor Family (Edinburgh) . .	107·7	88·4	479·4	3224

PERCENTAGE COMPOSITION OF CERTAIN FOODS.

	Proteids.	Fats.	Carbo-hydrates.	Salts.	Grains per lb.	
					Nitrogen.	Carbon.
Raw Meat (average)	15	8·5	·0	1·5	190	1900
Salt Meat . .	30·0	2·0	. .	20·0	325	1115
Pork (fat) . .	10·0	50·0	. .	2·0	100	4000
Eggs . . .	13·5	11·5	0	1·0	. .	. .
Milk . . .	4·0	3·5	4·5	0·7	45	600
Butter . . .	1·5	83·5	1·0	1·5	. .	6500
Cheese . . .	28·0	23·0	1·0	7·0	300	3300
Bread . . .	8·0	1·5	50·0	1·5	90	2000
Oatmeal . . .	13·0	6·6	65·0	3·0	140	2800
Potatoes . . .	1·5	0·1	23·0	1·0	22	770
Rice . . .	5·0	0·8	83·0	0·5	70	2700
Sugar . . .	·0	·0	96	·5	. .	3100

Calculation of Amount of Food Necessary.—To do this a table of the percentage composition of foods must be consulted, and after working out the amounts, it must be seen whether they agree with the standard diet. The digestibility of foods must also be kept in mind. Thus, it might be required to know if 2 lbs. of bread and ½ lb. of salt meat were sufficient for the needs of a man for one day. Consulting a table it is found that 100 ounces of bread contain 8 ounces of nitrogenous matter, and consequently 32 ounces will contain 2·5 ounces or 180 grains of nitrogen. In the same way the fats and carbohydrates are calculated, thus :—

[TABLE

	Nitrogenous Matters.	Fats.	Carbo-hydrates.	N.	C.
Bread 32 oz. . .	2·5	·5	16	180	4000
Salt Meat 8 oz. .	2·4	·16	0	162	557
	4·9	·66	16	342	4557

Such a diet, when compared with the standard, shows a deficiency of fats, and thus butter or other fat would have to be added. It is easier to calculate the amounts of carbon and nitrogen in the food given, and see how they compare with the standard amounts of these elements required. Health is much better maintained if variety is given in the diet; even an abundance of an unvaried diet will not maintain health. It is impossible to preserve health for any length of time if preserved food alone be eaten; it is absolutely necessary, in addition to vegetables or fruits, to have fresh animal food, or else scorbutic conditions develop.

Food Preservatives.—These are antiseptic substances added to foods which are liable to decompose, in order to retard or prevent putrefaction. Some of these are harmless, but are added in excessive amount, while others prove hurtful, though in very small amounts, when taken for prolonged periods. In the majority of cases the addition of such preservatives ought not to be permitted, as it allows of the sale of food which is old and stale, and which has lost the properties of fresh food. Such preservatives as the following are most usually employed:—

(1) Borax and Boracic acid. These are added to milk, butter, or beer; they can be detected by the green flame which the ash gives when burnt. Boracic acid may be used in a proportion of 0·25 per cent to preserve cream, and 0·5 in butter without giving rise to any taste.

(2) Salicylic acid is used to preserve the same articles.

(3) Formaldehyde, or more often it is added as formalin. If 2 to 3 drops of the latter are added to a pint of milk it will remain quite fresh for four or five days. It may be detected by diluting the milk with water; if strong (90 per cent) sulphuric acid (containing a trace of iron) be allowed to run below this, a violet line is formed in a few minutes at the junction.

(4) Sulphurous acid is almost harmless.
(5) Benzoic acid.
(6) Saccharine.

Standard Quality of Milk.—The cream should average 10 per cent. If this be removed the specific gravity of the milk will rise, but can again be made to fall by the addition of water to the milk; hence adulteration by skimming and dilution is not so easy to detect. The Board of Agriculture has fixed a standard below which a milk ought not to fall; viz. the specific gravity should average 1029, the total solids 12·5 per cent; the fat should not fall below 3·0 per cent; nor the "solids not fat" below 8·5 per cent. If milk is collected under cleanly conditions, and if it is at once cooled, it will keep fresh for a considerable time without the addition of any preservative. The milk from diseased animals should never be consumed by human beings, or given to animals, as the disease may be transmitted to those drinking it; this is especially true in the case of Foot and Mouth Disease (*Eczema Epizöotica*).

Butter (Standard Quality).—The water in butter should not exceed 16 per cent, the butter-fat should be above 80 per cent, and casein 2 to 3 per cent. The soluble or volatile fatty acids should not be less than 5 per cent, and the insoluble fatty acids not above 89·5 per cent.

Margarine or Butterine consists of a mixture of animal fat with vegetable oils (cotton, sesame, etc.), and a proportion of good butter. The great distinction between this and butter lies in the fact that margarine contains only about $\frac{1}{2}$ per cent of volatile fatty acids.

Starch.—The microscopic characters of the various starches (wheat, rice, sago, barley, arrowroot, maize, etc.) are so characteristic that each can easily be identified.

MEAT INSPECTION.

The Sanitary Inspector has no more important duty than that of inspecting, and it may be condemning flesh intended for human consumption. In disputed cases the Medical Officer of Health may be consulted, and hence a knowledge of the appearance of healthy and diseased flesh is important.

Internal Organs.—In examining the carcase of any animal, particular attention must be paid to the appearance and con-

dition of the internal organs, as they usually afford marked evidence of general disease.

Lungs.—These may show the presence of tuberculous pleurisy by a marked thickening, and grape-like projections on the surface of the lung. The lymphatic glands at the root may be tuberculous or caseating; while the lung itself may be infiltrated with miliary tubercle, or be the seat of tuberculous abscesses.

Liver.—This may show miliary tubercle, or in the sheep, liver flukes may be discovered.

Intestines.—The peritoneal coat may be covered with tuberculous masses ("grapes").

