Clinical diagnosis : a practical handbook of chemical and microscopical methods / [W.G. Aitchison Robertson].

CLINICAL DIAGNOSIS

A PRACTICAL HANDBOOK OF
CHEMICAL AND
MICROSCOPICAL METHODS

W. G. AITCHISON ROBERTSON

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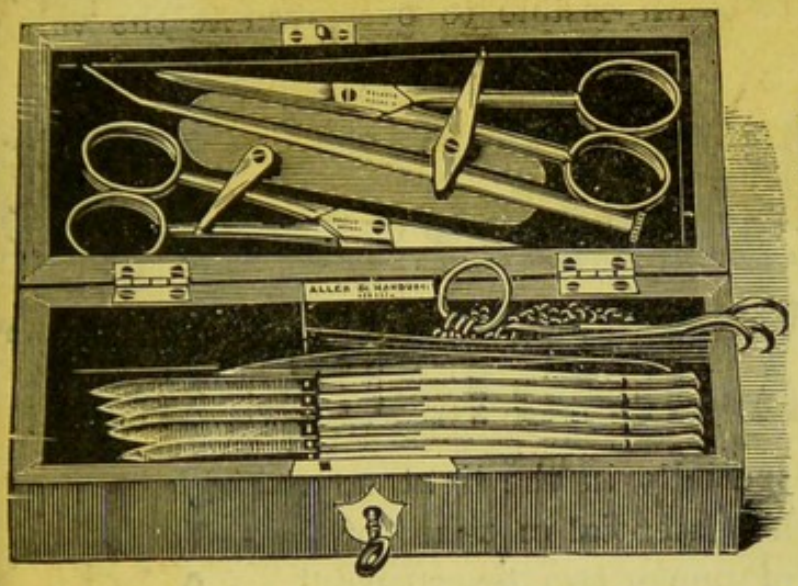

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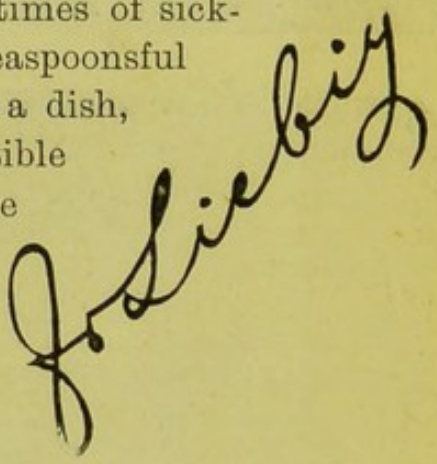

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CLINICAL DIAGNOSIS

A PRACTICAL HANDBOOK

OF

CHEMICAL AND MICROSCOPICAL METHODS

BY

W. G. AITCHISON ROBERTSON

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PREFACE.

This Handbook is intended to be a practical help to the student while studying Clinical Medicine, and to the busy practitioner to whom time is of importance.

Only those methods are given which the author has found easy, rapid, and reliable, neither requiring much chemical skill nor elaborate apparatus.

Mere working details are stated and no theories indulged in, these not being desired by the practical investigator.

Under each "method," the diseases in which divergences from the normal may be expected are tabulated.

That it may prove of practical value to workers in the field of Clinical Medicine is the sincere wish of the author.

W. G. A. R.

26 Minto Street,
Edinburgh, *May*, 1896.

CLINICAL DIAGNOSIS.

RESPIRATORY SYSTEM.

Nasal Secretion.

Normally.

Chiefly of mucus.

Microscopically.

Much epithelium, ciliated and squamous.

Leucocytes.

Micrococci.

Pathologically.

Acute Coryza—Excessive in amount.

Watery in character.

Epithelium in large amount.

Pus corpuscles „ „

Subacute Coryza

Not so excessive in amount.

Viscid.

Muco-purulent.

Epithelium in large amount.

Pus corpuscles „ „

Chronic Rhinitis.

(*a*) Copious, thin, watery, } or

(*b*) Viscid.
Greenish yellow.
Muco-purulent.

Tubercular Ulcer of Nose—Characters as in Chronic Rhinitis.
Mount and stain cover glass preparations for tubercle bacilli (p. 17).

SPUTUM.

The whole amount expectorated during the twenty-four hours should be collected ; placed in a glass vessel, and the following characters noted :—

1. Amount—Varies greatly—up to several pints daily.
   Scanty secretion.
      Early stage of bronchitis.
      Pneumonia.
   Profuse secretion.
      Bronchitis.
      Bronchorrhœa (several pints).
      Phthisis.
      Abscess of lung.
      Empyema.
      Bronchiectasis.
2. Reaction—Always alkaline.
3. Viscosity—Depends on amount of mucus present.
   Highly viscous.
      Early stage of bronchitis.
      Pneumonia.

Not viscous.

Œdema of lung.

Bronchorrhœa.

Bronchiectasis.

4. Odour.

Putrescent—Fœtid bronchorrhœa.

Oily putrescent—Bronchiectasis.

Gangrenous—Gangrene of the lung.

5. Colour.

Pale Amber = mucus—
as in bronchitis.

Whitish = mucus with air bubbles and few cells (like white of egg)—
as in bronchitis.

Yellowish = mucus with many pus corpuscles—
as in bronchitis.

Grey = mucus with dust particles—
as in chronic bronchial catarrh.

Blackish = mucus with larger carbon particles and pus corpuscles—
as in anthracosis.

Rusty = mucus with blood pigment—
as in pneumonia.

Red = mucus with blood—
as in congestion of lungs.
Phthisis.
Infarction in lungs.

Prune Juice = exudation of serum into lungs—
as in hypostatic congestion of lungs.

Later stage of pneumonia.

Green = pus in large amount—
as in empyema.

= pigment forming bacteria.

6. Shape of each sputum—

Seen by placing them in vessel of water.

Rounded and woolly = from phthisical cavity.
(If placed on a flat dish, it flattens out, and becomes coin-like or "nummular".)

Irregular and shaggy = less mucus in it—
as in bronchitis.

7. Layers into which it separates.

Pus being heaviest, sinks to bottom.

Mucus forms a layer above it.

If serum present, it floats above all.

VARIETIES OF SPUTUM.

1. Mucous sputum—Transparent—clear.
More or less viscid.

Occurs—Early bronchial catarrh.

2. Muco-purulent—Pus soon sinks to bottom, leaving clear mucus above.

Occurs in every inflammatory condition of lung or bronchi.

3. Purulent—

Occurs in suppurating cavities.
Empyema.

4. Serous watery—Copious thin fluid.
   Frothy.
   Contains much albumin.
   Occurs—Œdema of lungs.
5. Sanguineous—May be in streaks only, or
   Almost pure blood.
   Rusty colour (pneumonia).
   Blood may come from
   Mouth or teeth.
   Throat—ulceration.
   Larynx — Tubercular, specific or malignant disease.
   Lungs — Tubercle, congestion, new growths, infarction, aneurism, vicarious menstruation (?), mitral disease of heart, purpura, arthritis of old age.
6. Carbon particles present.
   Occurs—Town dwellers.
   Anthracosis.

NAKED EYE CHARACTERS.

1. Pin-head-like Bodies
   Yellowish grey in colour
   Opaque
   Flattened or biconvex
   } Tubercular nodules.
   Pick out several by means of sterilised needles.
   Examine microscopically for
   Elastic fibres (p. 9).
   Tubercle bacilli (p. 17).
   Occur in the sputa of phthisis.

2. Fibrinous Casts of smaller bronchi and bronchioles
   May be small branching filaments, uncoiled or
   Large and usually coiled.
   White or yellowish red in colour.
   Examine by floating them out in a glass vessel of water held over a dark background.
   Add acetic acid = swell up and disappear.
   Occurrence—(*a*) Fibrinous bronchitis—few and very large.
   (*b*) Croupous pneumonia—third to seventh day.

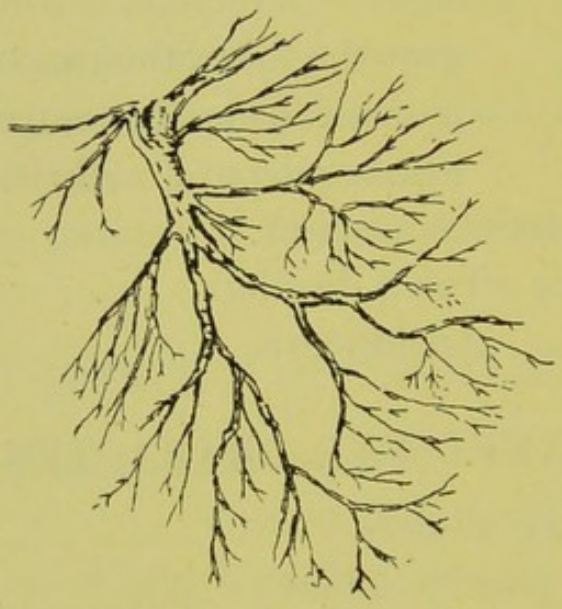


Fig. 1.—Fibrinous Cast.

3. Curschmann's Spirals.
   Small flecks or
   Fine twisted cylinders of varying length up to four inches.

Whitish or yellowish grey.
Exhibit great tenacity.
Occur in sputum of asthma.
Examine by microscope (p. 11).

4. Dittrich's Bodies.
Pin-head-like bodies.
Numerous.
Whitish yellow.
Fœtid.
Easily separated and crushed.
They are fungus growths.
Contain fat crystals and monads (p. 94).
Occur in
Fœtid bronchitis.
Gangrene of lung.

5. Calculi.
Small calcareous nodules.
Occur (rarely) in
Chronic phthisis.
Bronchiectasis.
Abscess of lung.

MICROSCOPICAL EXAMINATION.

Method.—Pick out small fragments from various sputa (chiefly from the more solid parts). Mix together on slide.

Place on cover glass and examine.

Methylene blue (a drop) may be added before covering.

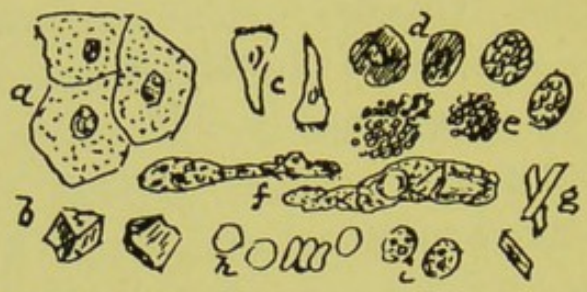


FIG. 2.—CONSTITUENTS OF SPUTUM.

(*a*) Squamous epithelium ; (*b*) Calcium carbonate crystals ; (*c*) Ciliated epithelium ; (*d*) Alveolar epithelium of lung ; (*e*) Alveolar epithelium degenerated ; (*f*) Myelin droplets ; (*g*) Hæmatoidin crystals ; (*h*) Red blood corpuscles ; (*i*) White blood corpuscles.

1. EPITHELIUM.

(*a*) Squamous cells—large.

From buccal mucous membrane.

Upper respiratory tract.

(*b*) Ciliated cells—rarely found.

From nasal tract.

Trachea.

Bronchi if catarrhal.

(*c*) Alveolar epithelium.

Small round or oval cells.

Nucleus evident on adding acetic acid.

Cell-contents granular, and often contain pigment, particles of blood, iron, or carbon.

Fat granules often present in them.

Cell envelope often apparently awanting. Then appear as granular masses.

Occur in

Pneumonia.

Chronic bronchitis.

Phthisis pulmonalis.

(The presence of these cells is often useful in helping towards an early diagnosis of tubercular disease of the apex of the lung.)

(*d*) Large alveolar cells, containing yellowish brown pigment, derived from the blood.

Occur—Retarded blood-flow through lungs, *e.g.*, Brown Induration.

2. Mucus Cells—

Large, with one nucleus.

3. "Myelin Droplets"

Consist of fat.

Formed by rupture of fattily degenerated epithelial cells.

4. Elastic Fibres

May be seen without preparation.

May add drop of solution of caustic potash to specimen on slide.

Method of isolating.

Boil sputum in solution of caustic potash (10 per cent.) for few minutes.

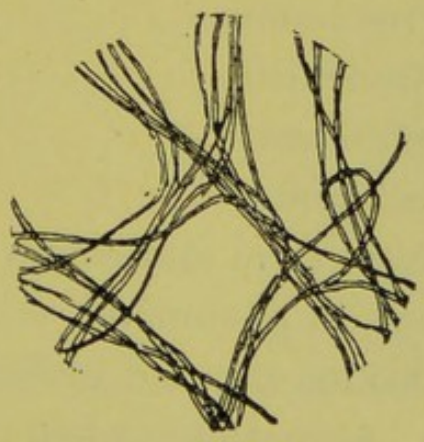


Fig. 3.—Elastic Fibres, Showing Alveolar Arrangement.

Pour into conical glass vessel.
Add four times its volume of cold water.
Allow to stand twenty-four hours.
Remove drop of sediment by means of pipette.
Examine by microscope.

Appearance of Fibres.

Sharp double contour.
Much curved.
Sharp, squarely broken ends.
Occur singly, or in
Alveolar arrangement—only when so found do they arise from breaking down of the alveoli.

Occur

Phthisis pulmonalis,
Phthisis laryngea,
} 90 per cent. of cases where elastic tissue is found.

Bronchiectasis.
Gangrene of lung.
Ulceration of larynx.
Abscess of lung.
Chronic Pneumonia.
Chronic Bronchitis.

5. Red Blood Corpuscles

Occur in all sputa.
Possess usual form and colour
(except in pneumonia = pale discs).
May be swollen up, and globular.
Rouleaux formation—when blood in large amount.

6. White Blood Corpuscles.

Large numbers present in every sputum.
Large granular cells.
Contain fatty granules,
pigment particles, as
carbon,
hæmatoidin.

7. Connective Tissue.

Results from destructive processes in
Alveolar walls.
Bronchioles—bronchi.
Present as connective tissue fibres or cells,
fragments of cartilage, etc.

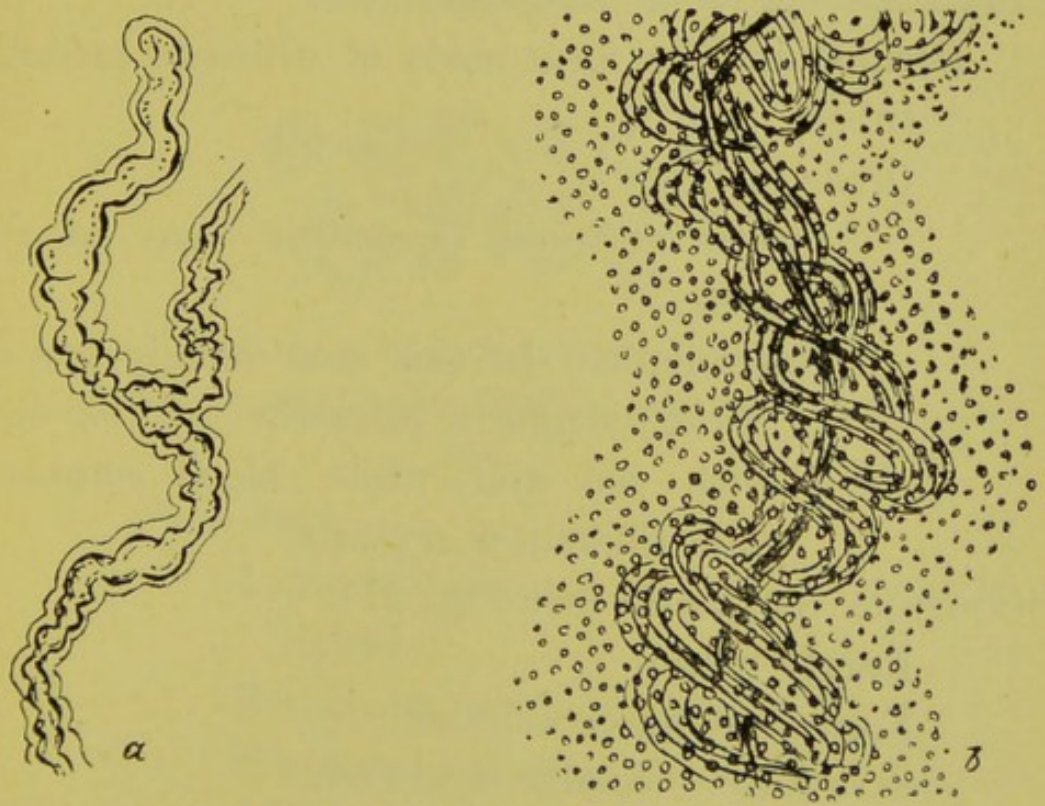


Fig. 4.—Curschmann's Spirals.
(*a*) Natural size; (*b*) Magnified.