Lymphatic Glands.—These are to be looked for behind the edges of the sternum, and in health are firm, moist, and pale grey in colour. If enlarged, soft, inflamed, or with hæmorrhagic effusions, the condition has usually been induced by an acute disease, such as swine fever, splenic fever, pleuropneumonia, etc. In other cases they show tuberculous deposits, or are caseating.

The Carcase has to be examined carefully. The inner surface of the chest should be inspected in order to determine whether the parietal pleura has been removed ("*stripped*") in order to hide the evidence of pleurisy or tuberculosis.

Dropsical Conditions are best seen in those localities where the connective tissue is abundant, *e.g.* in the flanks, under the breast or shoulders, or behind the kidneys.

Colour of Flesh.—If very pale the animal may have suffered from some wasting disease as indigestion, or from choking. If dark red or black, then death may have been due to suffocation, drowning, acute fevers (pleuropneumonia), or poisoning. A yellow colour, if slight, may be due to particular articles of diet, but if marked it points to jaundice. A green or iridescent colour in flesh is due to gangrene or putrefaction.

Firming of Flesh.—The flesh should firm soon, if the animal has been properly slaughtered and the carcase well bled. It firms slowly or imperfectly if the animal has been fed or watered shortly before it was killed; if bleeding has been insufficient; if much greasy water has been used in cleaning it; in hot, moist weather, or if the carcase has been hung in a close, badly ventilated chamber.

Odour of Flesh.—Ordinary healthy flesh of oxen or sheep has little or no smell; but the flesh of goats or boars is strong and offensive. Certain foods may give rise to characteristic

odours in the flesh, *e.g.* garlic, turnip; while such medicines as creosote, tar, or turpentine confer their characteristic odours. If the carcase be hung in air saturated with the smell of tobacco, paint, or tar, the flesh will smell of these. The odours due to uræmia, gangrene, putrefaction, etc., are characteristic.

Horse Flesh is much darker in colour, and coarser than ox flesh; the odour is heavy; the fat is soft, yellow, and almost uneatable; the bones are much larger and rougher; there are eighteen pairs of ribs as contrasted with thirteen, and the breastbone is keel-shaped while it is flat in the ox. The tongue is broad at the extremity and smooth on the surface, as contrasted with the pointed rough tongue of the ox. In the horse the liver is made up of three distinct lobes, and the gall-bladder is absent, while in the ox the liver consists of one continuous lobe, and the gall-bladder is present (a small supernumerary lobe is found in both).

Flesh which should be Condemned as Unfit for Human Food.—The flesh of all animals which have died from, or have been killed in consequence of suffering from acute infectious diseases (anthrax, pleuropneumonia, rinderpest, etc.), should be unhesitatingly condemned. Extreme emaciation the result of parasitic skin affections, or death from choking, empyema, "stomach staggers," acute indigestion, septic peritonitis, kidney disease, tedious labour, abortion, should cause the flesh to be rejected. The condition in sheep known as "*Braxy*" being due to a variety of causes, *e.g.* excess of turnip-feeding; dropsical conditions (wet braxy), anthrax, septicæmia, puerperal fever (red braxy) should lead to the rejection of all such carcases. A great quantity of "boneless meat" is imported into this country from America, and is subject to no adequate inspection, while the carcases of animals slaughtered here are carefully scrutinised.

Cystic Worms, *Cysticercus cellulosæ* ("bladder worm"), is the cystic condition of Tænia solium in the flesh or liver of the pig, ox, or sheep ("measles"), and gives the appearance of small whitish bodies, varying in size from a peppercorn to a cherry. These are soft when recent, but hard and gritty when old. They are embedded in the muscle fibre, which is pale, soft, and slippery. A lens will show the presence of the characteristic head with its four suckers in each bladder. Even though these cystic worms are destroyed by thorough cooking the

entire flesh should be condemned, lest it gives rise to tape-worm in man.

Cysticercus bovis is found chiefly in the muscles of the calf, and gives rise to the Tænia mediocanellata in man.

Echinococcus Cysts in the internal organs of herbivora should cause one to destroy these organs, though the carcase may be passed. The characteristic hooklets are easily recognised in the cysts.

Trematode Worms.—The liver fluke causes the death of many sheep, but as the affection is not communicable to man the flesh may be passed.

The *Trichina spiralis* is found cystic in the muscles of the pig, and can hardly be distinguished by the naked eye. Each cyst resembles a yellowish-white point, and contains a worm $\frac{1}{8}$ of an inch in length, coiled spirally. They can be detected by the aid of a pocket lens, and are present in greatest number at the extremities of the voluntary muscles, and especially in the diaphragm. The capsules are often calcified, and impart a rough feeling to the finger when drawn over the flesh. The entire carcase should be condemned, as when the flesh is eaten raw or imperfectly cooked it may give rise to fatal illness in those who partake of it.

Tuberculosis is chiefly met with in the lungs, pleura, peritoneum, lymphatic glands, liver, kidneys, and udder. If the disease has advanced to any marked extent it is wise to order the destruction of the entire carcase, as the lymphatic glands throughout the body may have become affected. Ordinary cooking (boiling or roasting) does not raise the temperature in the centre of masses of flesh sufficiently high to kill pathogenic organisms. If the disease be very limited, and confined to a small part of an internal organ, the carcase may be passed as food.

Laws Relating to Meat Inspection—Public Health (England) Act, 1875; Sale of Food and Drugs Acts.—Power is given to the Medical Officer of Health, or to the Inspector of Nuisances, to inspect meat exposed for sale or intended as food, and to seize such if unfit for food. If it is proved unsound, the person exposing it is liable to a penalty not exceeding £20, or imprisonment for any period less than three months.

Sale of Horse Flesh Act, 1889, prohibits the sale of horse flesh unless in a shop bearing a notice that such flesh is sold

there, nor must it be compounded with any article of food. The penalty for each infringement is £20.

Slaughter-houses.—The private slaughter-house should be entirely done away with, as no efficient means of meat-inspection can be practised so long as it exists. All abattoirs should be public in the interests of decency, humanity, cleanliness, and facility of inspection by qualified inspectors.

CHAPTER XII.

SOIL.