8. Spirals (Curschmann's).

Twisted elongated bodies.
Central dark thread, which
Winds with many kinks and bendings.
Spiral filaments form a thick network around it.
Outside this, a layer of epithelium, with
Charcot-Leyden crystals (perhaps).

They result from a desquamative catarrh of bronchi and alveoli; the products being cemented together by lymph exudation.

Occur in

Asthmatic paroxysms (almost every case).
Capillary bronchitis.
Pneumonia (? if simple).

9. Fibrinous Casts of Bronchi.

Formed in and form casts of ultimate bronchial tubes.

Occur in

Plastic fibrinous bronchitis—may be very long.

Pneumonia. In this case usually few and short; strongly refractile. Often along with red and white blood corpuscles and Charcot's crystals.

10. Corpora Amylacea (see Fig. 27).

Rarely found.
Form—round or angular.
Structure—usually stratified.
Central dark core.
Reaction—Solution of iodine = starch reaction.

11. Carbon Particles.

Free, or in

Alveolar epithelium.

Occur in those employed in dusty trades.

CRYSTALS.

1. Charcot-Leyden Crystals.

Colourless.

Shape—Very long pointed octohedra—often truncated.

Tests—Soluble on heating ;

in alkalis ;

acids, mineral or acetic.

Insoluble in ether, alcohol, chloroform.

Fig. 5.—Charcot-Leyden Crystals.
Alveolar Epithelium of Lung Variously Degenerated.

Occur in

Asthmatic seizure (chiefly in the solid particles).

Bronchitis, acute and chronic.

Fibrinous coagula.

2. Hæmatoidin Crystals.

Ruby red rhombic prisms, or as

Acicular crystals.
Amorphous masses.

Fig. 6.—Hæmatoidin Crystals.

Occurrence (*a*) May be found within white blood corpuscles = previous hæmorrhage into lung.
(*b*) When free, and in larger quantity = rupture of abscess into lung.

3. Cholesterin Crystals (see "Urine").
Highly refractile.
Large rhombic plates.
Usually in groups.
Reaction. Add little dilute sulphuric acid and tincture of iodine = play of colours in each crystal — violet — blue — green — red finally.
Occurrence—Pulmonary abscess.
Phthisis pulmonalis.
Old collections of pus.

4. Crystals of the Fatty Acids.
Long acicular crystals.
Singly, or in groups forming networks.
Resemble elastic fibres, but
Tests (*a*) Melt on heating object glass,
(*b*) Easily soluble in ether,
(*c*) Insoluble in water or acids.

Occurrence—

Fœtid bronchorrhœa.
Bronchiectasis.
Tubercular cavities.
Gangrene of lung.

5. Leucin—Shining spheres (see "Urine"). } Rarely present.
   Tyrosin—Sheaves of fine needle-like crystals. }
   Occur in Fœtid bronchitis.
   Empyema.

Inorganic Crystals.

6. Triple Phosphate.
   Characters.
   Frequently found.
   Occur in
   Decomposing collections of pus, *e.g.*,
   Septic abscess of lung.
   Bronchiectasis, etc.
7. Oxalate of Lime.

PARASITES.

I. Non-Pathogenic.

(*a*) *Moulds.*

1. Oidium albicans (Fig. 14, p. 42).
   Rarely found.
   May grow in bronchi.
2. Aspergillus fumigatus. } Sometimes present in abscess of lung.
3. Mucor corymbifer. }
4. Penicillium. }

(*b*) *Fission Fungi.*

1. Leptothrix—Often present in mucus plugs of fœtid bronchitis.
2. Sarcina pulmonis—Occasionally found. It is smaller than S. ventriculi.
3. Bacilli.
4. Micrococci. } Present in every sputum.

FIG. 7.—ASPERGILLUS FUMIGATUS. MUCOR CORYMBIFER.

II. PATHOGENIC FUNGI.

Method of Making "Cover Glass Preparations".

Clean carefully the cover glasses by washing in distilled water.

Then in absolute alcohol, and dry thoroughly.

Pick out by means of forceps and scissors several particles from the centre of the purulent masses.

Spread them evenly with the needle on one cover glass.

Lay a second cover glass over this layer.

Press the two together with forceps, so as to get a uniform film between them.

Wipe off what exudes round the edges with bibulous paper.

Slide the two cover glasses apart.

Allow them to dry under a bell jar, or

More rapidly, by moving them over a spirit lamp at a distance of eighteen inches from the flame.

When dry, the film may be further fixed on the glass by

Passing it moderately quickly three times through the flame of a spirit or Bunsen lamp (film surface upwards).

It is now ready for staining.

STAINING OF TUBERCLE BACILLI.

(1) ZIEHL-NEELSEN METHOD.

Reagent.

Concentrated alcoholic solution of fuchsin 10 c.c.

Solution of carbolic acid (5 per cent.), 90 c.c.

Mix.

This solution acts best when freshly prepared.

Method.

(*a*) Place a little of this reagent in a watch-glass.

Float a prepared cover glass on it, film side downwards.

Gently heat all by means of spirit lamp till the reagent begins to steam.

Keep it at this temperature for ten minutes.

(*b*) Remove the cover glass by means of forceps.

Wash in distilled water till no more colour comes off.

(*c*) Make dilute solution of mineral acid, 1 to 4 (*e.g.*, sulphuric acid, 2 c.c. ; water, 8 c.c.).

Dip cover glass into this for one or two seconds.

Then wash freely in distilled water.

The preparation has been decolorised sufficiently if a faint pink colour alone remain.

If pink is still deep however, again dip in acid solution, and wash.

All the acid must be removed by long continued washing, else the bacillary stain soon fades.

Dry cover glass thoroughly by aid of gentle heat.

Mount in Canada Balsam.

(Instead of drying by heat, it may be Dehydrated rapidly in absolute alcohol.

Cleared up in clove oil, and mounted.)

Bacilli are stained red in colour.

Contrast Stain.

The bacilli are rendered more evident by using a contrast stain for the groundwork. Thus,

After washing the acid from the preparation,
Place it, face downwards, in a watery solution of methylene blue for a few minutes.
Remove and wash in distilled water till no more blue comes off.
Dry and mount as above described.
Bacilli are now seen as red rods lying amongst blue cells or fungi.
This process is easy, rapid, and reliable.

(2) Heneage Girbes' Stain.

Reagent.

1. Rosaniline Hydrochloride, 3 grammes,
   Methylene blue, 1 gramme,
   } Mix in mortar.
2. Aniline oil, . . . 5 c.c.
   Absolute alcohol, . 20 c.c.
   } Dissolve.

Add slowly No. 2 to No. 1 till all stain is dissolved.
Then add (while stirring) 20 c.c. distilled water.
Keeps good for some time if tightly corked.

Method.