The Soil consists of the surface layer of the earth extending to a depth of a few feet, and contains a varying amount of organic matter. The *subsoil* extends several hundred feet below this before it merges into those formations from which it takes its origin, and contains but little organic matter.

Ground Air.—Air is present along with moisture in every soil to a greater or lesser degree, and also in the softer forms of rock. In loose sand it may amount to 50 per cent of the volume. The ground air may be very dangerous in "made soils," and consequently it is inadvisable to build dwelling-houses over such soil.

Nature.—Ground air differs much in composition when contrasted with atmospheric air, the oxygen being in small amount, and decreasing with the depth of the soil; the carbonic acid is in large amount, and is produced by the decomposition of organic matter, as are also such gases as marsh gas, sulphuretted hydrogen, ammonia, and organic effluvia; it is always full of moisture. Coal gas or cesspool air may gain entrance to the ground.

The Carbonic Acid Gas varies in amount with the nature of the ground, with the season (maximum being in July), and with the depth—the deeper the ground the greater the relative amount.

Movement of Air in the Soil.—Air is constantly in motion, either passing into or out of the soil. This movement is brought about (1) by the laws regulating the diffusion of gases, (2) by the action of winds, (3) by rainfall, (4) by the rise or fall in the level of ground water, (5) by variations in the temperature of the atmosphere or of the soil; the aspirating effect of warm houses on the air beneath them has to be remembered, and (6) by differences in barometric pressure.

Pore Volume or Porosity corresponds to the amount of air in the soil.

Estimation.—(1) In loose soil. The soil is dried at 212° F., powdered and placed in a burette, the lower end of which is connected by means of an elastic tube (furnished with a clip) with another one filled with water. If the water is allowed to run into the first tube until the soil is just covered, and a reading be taken of the number of cubic centimetres of water used then

$$\frac{\text{amount of water} \times 100}{\text{c.c. of dry soil}} = \text{percentage of air in the soil.}$$

(2) In rock. A piece of the rock is weighed when dry, and also when saturated with water; then

$$\frac{\text{weight of water taken up} \times 100}{\text{weight of dry rock} \div \text{specific gravity}} = \text{per cent of air in the rock.}$$

Moisture in Soil or Absorbability.—This exists along with ground air in the higher levels of the soil. The amount present will depend on (1) the nature of the soil—clay soils may retain as much as 20 per cent, chalk 12 to 16, humus 40 to 60, and granite $\frac{1}{2}$ to 4 per cent; (2) the rainfall or ground water; (3) temperature; (4) rate of evaporation; (5) inclination of the ground.

Soils are Divided into (1) Sandy soils, which consist almost entirely of sand. (2) Clays are stiff damp soils, and are composed mainly of silicate of alumina. (3) Loams are mixtures of sand, clay, and organic matter. (4) Marls consist of clay, sand, and lime in varying proportions. (5) Humus consists of the products of vegetable decomposition. Soils are also classified as (*a*) Permeable, *e.g.* chalk, sand, sandstone, humus, etc.; (*b*) Impermeable, clay, trap rock, granite, dolomite, limestone, etc.

Ground Water or Subsoil Water.—Less and less ground air is found in the soil as the depth is increased, until the particles of the soil are entirely surrounded by water. This corresponds to the level of the ground water. Depending on the depth at which the impermeable stratum lies from the surface or on the outflow, the level of this ground water may vary from being at the surface of the soil to many hundred feet below it. In marshy localities the level of the ground water corresponds to the ground level, though in dry

seasons it may fall far below the latter. It may form large lake-like underground reservoirs or rivers, and is in constant movement, flowing to lower levels, and either emptying into the sea or into rivers. The level of the ground water is constantly rising or falling, according to the amount or continuity of the rainfall, and hence the danger of the contamination of water-supplies (wells) if it rises to the level of the polluted superficial layers of the soil (see Pettenkofer's views). Dwelling-houses should not be built over areas where the permanent level of the ground water is less than 20 feet below the surface of the ground, or where there are great variations in its rise or fall, because polluted air may be forced into dwellings as the ground water rises.

Temperature of the Soil.—The superficial layers vary greatly from day to day as regards their temperature, but the range of daily temperature lessens as the depth increases, until the limit of daily range is reached at 4 feet. At low levels of the soil the maximum temperature is remote in point of time as compared with the atmospheric maximum. In Edinburgh the maximum temperature, as recorded by the 24 feet deep thermometer, is in January, while the minimum is reached in July.

Absorption of Heat by Soil.—Sand absorbs almost all the heat which falls on it, while clay absorbs 70 per cent, chalk 60 per cent, and humus 50 per cent. Moist, damp soils are slow to heat, and are known as "cold soils."

Purification of the Soil.—The organic matter in the soil is constantly being broken up into simpler compounds. Nitrifying organisms split up complex nitrogenous bodies into ammonia, nitrites, and nitrates, and these are used up by growing plants and vegetables. In inhabited districts the soil contains much organic impurity of animal origin, while in country districts it contains little, and this chiefly of vegetable origin. The superficial layers of the ground are crowded with micro-organisms; these diminish with increasing depth until at a distance of 10 feet the soil is practically germ-free. Most of the pathogenic organisms have but a short lifetime in the soil; if they are kept moist, however, many of them will persist for several months (*e.g.* typhoid bacilli), especially if organic matter be abundant.

Permeability of a Soil corresponds to the rate of percolation through it; thus, chalk is freely permeable, while clay is almost impermeable. The permeability depends on the size of the

particles, and consequently on the size of the pores; the finer the particles are, the less permeable is the soil.

"**Made-soils**" consist of earth, refuse, ashes, rags, brick, etc., which have been cast into a hollow so as to fill it up. Dwellings should not be built over these until the lapse of several years. If erected earlier, they must be built on arches, or the ground under them must be covered with a layer of concrete.

CHAPTER XIII.

DISPOSAL OF THE DEAD.

The usual method of disposal of the dead in this country is earth burial. There is no danger to the health of the community if this is carried out properly. If graveyards are overcrowded, however, and surrounded by dense populations, or if water used for drinking purposes filters through them, then serious danger to the public health may arise. Previous to the year 1848 many churchyards were grossly overcrowded, and the populace living in their vicinity suffered in health. Damp soils retard decomposition, and favour the production of adipocere.

Overcrowded Graveyards.—These may be closed to future interments by an Order from the Local Government Board, if it can be shown that the soil exhales a fœtid odour, or if no fresh grave can be dug without disturbing the position of existing coffins or exposing parts of corpses. Any graveyard or cemetery so situated, or so crowded, or otherwise so conducted, as to be offensive, injurious, dangerous to health, or contrary to decency is a nuisance (Burial Act of 1853), and may be dealt with as such.

Burials under Churches.—These may only take place in cathedrals or churches erected previous to 1848; no burial is allowed under churches erected subsequent to this date (Public Health Act, 1848).

Disused Cemeteries.—If the ground has been consecrated, then it cannot be built over except for the purpose of enlarging a pre-existing church, but may be laid out as a public space or garden (Disused Burial Grounds Act, 1884).

Cemeteries.—In selecting a *site* for a new cemetery, it has to be borne in mind that, by the Public Health Interments Act of 1879, Public Authorities are not allowed to place such within

200 yards of any dwelling-house without the consent of the owner or occupier. (There is no restriction, however, as to the proximity to graveyards at which dwellings may be built.) A cemetery should be in a situation freely exposed to winds, and not in a closed hollow space. It ought not to be on ground at a higher level than dwellings, lest water should filter down from the graveyard, and pollute the water-supply of these habitations. It must be protected from the risk of rivers or streams overflowing, and the drainage must not be led into streams or rivers used for drinking purposes. A wall at least 8 feet high must surround it. A set of Model Bye-laws for Cemeteries has been drawn up by the Local Government Board.

The Soil should be a light, dry, porous one, preferably loam or sandy mould, in order to favour rapid decomposition of the body, and it must be thoroughly under-drained to a depth of 10 feet. Clay soils are difficult to drain, and retard decomposition for long; deep cracks may form in dry weather, and, through these, gases of decomposition may find a ready exit; moist soils must be avoided. If there is underlying rock it must not be nearer to the surface than 8 feet.

Graves.—The Burial Act of 1855 states that the depth of each grave must be 5 to 6 feet, and that the amount of soil above a coffin must not be less than 4 feet; an area of 6 square feet must be allowed to each grave; 1 foot of soil must intervene between adjoining layers, and between superimposed coffins. By a Regulation of the Home Office, a grave must not be reopened for a period of fourteen years if it contains the body of an individual above twelve years of age, nor until a period of eight years for individuals below this age; these are the average periods which elapse before a corpse is entirely decomposed. A grave may, however, be reopened at a much earlier period in order to receive the body of another member of the same family; if so, 1 foot of earth must be left above the earlier buried coffin.

Grave Spaces for persons above twelve years of age should be at least 9 feet by 4 feet or 4 square yards; if under twelve years 6 feet by 3 feet or $4\frac{1}{2} \times 4$ feet (2 square yards).

Calculation of Area Required for a Cemetery.—The average mortality is 20 per 1000, but it is well to allow for a larger increase in case of epidemics, and hence the number of 30 per 1000 should be taken. Each grave occupies on an average

3 square yards in extent, and as a rule it is reopened but once in ten years. If a population were 250,000 then the area for a graveyard would be $250 \times 30 \times 3 \times 10 = 225{,}000$ square yards, or (dividing this by 4840) 46 acres. One acre is the minimum area for a population of 4000. The whole area should be laid out tastefully, and plentifully planted with shrubs, bushes, etc. The grass should be cut frequently, and the graveyard kept clean and tidy. The more vegetation there is, the more rapid will be the absorption of organic matter from the soil.

Coffin.—The nature of the coffin has much to do with the rate of putrefaction. The more air-tight the casing, the slower is the rate of decomposition, hence wicker-work or thin deal coffins allow of early re-solution of the body, while oaken or leaden coffins retard it indefinitely.

CREMATION.

The destruction of the dead body by burning is, on sanitary grounds, to be advocated. Objections to it are chiefly based on sentimental or so-called religious grounds. The former may easily be dispelled if one thinks of the loathsomeness of decomposition as it takes place in earth burial, and of the danger which it may bring to the living; the latter objections are, however, not so easily overcome. It is also asserted that the total destruction of the body may get rid of the evidences of murder, poisoning, criminal abortion, etc. Before a body can be cremated, however, by the Cremation Act, 1902, two separate certificates as to the cause of death must be obtained from two medical men, and if these are not satisfactory a post-mortem examination of the body must be made. A very searching series of questions have to be answered in the application form, as well as in the medical certificates. Every Cremation Authority must appoint a medical referee, and a deputy medical referee approved by the Home Secretary, either of whom examines the certificates, and if satisfied, allows the cremation to proceed. Then, as regards the evidences of poisoning; unless a body is exhumed very shortly after death, the ordinary organic poisons will have been destroyed during the process of putrefaction, and as regards the chief metallic poisons, an excess of any of these in the ashes (arsenic, antimony, mercury, lead) would be as conclusive of poisoning as if they

had been found in the tissues of the dead body. The above precautions render it very difficult for any criminal case to escape detection before the body has been cremated. Any person who makes a false declaration or signs a false certificate, with a view to procuring the burning of any human remains, is liable to imprisonment for any period not exceeding two years.

The Crematorium is a receptacle heated by gas-burners or directly by a furnace. The flames play over the corpse and reduce it in less than two hours to a whitish-grey heap of ashes, weighing less than 3 lbs. The effluvia pass up a chimney, and are destroyed by being reburnt. The ashes are preserved in a sealed urn, which may be buried or placed in a columbarium adjacent to the crematorium.

Public Mortuaries should be erected by the Local Authority, so that dead bodies may be conveyed there until they are identified and removed. In other cases it is impossible to keep a corpse at home on account of its infectious nature; because of the small size of the dwelling or the number of its occupants, and hence a public mortuary is a necessity in the poorer districts of cities.

CHAPTER XIV.