Cover glass preparations are made and placed film side downwards on a small quantity of this stain, which has been warmed in a watch-glass.
Remove in 5 minutes.
Wash in alcohol till no more colour is removed.
Dry. Mount in xylol balsam.

(3) Weigert-Ehrlich Method.

Aniline water gentian (or methyl) violet solution.

Reagent.

(*a*) Dissolve gentian or methyl violet in 5 c.c. absolute alcohol in a perfectly clean test tube till an object cannot be distinguished through the solution.

(*b*) To 6 c.c. distilled water in another test tube add 10-15 drops of aniline oil.

Mix—Filter through filter paper previously moistened.

Add few drops of No. *a* to the filtrate till a slight haziness results.

Method.

Cover glass preparations are floated, face downwards, in this stain for twenty-four hours.

Remove and wash in dilute nitric acid (1 in 4) till no longer blue, but faintly green in colour.

Wash, dehydrate in absolute alcohol, clear in oil of cloves ; mount in balsam.

Bacilli appear as minute blue rods.

As *Contrast stain*, vesuvin or Bismark-brown may be used in watery solution as with methylene blue (1).

The whole method may be shortened if the stain be heated in a watch-glass. Then only a few minutes are necessary, but the aniline dye requires to be stronger in that case.

a. Tubercle Bacilli.

Characters

Appear singly ; but
Groups more frequently found.
Each small rod-like.
May be slightly curved.
Length, 1·5 to 3·5 μ =
Quarter to half diameter of red blood corpuscle.
Ends rounded off.
Spore formation often seen in them giving appearance as if each were broken up into three or four segments.

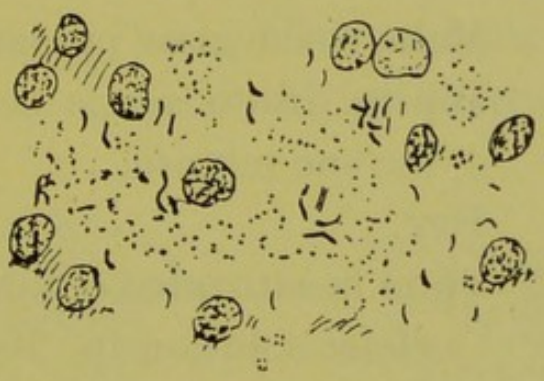


Fig. 8.—Tubercle Bacilli.

β. Pneumonococci.

Found in sputum of pneumonia.

Characters.

Each a thick short rod.
About 1 μ in length.

Two lie together usually—Diplococcus.

Aggregated in chains sometimes.

Colourless capsule surrounds many diplococci.

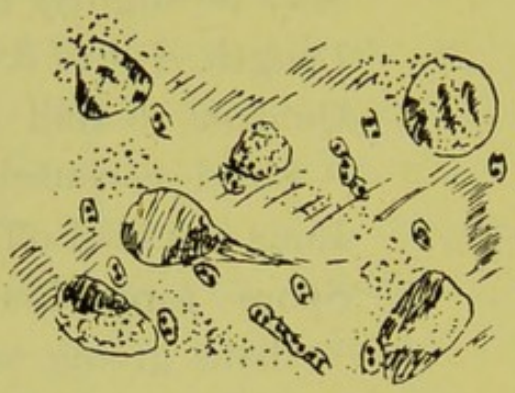


FIG. 9.—PNEUMONOCOCCI.

Method of Staining.

1. *Friedländer's Method.*

Make cover glass preparation.

Dip in dilute acetic acid (1 per cent.) for one minute.

Dry.

Stain in saturated aniline water gentian violet solution (p. 20).

Wash freely in water.

Dry and mount in balsam.

Cocci appear as dark blue rods.

Capsules stain a clear grey-blue colour.

2. *Gram's Method.*

Stain the preparations as in Friedländer's method (above).

Place in solution of iodine in iodide of potassium (iodine, 1 gramme; iodide of potassium, 2 grammes; distilled water, 300 c.c.) for two to three minutes.

Transfer to absolute alcohol.

Allow it to remain so for some time.

Then clear in clove oil.

Mount in Canada Balsam.

All the elements are colourless except organisms, which are dark blue.

Contrast Stain—Eosin may be employed.

γ. ACTINOMYCES.

Appear as

Very small whitish or greenish-yellow nodules in the sputum.

Cover glass preparations made, and

FIG. 10.—ACTINOMYCES GRANULES. THREADS MAGNIFIED.

Stained by Gram's method

Show radial arrangement of

Small pear-shaped bodies which form the nodule.
Network of threads alone visible at centre.
Each thread composed of a series of minute round bodies.
Yellow elastic fibres.
Leucocytes.
Fattily degenerated cells.
} Present.

δ. Influenza Bacillus.

The bacilli appear singly, or in
Groups.
Often fill up pus cells.
Stain in any of the basic aniline dyes, as dilute Ziehl-Neelsen's fluid.

ϵ. Diphtheria.

With platinum needle, sterilised in a flame, remove some of the secretion from under side of a shred of membrane, and make cover glass preparations.

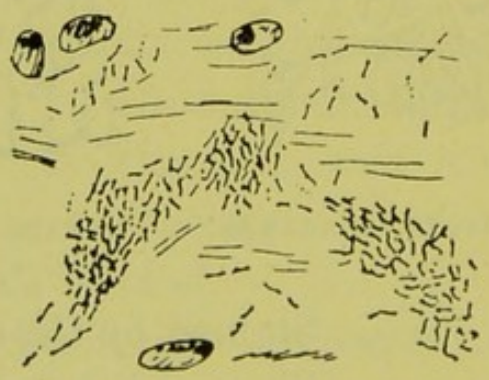


Fig. 11.—Bacilli of Diphtheria.

Stain in alkaline solution of methylene blue.

Bacilli are in form of rods as long as those of tubercle bacilli, but twice as broad.

Ends often club-shaped.

Method of Cultivation.

A sterilised swab of cotton wool is pressed on the exudation in the throat.

Then holding this by a pair of forceps brush it lightly over a tube of Löffler's serum (prepared with a large slanting surface).

Cork this and keep at temperature of 38° C. for four hours.

At end of this period take a sterilised platinum loop and brush it lightly over the surface of the culture medium.

Then rub loop into minute drop of distilled water on a sterilised cover glass.

Spread fluid evenly over cover glass.

Dry thoroughly.

Stain in methyl violet.

Bacilli are not numerous but are characteristic.

If it be a case of false diphtheria only micrococci are found.

ζ. Micrococci.

These are found in very many different conditions of the lung and arranged in tetrads similar to sarcinæ ventriculi.

III. Animal Parasites.

a. Echinococcus.

This may exist in the sputum in the form of

Cysts.

Pieces of hydatid membrane.

Hooklets.

Sputum is bloody, or

Mixed with bile (if cysts have been in the liver).

Membrane is white.

Edges enrolled.

Microscopically, shows the parallel streaking in those of older formation.

Hooklets are very diagnostic.

Scolices seldom found—if so, are broken up usually.

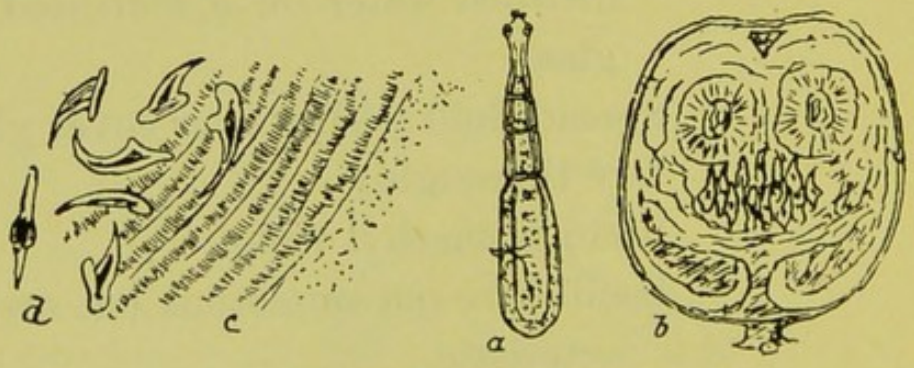


Fig. 12.—Tænia Echinococcus.

(*a*) Four times natural size ; (*b*) Scolex or head (×350); (*c*) Ectocyst laminated ; (*d*) Hooklets (×350) (compare with Fig. 22).

β. Distomum Pulmonale.

Sputum—Clear or dark red mucous.
Blood in points or streaks.
Microscopically—
Red blood corpuscles.
White blood corpuscles.
Charcot's crystals—many.
Eggs of the parasite—as brown points, oval with pale brown coverings.

CHARACTERISTIC SPUTA.

1. Bronchitis.

(*a*) *Acute.*

First day—
Thin and watery.
White frothy expectoration.
Mucus and few leucocytes.
Second stage—
Thicker and more viscid.
More mucus.
Epithelium and mucous corpuscles largely present.
Later—
Purulent and greenish.
Many pus and epithelial cells.
Cylindrical and goblet cells.

(*b*) *Chronic.*

Sputum—Greenish yellow in colour or
Dark grey from dust.

Very viscid.
Sputa often nummular in form.
Fibrinous coagula of minute bronchioles sometimes present.
Microscopically.
Pus.
Epithelial cells, fattily degenerated—often containing black pigment and seldom ciliated.
Many fungi.
Triple phosphate crystals.

2. Bronchiectasis.

Sputum—Odour disgusting.
Thin oily fluid.
Forms three layers on standing.
At bottom—Cellular debris.
Above this—Greenish watery layer.
On top—A froth.

Microscopically.
Pus cells, fattily degenerated.
Epithelial cells—degenerated.
Red blood corpuscles.
Hæmatoidin crystals.
Crystals of the fatty acids.
Elastic tissue.
Plugs of inspissated mucus.

Leucin and tyrosin occasionally.
Putrefactive bacteria.

3. Fibrinous Bronchitis.

Sputum—Frothy mucous.
Muco-purulent.
Tinged with blood sometimes.
Branching fibrinous trees—*characteristic.*

Microscopically.

Charcot-Leyden crystals attached to coagula (p. 13).
Curschmann's spirals—less frequently seen (p. 11).
Hæmatoidin crystals.
Ciliated epithelium (very seldom).

More frequent in males than females.

4. Fœtid Bronchitis.

Sputum—Copious.
Watery.
Offensive.
Dirty green or grey-green colour.
Forms three layers on standing.
Upper—Dirty mucous froth.
Middle—Watery greenish yellow.
Often shaggy discoloured projections.

Lower—Thick purulent layer.

Microscopically.

Dittrich's corpuscles (p. 7).

Pus and epithelial cells degenerated.

5. Croupous Pneumonia—Lobar.

Sputum shows at the different stages of the disease marked changes of great diagnostic value.

In beginning (= engorgement).

Sputum—Very scanty.

Tough viscous.

Yellowish red.

Streaked with blood.

Microscopically.

Many red blood corpuscles singly or in rouleaux.

Delicate strands of fibrin entangling these.

Round cells—Both recent and old.

Second Stage (= hepatisation).

Sputum—More abundant.

"Rusty" or saffron coloured, or Bloody mucous sputum.

Very tenacious—adheres closely to vessel—hardly can be pulled away from it. Vessel may be inverted without the sputum falling out.

Many large air bubbles in it.

(Sputum may be grass green in colour from change of hæmoglobin into bilirubin, and its oxidation into biliverdin.)

Microscopically.

Red blood corpuscles—shrivelled.
Pus corpuscles.
Alveolar epithelium.
Hæmatoidin crystals (sometimes).
Fibrinous casts of smaller bronchi.
Divided fibrin threads.
Curschmann's spirals.

Third Stage (= resolution).

Sputum—Colour fades from day to day, becoming
More and more yellow.
Muco-purulent.
More watery.
Pours from vessel more easily—viscidity decreases.
Total quantity increases.

Microscopically.

Round cells, with marked fatty degeneration.
Granular cells.
Fat free in small or large droplets.
Spirals. } Numerous in early period of third stage.
Coagula. }

"*Prune Juice Sputum*"

Seen in cases which end fatally.

Due to œdema of lungs from failure of heart.

Sputum—Watery.

Dark brown.

Methæmoglobin alone forms the pigment.

6. Acute Pulmonary Tuberculosis (Miliary Tubercle).

Early—Sputum.

Viscid. } As in early stage of
Scanty. } bronchitis.

Microscopically.

Tubercle bacilli.

Few in number.

Spore formation always seen.

Later—Sputum.

Purulent.

Microscopically.

Elastic tissue.

Alveolar epithelium.

Tubercle bacilli in large number.

7. Phthisis Pulmonalis Chronica.

Sputum—Thick—Viscid.

Greenish yellow.

Muco-purulent.

Blood in streaks, or mixed with it frequently.

Tubercle nodules present, grey in colour.

Shape of sputum—nummular.

Microscopically.

Pus cells.
Red blood corpuscles.
Elastic fibres in alveolar form.
Alveolar epithelium.
Crystals of fatty acids. } Occasionally.
Tyrosin. }
Crystals of phosphates and chlorides. }
Cholesterin. }
Hæmatin. }
Tubercle bacilli *invariably*.

The more severe the case, the greater the fever. } = the greater the number of bacilli present.

8. Pertussis (Whooping Cough).

Early—Clear ropy.
Tenacious.
Mucous.
Later—Muco-purulent.

Microscopically.

Pigmented alveolar epithelial cells.
Spiral formations of oval, columnar, or ciliated cells.
Charcot-Leyden crystals — small in size.
Granular casts of ultimate bronchioles —small in size.

Small cocci in pairs.
Larger cocci in tetrads.

9. Asthma.

Quantity—Large, or
Very small.
Colour — Greyish white mucous sputum.
Runs easily together.
Very tenacious.
Fine grey or yellowish plugs or threads of fibrin = spirals.

Microscopically.

Curschmann's spirals.
Charcot-Leyden crystals.
Eosinophilous cells (*q.v.*).

10. Abscess of Lung.

Sputum—Pure pus held together by mucus.
Light green colour.
Odour putrescent.

Microscopically.

Pus cells.
Blood corpuscles.
Fatty epithelium.
Elastic fibres.
Hæmatoidin crystals.
Cholesterin.
Fatty crystals.
Fungi—Non-pathogenic.
Chiefly staphylococcus pyogenes aureus.

11. Gangrene of Lung.

Sputum—Quantity abundant, 250-500 c.c.

Thin.

Dark greenish.

Penetrating gangrenous odour.

Forms three layers on standing.

Lowest—Thick brownish green.

Above this—Thin watery layer.

Top—Frothy greenish stratum.

Microscopically.

Elastic fibres in alveolar arrangement.

Phantom red blood corpuscles.

Fatty globules.

Leucin and tyrosin.

Crystals of fatty acids.

Dittrich's corpuscles—dirty greyish yellow.

Hæmatoidin crystals or masses—seldom.

Fungi—numerous.

12. Hæmorrhagic Infarction of Lung.

Sputum—Dark red or black.

Microscopically.

Rusty pigment masses of Hæmatoidin.

13. New Growths in the Lung or Larynx.

Sputum—Scanty.

Muco-sanguineous, rosy,—like Meat washings.

Hæmoptysis frequent =

Bright red sputum.
Fragments of tumour itself (when growth is in larynx) may be seen in sputum.

Microscopically.

Blood corpuscles.
Pus corpuscles.
Characteristic cells, or even
Cell nests of epithelioma may be present.
Fragments of tumour exhibit their structure.

Dust Diseases.

14. Anthracosis.

Colour—Dark brown or black.
Very viscid.

Microscopically.