SANITARY ADMINISTRATION AND SANITARY LAW.

It is impossible, in the limits of this work, to do more than summarise the chief points in connection with the administration of sanitary matters, and to indicate the chief provisions of the more important Sanitary Laws.

Sanitary Administration.—The Local Government Board is the central authority in each of the constituent parts of Great Britain. It is the Court of Appeal, and supervises the work of Local Authorities, with whom it may interfere if it thinks that they are neglecting the care of the health of their communities.

In England and Wales, the Local Government Board consists of a President along with certain *ex officio* members, *e.g.* the Lord President of the Privy Council, the principal Secretaries of State, the Lord Privy Seal, and the Chancellor of the Exchequer. Under these the work is carried out by medical officers, inspectors, etc. The duties of the Board are, Local Government; Registration of Births, Marriages, and Deaths; Public Health; Drainage; Dwellings for the Poor; Local Taxation; Prevention of Disease; Vaccination, etc. The inspectors may hold local inquiries when these are considered necessary. The auditors of the L.G.B. investigate the accounts of Local Authorities, and disallow all payments which have been made improperly.

In Scotland the President is the Secretary for Scotland; the Solicitor-General and the Under-Secretary are also members *ex officio.*

Local Authorities.—The country is divided into (1) Urban, (2) Rural districts, and (3) Parishes. In towns, the Mayor and Aldermen, or the Provost and Magistrates, form the Local Authority; in counties, the County Council, and in Parishes the

Parish Councillors control the administration of questions affecting Public Health, and frame bye-laws for regulating their own districts; these, after confirmation by the L.G.B., have all the force of an Act of Parliament. Each Local Authority (L.A.) appoints one or more Medical Officers of Health (M.O.H.), Surveyors (in England), and Sanitary Inspectors (S.I.).

Medical Officer of Health.—His duties are to keep himself informed of all conditions which affect the health of the community, and to advise the L.A. on all such matters; he must inquire into offensive trades, and into the cause of outbreaks of infectious diseases, and must furnish an annual report. He must direct the work of the S.I., and may himself be called on to inspect, and if necessary condemn, the carcases of animals. In seaports the Port S.A. appoints a M.O.H., whose duty is confined to ships and hospitals set aside for the isolation of infective patients removed from vessels.

The Sanitary Inspector (*Inspector of Nuisances*) ought to act under the direction of the M.O.H., to whom he ought to report all nuisances, infectious diseases, diseased meat; he should procure samples of food for analysis, etc. He is usually the holder of a certificate granted by a Sanitary Board after examination.

Model Bye-laws.—The L.G.B. have framed a series of model bye-laws, which form the basis of those drawn up by L.A.'s for the regulation of their own areas. A bye-law has no force until it has been submitted to, and confirmed by the L.G.B.

Regulations may, however, be drawn up by the L.A., and do not as a rule require confirmation. The L.G.B. also, from time to time, issues regulations dealing with such subjects as plague, cholera, milk-shops, etc.

Legal Proceedings.—Any individual may make a complaint to, or lodge a memorial with, the L.A. or L.G.B., and either of these Boards may institute (1) Criminal proceedings, and obtain penalties provided by the Acts; (2) Civil actions to recover damages may be brought by any person who is aggrieved.

SANITARY ACTS.

Sanitary matters are controlled mainly by four Public Health Acts, viz. the P.H.A. (England and Wales), 1875; P.H.A. (London), 1891; P.H.A. (Ireland), 1878, and the

P.H.A. (Scotland), 1897. In the following summary no distinction is made between the laws regulating sanitary matters in England and Wales, Ireland or Scotland, as, generally, there is little difference in their administration.

Infectious Diseases Notification Acts (England and Wales, 1889 and 1899). Every medical practitioner must notify to the M.O.H. the occurrence "forthwith on becoming aware" of any case of infectious disease which he has been called to attend, or has been attending, and which is included in the Notification Act. The penalty for omission is 40s. The fee paid to the private practitioner for each notification is 2s. 6d., or if it occurs in his practice as Medical Officer of any public institution, 1s. In the event of there being no medical attendant, the head of the household must notify the disease. Sanitary Authorities throughout England, Wales and Scotland must adopt the above Act, but in Ireland it is optional.

Infectious Diseases Prevention Act, 1890.—This deals with the compulsory disinfection of infected articles and rooms, or with the destruction of infected bedding.

Compulsory Removal to Hospital.—A Justice may, on a medical certificate, order the removal of a patient suffering from infectious disease, to an hospital if he is on board ship, or without proper lodging, or lodged in a room occupied by more than one family. If in a common lodging-house, the Justice's order is unnecessary. Penalty for disobedience, £10.

Exposure while Infected.—A penalty of £5 may be imposed on any one, (1) who knowingly exposes himself while suffering from infectious disease, in any street or public place or conveyance, (2) exposes an infected child or person in this way, or (3) who sells or gives away infected articles.

Infected Houses.—A penalty of £20 may be inflicted on any one who lets for hire, part, or whole, of an infected house, inn, or hotel. If a false answer is given as to Infectious Disease having been present during the preceding six weeks, the penalty is the same.

The owner of any vehicle, which has conveyed a patient suffering from infectious disease, must have it disinfected under a penalty.

Milk-shops or Dairies.—Sections of the 1890 Act deal with the inspection of dairies or cow-sheds if Infectious Diseases are thought to be spread by the milk, and for disinfection and cleansing of such premises.

By the Scottish Act, 1897, parents who send their children to school, if they have suffered from infectious diseases within three months, and without a medical certificate, are liable to a penalty of 40s.; and a fine of £10 may be imposed on any one who, while suffering from infectious diseases, handles food of any description. If the milk be the cause of infectious diseases, the dairyman may be prohibited from selling such until its infectivity has gone.

Prevention of Epidemic Diseases Acts (P.H.A., 1875) deals with the method of preventing the spread of formidable epidemics as cholera and plague, by regulating the speedy interment of the dead, house-to-house visitation, supplying medicines and disinfectants, etc. Regulations for the guidance of *Port Sanitary Authorities* are framed by the L.G.B. from time to time, *e.g.* the provision for the reception on shore of persons suffering from cholera ("*Cholera Order*"), plague, or yellow fever, who have been removed from vessels; stating the mooring-place of such infected vessels; the examination of those on board by the M.O.H. Each person allowed to land must give the address of his destination, and his name must be transmitted to the L.A. of his intended residence. The ship must be disinfected. The master of a vessel on which any of the above diseases exist, must hoist a yellow flag when he comes within the three-mile limit of the shore.

Water-supply (P.H.A., 1875).—A water-supply to a town may be given either by a private company or by the L.A. The latter must see, however, that the supply is adequate and good; if not, it must provide such, and indeed, may be compelled to do so by the L.G.B. The L.A. must not compete with any existing water company, if it provides a good supply. In rural districts it is illegal to construct a dwelling-house without first obtaining a proper water-supply, and it may not be occupied until a certificate be granted by the L.A. stating that the water-supply is adequate. The L.A. may close any well, etc. if the water is impure, and may compel the owner of property in a town to obtain a water-supply if the cost is not prohibitive. The owners of the water-supply must lay water mains to newly built districts if the water-rate leviable will amount to one-tenth of the cost of providing and laying pipes. The water-supply is designed for "domestic purposes" only. Special rates have to be paid if it is employed

for trade purposes, for stables, byres, coach-houses, or for watering gardens. Penalties are imposed for wasting water, as also for polluting it while in storage tanks or during distribution. When a cistern supplies both house and water-closet, it may be dealt with as a nuisance.

Rivers Pollution Prevention, 1876, 1893, and P.H.A. (Amend.), 1890. These Acts prohibit the passing of solid materials so as to obstruct the flow, or any sewage, or poisonous or polluting matters into streams so as to affect the health of districts through which they pass. Industries which may lead to river pollution are coal-mining, chemical, paper, print, or oil-works, and distilleries.

Nuisances (P.H.A., 1875).—In a popular sense these are acts which cause annoyance, inconvenience, or actual injury. In law two kinds of nuisances are described: (1) private, or those which affect but few individuals, (2) public, or offences which annoy the whole community. Only a certain class of nuisances come under the Sanitary Acts, viz. those which injure health, and which are known as "statutory nuisances." The Act furnishes machinery for expeditiously or summarily dealing with this class of nuisance. Any person aggrieved, however, may take proceedings at Common Law (if he is not satisfied with the remedies provided by the Special Acts) for the suppression of nuisances which interfere with his comfort or enjoyment, as for example, disagreeable smells which prevent him opening the windows of his house.

Such nuisances as the following may be dealt with summarily: any premises in such a state as to be injurious to health; any pool, ditch, gutter, water-course, privy, urinal, cesspool, drain, or ashpit so foul or in such a state as to be injurious to health; any animal so kept; any accumulation which is injurious to health; any house or part of a house so overcrowded as to be dangerous to the health of the inmates; any factory over-crowded, not kept clean or well ventilated; any furnace which does not consume its own smoke; any chimney sending forth much black smoke, etc.

Summary Suppression.—The L.A. or any person aggrieved (either owner or tenant of property) in the district, may take summary means to suppress the nuisance.

Information may be lodged with the L.A. by any person aggrieved; any two householders in the district; the relieving officer or policeman. The L.A. then considers this, and if

satisfied serves a notice requiring the abatement of the nuisance.

Powers of Inspection.—Inspectors have the right of entrance to any premises at which work is being carried on, or at all times between 9 A.M. and 6 P.M. Periodical inspection should be made.

Procedure.—If the notice has been ignored a summons is served at the instance of the L.A., ordering the author of the nuisance to appear at a Court of Summary Jurisdiction. If the latter is satisfied, a fine of any sum not exceeding £5 may be inflicted. A dwelling may be closed by order of the Court until it has been made sanitary. Penalties are inflicted for each day a nuisance lasts after the order has been issued.

Smoke Nuisance Prevention.—Every furnace must, "as far as practicable, consume the smoke" arising from the combustibles. This applies also to the smoke issuing from the funnels of steam-ships while lying at ports or piers. The penalty for a first offence is any sum under £5. As a rule, a time-limit for the escape of black smoke is allowed of not more than six minutes per hour.

Offensive Trades (P.H.A., 1875).—Trade processes which give origin to offensive odours may readily become nuisances, especially if carried on in towns. Without the consent of the urban L.A. given in writing, such businesses as the following may not be commenced, *e.g.* blood, bone, soap, and tripe-boiler, fellmonger, and tallow-melter. A penalty of £50 may be incurred for establishing any of these without consent. It is difficult to interfere with old-established businesses, as they have a kind of prescriptive right. Many other trade processes are included under more recent Acts, *e.g.* tanner, gluemaker, gut-scraper, bone-manure manufacturer, knackeries, slaughter-houses, etc.

Proceedings.—These may be summarily dealt with by the M.O.H., by 2 qualified medical practitioners, or by 10 ratepayers who state that the effluvia cause a nuisance. In the bye-laws various means of preventing the escape of effluvia are indicated.

Removal of Refuse.—Many of the provisions of the Public Health Acts deal with the sanitation of private houses, schools, factories, etc. These must have proper privy, water- or earth-closet, and ashpit accommodation. If the owner refuses to provide these, the L.A. may erect them at his expense.

Penalties are enacted for failure to comply with the regulations, and if the appliances are insanitary they may be dealt with as nuisances.

Drains must be made from each dwelling-house by the owner, and must be kept in good repair by him. If the public sewer is within 100 feet, the drain must be connected with it; if there is no sewer, a proper cesspool must be built by the owner.

Sewers belong to the S.A., and must be kept in repair by them, so as not to become nuisances. The L.A. has the power to carry any sewer through, across, or under any public or private property. If the waste water from factories be harmless to sewers, or to the effluent when used for irrigation purposes, it may be discharged into sewers on the L.A. consenting.

Disposal of Sewage.—Sewage may not be passed into streams, rivers, lakes, etc., until it has been purified.