Alveolar epithelium.
Pus corpuscles.
Carbon particles, isolated, or
Within leucocytes or epithelial cells.
Elastic tissue—frequently.

15. Siderosis.

Colour—Dark.
Muco-purulent.

Microscopically.

Leucocytes.
Alveolar epithelium.

Brown pigment granules within epithelial cells.

Tests for

Iron Particles.

Add to slide preparation drop hydrochloric acid and drop ferrocyanide of potassium =

Granules become intensely blue.

Stone Particles.

Add drop of acid = effervescence = carbonate.

DIGESTIVE SYSTEM.

SALIVARY SECRETION.

SALIVA.—Mixed secretion from parotid, submaxillary and sublingual glands.

Method of Collection—Let patient wash mouth out with solution of bicarbonate of soda, and then with cold water. On inhaling the vapour of acetic ether or acid, or on touching the inside of the mouth with a rod dipped in dilute acid, the secretion begins.

Total Daily Secretion—800-1500 c.c.

NORMAL SALIVA.

Naked Eye Appearances—Slightly opalescent.
Thickish, slimy, clear fluid.
Specific gravity—1002-6.
Reaction alkaline.
Particles of mucin suspended.
Becomes cloudy from precipitation of calcium carbonate.

Microscopical Characters.

(1) Large flat polygonal epithelial cells, each with a large nucleus = shed from mucous membrane of mouth.

(2) Salivary corpuscles in large number.
They resemble leucocytes, but are larger and more granular.

(3) Micrococci and bacilli in very large number, *e.g.*,
Spirochæte buccalis.
Leptothrix (from decaying teeth).
Bacilli resembling the comma bacillus.

FIG. 13.—BUCCAL SECRETION.

(*a*) Various fungi ; (*b*) Leucocytes ; (*c*) Leptothrix buccalis ; (*d*) Salivary corpuscles ; (*e*) Squamous epithelium ; (*f*) Comma bacilli of mouth ; (*g*) Spirochæte buccalis.

Chemical Composition.

(1) Mucin—Add acetic acid = coagulation.

(2) A globulin proteid.
Heat = coagulated.

(3) Ptyalin—
Add starch solution = maltose formed = Fehling's solution reduced.

(4) Potassium sulphocyanide.
Add drop of ferric chloride = red colour.
Add mercuric chloride = colourless.

(5) Mineral matters.

Chlorides of sodium and potassium.
Calcium carbonate and phosphate.
Magnesium phosphate.

Activity of Ptyalin Ferment.

Add a little saliva to starch solution in test tube.
Warm for 5 minutes = maltose formed.
Maltose + Fehling's solution = yellow or red precipitate of sub-oxide of copper.

Estimation of the Rapidity of Conversion of Starch.

Take 5 c.c. of a 1 per cent. starch solution.
2 c.c. saliva.
10 c.c. water.
Keep at body heat (38° C.).
Test at end of each minute the degree of conversion by taking one drop out of test tube, and adding it to a drop of iodine solution on a slab.

At first = deep blue colour = starch unchanged.
Later = violet colour = soluble starch (goes through a filter).
Add tannic acid or alcohol = precipitate.
Still later = reddish = erythrodextrin.
Add tannic acid = no precipitate.
Add alcohol = precipitate.
,, ,, = no reaction = achroodextrins.
,, ,, = ,, ,, = maltose— reduces Fehling's solution.

Secretion Diminished.

(1) Most general fevers.
(2) Inflammation of salivary glands.
(3) Acute nephritis.
(4) Diabetes.
(5) Certain drugs, *e.g.*, atropia.

Secretion Increased.

(1) Inflammation of buccal mucous membrane.
(2) Some cases of pregnancy.
(3) Certain drugs, *e.g.*,
Pilocarpin.
Pyrethrum.
Mercury.

ALTERATION IN CONSTITUTION.

REACTION.

Acid, as in Acute rheumatism.
Mercurial poisoning.
Diabetes.

UREA—Has been found in cases of
Nephritis.

FUNGI present in many diseases of the mouth.
e.g., ulcerative stomatitis.

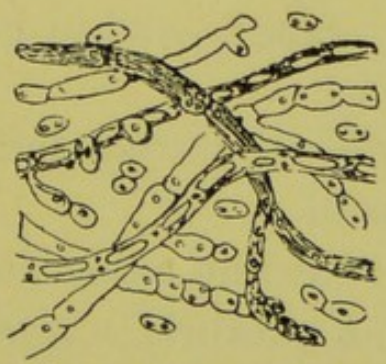


FIG. 14.—OIDIUM ALBICANS.

THRUSH (Oidium Albicans).

Remove piece of the white patch.

Mount on slide with drop of glycerine.

Consists of

Epithelial cells.

Leucocytes.

Branching filaments of the oidium—

Made up of finely granular segments joined end to end.

Each segment has a clearly marked nucleus at either end.

Many spores in meshes of network.

MICROCOCCI AND BACTERIA.

Take scraping from between the teeth.

Make a cover glass preparation of this (p. 16).

Stain in methyl blue or violet, and mount.

Consists of

(1) Spirochæte buccalis—

Very mobile fine threads, resembling Spirillum of relapsing fever.

(2) Leptothrix buccalis—

Long bacilli arranged in ribbons.

(3) Many micrococci—

Singly, and in zooglœa.

TARTAR.

Stony matter surrounding base of teeth.

Consists of

Calcium carbonate and phosphate.

Leptothrix.

Mucus.

The Tongue.

Fur on the Tongue.

Consists of

Polygonal epithelial cells.
Salivary corpuscles.
Fungi.
Bacteria.

False Membranes.

Situation—Usually on tonsils or uvula.

Varieties.

(1) Simple croupous deposit.
(2) True diphtheritic membrane.
(3) Thrush.

Microscopically.

The first two exhibit

(*a*) Felted network of fibrin.
(*b*) Thick layer of proliferating epithelial cells.
(*c*) Red blood corpuscles.
(*d*) Pus corpuscles.
(*e*) Micro-organisms of all varieties.

GASTRIC SECRETION.

Composition of Normal Gastric Juice.

Water, ...	99·44	per cent.
Pepsin, ...	0·32	„ „
Hydrochloric acid, . .	0·02	„ „
Sodium chloride, . .	0·14	„ „

Potassium chloride, . .	0·05	per cent.
Calcium chloride, . .	0·006	„ „
Other mineral salts, . .	0·012	„ „

Naked Eye Characters.

Thin colourless fluid.
Acid reaction.
Odour peculiar.
Specific gravity, 1001-1010.
Not coagulable by heat.

Order in which to Examine the Gastric Contents.

1. Reaction.
2. Total percentage acidity.
3. Presence of free hydrochloric acid.
4. Quantitative estimation of hydrochloric acid.
5. Presence of lactic, acetic, butyric } acids.
6. Presence of pepsin and its activity.
7. Presence of milk-curdling ferment.
8. Presence of proteids and their nature.
9. Presence of starch, dextrins and sugar.
10. Microscopical examination.

Method of Withdrawing the Stomach Contents.

Dip the rounded end of the elastic stomach tube into water.
Let patient open his mouth and bend head forward.
Hold tube about four inches from its extremity.
Pass it to back of throat.

Elevate the hand holding tube.

Rapidly, but gently, pass the tube onwards into the stomach.

If retching begins, tell patient to swallow his saliva.

Hold down the tongue with forefinger of left hand if it be in the way.

Gastric contents now run out from tube.

If not flowing readily, cause patient to compress the abdomen, cough or retch, when tube soon fills.

Syphon action may be made use of by attaching a longer tube to the distal extremity of the stomach tube.

Period when Gastric Contents should be Withdrawn.

Patient takes a "test meal" on empty stomach.

Test Meal consists of

(1) Oatmeal boiled in water (this is the best), or

(2) Ordinary dry roll or bread.

Warm water or weak tea, 15 ounces.

Withdraw part of stomach contents at the end of the first and second hours.

Examination of Stomach Contents.