Scavenging and Cleansing (P.H.A., 1875).—L.A. may make bye-laws imposing the duty of cleaning ashpits, privies, cesspools, earth-closets, etc. upon the occupier, or they may themselves undertake the duty, and are then liable to penalties if they neglect to perform it. House and street refuse is now generally removed by the L.A. The L.A. may compel the owner or occupier of a house to have it cleaned or whitewashed, if it is in a filthy condition. Other sections deal with the keeping of swine, stagnant water, soakage from privies, etc. The privy, if badly kept, may easily become a nuisance within the meaning of the Public Health Acts.

Pig-stys and the Keeping of Animals (P.H.A., 1875).—In towns, to keep swine or a pig-sty in any dwelling-house constitutes a nuisance, as does also any animal so kept as to be a nuisance or injurious to health. Model bye-laws have been drawn up as to the keeping of animals.

Slaughter-houses are regulated under the P.H.A. (England) of 1875 and in Scotland, 1897; they include knackers' yards or any buildings used for the slaughter of animals for sale. Each must be 100 feet distant from any dwelling-house, and must be properly paved, drained, ventilated, and supplied with water. Each booth must be lined with an impervious material. The animals must be humanely slaughtered.

Unsound Food.—The M.O.H. or S.I. may at all reasonable times inspect any flesh, or other material intended to be sold

as food for man, and may seize it if they think it unfit. On the order of a Justice such unsound food may be destroyed, and the owner may be fined any sum not exceeding £20, or three months' imprisonment. A similar penalty may be inflicted for obstructing any of these officials.

Dairies, Cow-sheds, and Milk-shops Orders (1885, 1887, 1899).—All those who keep cows or dairies must be registered. Each cow-shed is licensed for a certain number of cows (each cow must have 800 cubic feet of air space and 50 feet of floor space), and must be kept clean, well ventilated, and have a proper water-supply. No cow-keeper or dairy-worker who is suffering from a dangerous infectious disease, or who has recently been in contact with a person so suffering, is allowed to milk cows or handle milk in any way. No water-closet, privy, cess-pool, or urinal, may communicate with any dairy or milk-shop, and the latter must be carefully isolated from any sleeping-room. The milk of cows suffering from cattle plague, pleuro-pneumonia, foot and mouth disease, or tubercular deposits in the udder, must not be mixed with other milk or sold as human food, or must not be given to animals unless it has been boiled. All vessels used for the storage of milk must be thoroughly cleansed with steam, or boiling water.

Common Lodging-houses (P.H.A., 1875).—A common lodging-house is defined as a house or part of a house in which poor people are lodged for hire, for any term less than a week at a time. After inspection and approval by the L.A. each must be registered in the name of the keeper. Bye-laws regulate the number of lodgers to be kept; in each room a notice must be fixed stating how many individuals may be accommodated in it (the cubic space to each ought not to be less than 300 feet). The Common Lodging-house must be kept clean and well ventilated, and notice of any case of infectious disease must be at once sent to the M.O.H. The walls and ceilings must be whitewashed twice each year, and the water-closets and water-supply must be adequate. (One closet must be allowed to every 20 lodgers.)

Houses Let in Lodgings may be subject to bye-laws as regards registration, inspection, number of lodgers, etc.

Underground or Cellar Dwellings.—The Act prohibits the use of dwellings below the level of the adjoining street. If such are used for dwellings, the cellar must be 7 feet in height from floor to ceiling, 3 feet of this height being above the level of

the street or ground adjoining; there must be an open area outside extending along the front, and at least 2½ feet wide and sunk 6 inches below the level of the floor of the cellar; there must be a a proper drain, water or earth closet or privy and ashpit, and also a fireplace with chimney, and an outside window of at least 9 superficial feet.

Canal Boats Acts, 1877 and 1884.—Each boat must be registered and licensed as to the number, age, and sex of the occupants, having regard to ventilation and separation of the sexes. They must be kept clean, and any infectious case on board must be notified at once.

Dwellings.—*Erection of Buildings in Towns.* — The P.H. Acts regulate the formation of streets, as to their width, level, drainage, etc.; buildings must be of certain heights, well drained, ventilated, etc. Insanitary dwellings may be closed by order of the L.A. until they have been put in a sanitary condition.

Housing of the Working Classes Acts, 1885, 1890, 1894, 1900 and 1903. The Act of 1900 consolidated and amended the previous acts.

Part 1 deals with *Unhealthy Areas*, and allows of measures being taken to pull down and clear the buildings in an overcrowded or insanitary area, when such is injurious to the health of the community.

Complainants.—These may be the M.O.H. himself, and he must report to the L.A., if 2 or more Justices of the Peace or 12 ratepayers lodge complaints to him regarding a certain area.

Advertisement.—The improvement scheme must be well advertised in a local paper.

Sanction of L.G.B. must be obtained before the scheme is commenced. A local inquiry is held and a *Provisional Order* is granted, and this must later be confirmed by Parliament. Compensation has to be paid to the owners of the property demolished, and a special rate (not exceeding 2d. in the £1) may be levied.

Part 2 deals with *Unhealthy Dwelling-houses.* The M.O.H. must report to the L.A. any dwelling-house which is in a state so dangerous or injurious to health as to be unfit for human occupation.

Complaints may be brought to the M.O.H. by 4 or more householders living in the street, and he must report this in

writing to the L.A. If the latter take no action, the complainants may appeal to the L.G.B. to hold a local inquiry.

Closing Orders may be made by the L.A., and after notice has been sent, each tenant must vacate the house within seven days.

Demolition.—If the house is not made sanitary, the L.A. may order its demolition, and if this be not done by the owner, it may be carried out by the L.A. at his expense.

Obstructive Buildings.—Any building which (though not itself unfit for habitation) is so near other buildings as to make them unfit for habitation, may be demolished.

Dangerous Buildings.—The Act provides for the pulling down of dangerous properties in towns.

Factory and Workshop Act, 1901.—*A Factory* is a place in which mechanical power is used in the process of manufacture, or where dyeing, bleaching, etc., are carried on. It is called a *workshop* if mechanical means are not employed. Factory Inspectors appointed by the Home Office enforce the provisions of the Act, or the L.A. may prosecute. Factories are divided into (1) Textile, or those which deal with fibrous materials, and (2) Non-textile. Both must be regulated for the protection of the public health as well as of the operatives themselves. Children under the age of fourteen, and young persons between fourteen and eighteen years, and women, may only be allowed to work during limited and specified periods. Every factory must be kept clean, not overcrowded, and well ventilated so as to render gases or dust evolved innocuous. A factory or workshop is overcrowded if each worker has less than 250 cubic feet of space, or less than 400 cubic feet if working overtime. In each room of a factory or workshop a notice must be fixed specifying the number of persons who may be employed in each. Ceilings and walls must be whitewashed, painted, or washed every fourteen months, and an adequate number of sanitary appliances must be provided. Any case of industrial poisoning must be at once reported to the Chief Inspector of Factories, Home Office, London, by the medical practitioner in attendance. The fee for this notification is 2s. 6d., and failure to notify may incur a penalty of 40s. Extraction of dust by fans may be insisted on by the Factory Inspector. All machinery must be so fenced as not to be dangerous to the operatives. Young persons and children are prohibited from working with white lead, or in silvering mirrors

with mercury, and no one may eat their meals in factories or workshops where poisonous materials are dealt with. Certain holidays are prescribed. In cotton cloth factories the degree of humidity is specified by law. In all factories where artificial humidity is required, wet and dry bulb thermometers must be provided, and their readings have to be recorded three times each day. During working hours, the ventilation of such factories is required to be such that the carbonic acid gas in the air of any part of the factory must not exceed 9 parts per 10,000 of air nor the temperature be raised artificially beyond 70° F. unless in cases where artificial humidity is essential.

Bakehouses must be kept very clean, and must not be underground. In laundries the hours during which women, young persons, or children may work, are strictly defined. It is not allowed that work should be given out from factories to be done at home, if any case of infectious disease is present there.

Alkali Works Regulation Acts, 1881, 1892, and 1901.—These deal with the regulation of chemical works, so that the escaping acid gases are kept at a low percentage. The owner must take the best practical means for doing so, and neglect may lead to a fine of £20 for the first offence and £50 for subsequent transgressions. Inspectors appointed by the L.G.B. visit these works either during day or night at frequent intervals.

Inebriates Act, 1898.—Criminal habitual drunkards, and those convicted of drunkenness four times within a year, may be detained after the expiry of their sentence, in a State Inebriate Reformatory, for any period not exceeding three years.

The Sale of Food and Drugs Acts (1875, 1877, 1899).—It is an offence to adulterate any article of food or drink so as to make it injurious to health, or so as to affect its quality, and a penalty of £50 may be inflicted for a first offence. Any one who sells an article which is not of the nature of that demanded commits a fraud, and a £20 fine may be incurred. If the article is mixed, then a label distinctly stating so, protects the seller.

Powers of Purchase.—Any M.O.H., S.I., or Policeman, or their agent may purchase samples for analysis, but certain formalities must be observed; thus, the purchaser must state, after the article is bought, that it will be analysed by the

public analyst. He must then divide the article into three parts, each being labelled and sealed, and if the seller desires, one part must be left with him, one part being analysed, and one kept for future comparison.

Margarine may not be sold unless on each cask the name be plainly printed, as well as on each paper in which it is wrapped (Act 1887).

Sale of Milk Regulations, 1901.—Samples of milk may be procured at the place of delivery; refusal to give these may entail a fine of £10. If a sample of sweet milk contains less than 3 per cent of milk-fat it is presumed to have been watered, or else the fat has been abstracted. The same is presumed, if it contains less than 8·5 per cent of milk solids other than fat, or, in the case of skimmed or separated milk, if it contains less than 9 per cent of milk solids.

Infant Life Protection Act, 1897.—This Act is intended to do away with the baby-farmer. Any one who receives for hire more than one child under the age of five years, and for a longer period than forty-eight hours, must notify the L.A. Failure to notify or false statements may lead to fine. Male or female inspectors may be appointed. Any person who receives an infant under two years for a lump sum under £20, and with no agreement for future payments, must give notice to the L.A. within forty-eight hours.

Vaccination (England, Wales, London). A Public Vaccinator is appointed for each district by the Guardians. Every child must be vaccinated within six months of its birth. If requested, the Public Vaccinator must visit the house for the purpose of vaccinating the child. If the child is not vaccinated within four months, the Public Vaccinator must, after twenty-four hours' notice, visit the house and offer to vaccinate the child with glycerinated calf lymph. Vaccination may be postponed for a period not exceeding two months if the surroundings of the house are insanitary, if infectious disease is prevalent, or if the health of the infant is not good. A certificate to this effect must be sent to the Vaccination Officer. If, after three attempts, vaccination is unsuccessful, a certificate of insusceptibility may be transmitted. Certificates of successful vaccination must be sent within seven days of ascertaining this. Every parent neglecting to have his child vaccinated is liable to a penalty of 20s. unless he furnishes a reasonable excuse, or unless he transmits a certificate granted by 2 Justices, a

Stipendiary, or a Metropolitan Police Magistrate, that he has "conscientious objections" to vaccination because of its danger to the child's health. The certificate has to be obtained within four months of its birth. This clause has lately been extended to Scotland.

Midwives Act, 1902.—Every woman calling herself a midwife must be certified under this Act, and must hold a certificate in midwifery granted by a licensing body approved of by the Central Midwives Board. The latter exercises control over all certified midwives.

Aliens Act, 1905.—Immigrants are only allowed to land at ports in the United Kingdom where there is an Immigration Officer, and then not until they have been inspected by him along with a medical inspector. Undesirable immigrants may not be allowed to land, but they or their agents may appeal to the immigration board of the port. An immigrant is considered undesirable if he has not a sufficient sum of money in his possession; if he is a lunatic or idiot, or is likely to become a charge on the rates through age or infirmity; the infectious disease of trachoma often leads to deportation.

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