Filter the stomach fluid = clear watery filtrate.

Test reaction = acid—usually due to hydrochloric acid.

Degree of Acidity of Gastric Contents

Varies with the period of digestion.

1. Within fifteen minutes from ingestion in health there is no *free* acidity.

The acidity present is due to acid salts present in the food.

Free lactic acid is sometimes found, but it is due to disease of the stomach, or has been ingested in the food (cannot be, however, if the oatmeal test meal be taken).

There is *no free* hydrochloric acid present, it being combined with the proteids to form acid proteids.

Starch digestion proceeds during this period.

2. *Free* hydrochloric acid now begins to appear, and reaches its maximum about one hour after the test meal has been taken.

   If no free hydrochloric acid be found two hours after taking the test meal there is serious organic disease in the stomach.

Total Acidity of Gastric Contents.

Estimation

By titrating against standard caustic soda solution.

Standard Alkaline Solution.

1. Dissolve 40 grammes dry caustic soda (Na = 23, H = 1, O = 16) in distilled water and dilute to one litre = normal solution. Each c.c. contains, therefore, 0·040 grammes caustic soda.
2. Take 100 c.c. of this solution, and again dilute to one litre = decinormal caustic soda solution. Each c.c. contains 0·004 grammes caustic soda.
3. Greater accuracy is obtained by
   Taking 100 c.c. of No. 2 (decinormal solution),

and diluting to 1 litre = centinormal caustic soda solution. Each c.c. contains 0·0004 grammes caustic soda.

Place this in burette.

Method.

Take 10 c.c. of unfiltered gastric fluid in small glass flask.

Add 50 c.c. distilled water.

Add phenol phthallin—few drops of an alcoholic solution.

Now run in from the burette the standard soda solution—shaking the mixture during the process.

Till a pink colour appears in the gastric fluid.

Read off the number of cubic centimetres of caustic soda (decinormal or centinormal) required to neutralise the acidity of the gastric fluid.

Calculate percentage amount of total acidity.

Example. If 8·3 c.c. decinormal soda solution have been required to neutralise the acidity of 10 c.c. gastric fluid, this is equal to 83 per cent. (for 100 c.c. gastric fluid is neutralised by 83 c.c. decinormal soda solution).

This acidity may be due to free acid, or to acid salts.

If acid salts be small in amount, acidity may be expressed as *hydrochloric acid* (H = 1, Cl = 35·46), so 36·46 grammes hydrochloric acid diluted to 1 litre = normal solution. Each c.c. of decinormal solution = 0·003646 grammes hydrochloric acid, and this is exactly neutralised by one c.c. decinormal caustic soda solution = 0·004 grammes caustic soda.

To obtain the Percentage Amount of Hydrochloric Acid.

Calculation.

Multiply number of c.c. of standard decinormal alkaline solution used to neutralise 10 c.c. of gastric fluid by 0·03646.

Example. 8·3 c.c. used × 0·03646 = 0·302 per cent. hydrochloric acid (for each c.c. decinormal alkaline solution = 0·0036 grammes hydrochloric acid — 0·003646 × 8·3 = 0·0302 = hydrochloric acid in 10 c.c. gastric fluid = 0·302 per 100 c.c.).

Tests for Free Hydrochloric Acid.

1. Gunzburg's Reagent.

Phloroglucin, . 2 grammes.	Dissolve.
Vanillin, . . . 1 gramme.	Keep in dark
Absolute alcohol, 30 grammes.	bottle.

Method.

Place few drops of this in porcelain capsule.

Add few drops of gastric contents.

Gently heat over flame.

Fine red streaks at margin, or small pinkish red patch = free hydrochloric acid

(organic acids, albumin, or salts do not interfere with this reaction).

2. Boas' Test.

Resorcin solution, 5 parts.

White sugar, . . 3 ,,

Dilute spirit to . 100 ,,

Method.

Place 5 drops of this in porcelain capsule.

Add 5 drops gastric contents.
Evaporate to dryness with gentle heat.
Rose colour = free hydrochloric acid.

3. Congo Red.

Dissolve 0·1 gramme Congo red in 100 c.c. distilled water.
Dip strips of bibulous paper in this, and dry them.

Method.

Dip such a strip in gastric fluid.
Blue colour = free acids (organic or inorganic).
Drop into test tube containing sulphuric ether = blue disappears if due to organic acid.
Blue colour persists = mineral acid (HCl).
Acid salts do not affect the red colour.

4. 00 Tropæolin Test.

Make saturated solution of this dye = dark yellowish red.
Add gastric contents = dark brown colour = free hydrochloric acid.
(With acid salts it becomes clear yellow.)

5. Benzo-Purpurin, 6 B.

Make dark red solution, or use in strips, as with No. 3.
Add gastric contents.
Light violet colour = free hydrochloric acid.
Brownish violet = organic acids. (Test with sulphuric ether as in No. 3.)
(No reaction with peptones or albumins.)

Quantitative Estimation of Free Hydrochloric Acid.

1. Most ready method is that of

Mintz-Boas.

Take 10 c.c. gastric contents.

100 c.c. sulphuric ether.

Shake well up.

Separate ethereal extract, which has in solution all organic acids.

Hydrochloric Acid (being insoluble in ether) is left in the gastric fluid.

Run into this the decinormal soda solution from the burette until Congo red paper is no more blued by it.

Read off number of cubic centimetres of standard soda solution used.

Calculate amount of free hydrochloric acid present.

Example. 6·5 c.c. alkaline solution used 6·5 × 0·003646 = 0·02369 grammes hydrochloric acid in 10 c.c. stomach contents = 0·2369 per cent.

2. Sjoqvist's Method.

Place 10 c.c. filtered gastric fluid in a platinum crucible, and add an excess of carbonate of barium, which must be free from chlorides. Evaporate to dryness, and gently char for some time, by which the organic baryta salts are decomposed into barium carbonate, while the chloride of barium remains unchanged. When cold, the residue is repeatedly washed with boiling water, and filtered till filtrate amounts to 50 c.c. A standard solution of bichromate of potash (8·5 grammes to the litre) is run into this filtrate, and precipitates the barium as the chromate. The "indicator" consists in adding to the filtrate one-third of its volume of alcohol, and 4 c.c. of a solution con-

taining 10 per cent. acetic acid, and 10 per cent. sodium acetate. The potassium bichromate solution is allowed to run from a burette until a tetra-paper (tetramethylparaphenyldiamine) when dipped into the mixture becomes faintly blue. From the amount of standard solution used we readily tell the amount of barium chromate formed, and consequently the amount of free hydrochloric acid present.

Free Hydrochloric Acid.

Diminished.

1. Most febrile diseases.
2. Chronic wasting diseases.
3. Phthisis.
4. Bright's disease.
5. Chlorosis.

   Pernicious Anæmia.
6. Simple Gastric Catarrh.

   Acute.

   Chronic.
7. Cancer of stomach.

   (Usually the acid is entirely absent.)

Increased.

Gastric ulcer (usually).

Absent.

Normally absent from gastric contents up to first half-hour after food is taken.

If not present up to three hours after food is taken = very deficient secretion or total absence.

In disease—Absent in protracted scurvy.
Cancer of Stomach.

Organic Acids.

Lactic Acid.

In healthy conditions of the stomach lactic acid is not secreted.

It may be present early in digestion, but has then been introduced in the food, or is the result of disease.

Tests—

1. Take 20 c.c. stomach contents.
   Add 100 c.c. sulphuric ether = lactic acid dissolved in it.
   Decant off ethereal extract.
   Add water to ,, ,, = watery solution of lactic acid.
   Heat with dioxide of manganese and sulphuric acid in porcelain basin =
   Lactic acid decomposed into formic and acetic aldehyd.
   Add drop of iodine solution = smell of iodoform.
2. Make dilute (almost colourless) solution of neutral perchloride of iron.
   Fill two similar test tubes with this.
   To one add few drops of filtered gastric fluid.
   Colour = much darkened — canary yellow = lactic acid or lactates.
   Compare the two tubes.

Fallacies—Alcohol, Sugar, Phosphates } cause production of yellow colour.

If so, extract free lactic acid by shaking up with ether; decant off ethereal solution.

Evaporate off ether. Redissolve residue in water, and apply test to this.

3. Uffelmann's Reaction.

Reagent—20 c.c. water.

10 c.c. solution of carbolic acid (4 per cent.).

Add few drops perchloride of iron solution = amethyst-blue colour.

Add gastric fluid = yellow colour if lactic acid present.

Fallacies (as under No. 2).

Quantitative Estimation.

Proceed as in the Mintz-Boas' Method (p. 49).

Titrate the ethereal extract of lactic acid against the decinormal alkaline solution.

Calculation—1 c.c. decinormal soda solution = 0·009 grammes lactic acid.

Therefore multiply the number of cubic centimetres of standard soda solution used by 0·009 = amount of lactic acid in 10 c.c. gastric fluid. Multiply this by 10 = percentage.

Lactic Acid.

Present—(1) Carcinoma of stomach—*always*.

(2) Various fermentations in the stomach.

(3) Therefore in simple and malignant stricture of stomach.
(4) Acute gastritis.

BUTYRIC ACID.

An ethereal extract of the gastric fluid has the characteristic odour of butyric acid.

With Uffelmann's reagent a yellowish red or brown lustre appears.

ACETIC ACID.

(1) This is easily recognised by its smell, which is specially evident in an ethereal extract.
(2) Neutralise ethereal extract with carbonate of soda.
Add few drops of neutral solution of ferric chloride.
Acetic acid present = blood-red colour produced.

PEPSIN.

The presence and power of this ferment is estimated in the gastric fluid as follows :—

Acidify with very dilute hydrochloric acid solution if feebly acid or alkaline.

Add a morsel of well-washed blood fibrin.

Keep at temperature of 40° C.

Fibrin dissolved in short time = pepsin present.

If not dissolved in 7—8 hours = pepsin absent or present in very small amount.

Milk-Curdling Ferment.

Presence of this ferment shown thus :—

Take fresh cow's milk, neutralise and boil.

Add an equal amount of neutralised filtered gastric fluid.

Keep all at 40° C.

Casein precipitated in flakes within 30 minutes = milk-curdling ferment.

PRODUCTS OF GASTRIC DIGESTION.

1. Acid Albumin or Syntonin (*q. v.*).

   Test—Neutralise carefully = precipitate of syntonin
   add excess of alkali = syntonin redissolved.

2. Peptones.

   Tests—(1) Biuret reaction (*q. v.*).
   (2) Neutralise and saturate with ammonium sulphate to precipitate albumoses.
   Test filtrate for peptones.

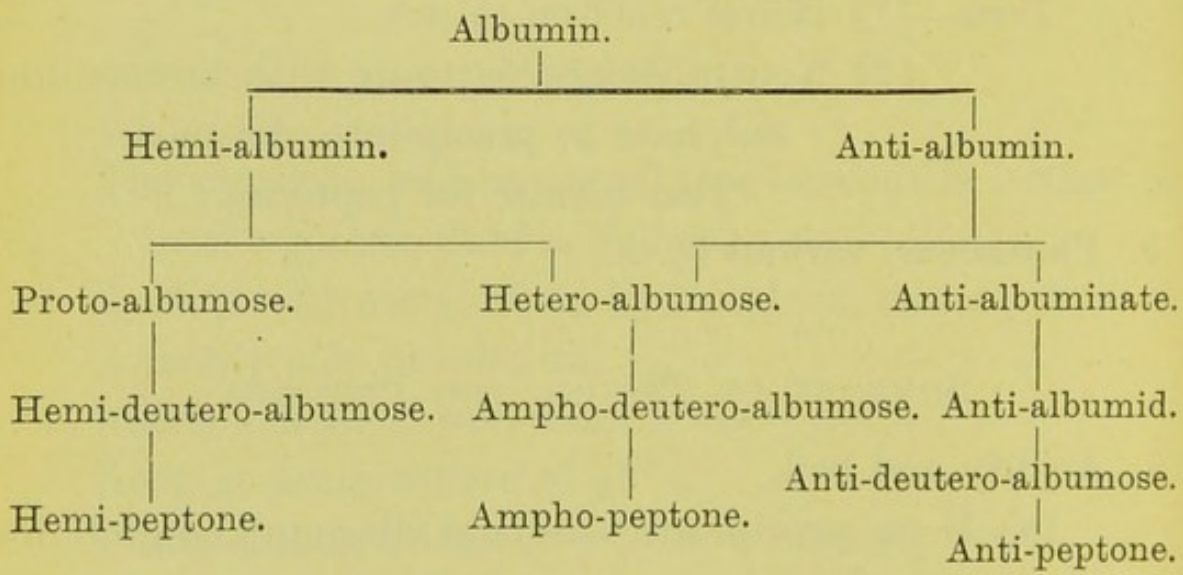
3. Proteoses, various (*q. v.*)

Summary of Testing for Proteids.

1. Acidify and boil.
   (*a*) If no precipitate = serum albumin and globulin absent.
   (*b*) If precipitate = serum albumin or globulin present.

2. Neutralise and add sulphate of ammonium in excess.
   (*a*) If no precipitate = globulin and hetero-proteose absent.
   (*b*) If precipitate = globulin or hetero-proteose present.
3. Saturate with sulphate of ammonium and filter.
   If filtrate give no reaction with nitric acid or biuret reaction = peptone absent.
4. Peptone alone present = biuret reaction.
   Nitric acid = no reaction.
   Ammonium sulphate = ,,
   Acidification and boiling = ,,

The hydrating action of gastric digestion on proteids has been graphically represented as follows :—



The tests for albumins, albuminates, and peptones are given further on ("Urine").

Proto-Albumose.

Tests—1. Soluble in hot and cold water. (So differing from globulin).
2. ,, ,, weak saline solutions.
3. Precipitated by saturation with chloride of sodium.
4. ,, ,, ,, ,, sulphate of magnesium.
5. ,, ,, ,, ,, sulphate of ammonium.
6. ,, ,, cold nitric acid, dissolves on heating, and reappears on cooling.
7. Biuret (red violet) reaction.
8. Precipitated by acetic acid and ferrocyanide of potassium.

Hetero-Albumose.

Tests—1. Insoluble in hot or cold water.
2. Soluble in *weak cold* solution of sodium chloride—not in hot.
3. }
4. }
5. } As above.
6. }
7. Biuret reaction—Red violet.
8. Precipitated by acetic acid and ferrocyanide of potassium.

Deutero-Albumose.

Tests—1. Soluble in hot and cold water.
2. Soluble in weak saline solutions.
3. *Not* precipitated by saturation with chloride of sodium.
4. ,, ,, ,, ,, ,, sulphate of magnesium.
5. Is ,, ,, ,, ,, sulphate of ammonium.
6. Nitric acid only precipitates it in presence of excess of sodium chloride.
7. Biuret reaction.
8. Precipitated by acetic acid and ferrocyanide of potash.

Peptones.

Tests—1. Soluble in hot and cold water.
2. ,, ,, weak saline solutions.
3. Not precipitated by saturation with chloride of sodium.
4. ,, ,, ,, ,, ,, sulphate of magnesium.

5. Not precipitated by saturation with sulphate of ammonium.
6. ,, ,, ,, nitric acid.
7. ,, ,, ,, acetic acid and ferrocyanide of potassium.

Digestion of Starch in the Stomach.

Starchy matter is normally changed into sugar by the end of one hour through the action of saliva swallowed with the food.

Test the Condition of the Starch in the gastric contents by adding a drop of iodine solution (see page 40).

If purplish colour is given by fluid which has been one hour in the stomach = faulty amylolysis owing to failure in secretion of ptyalin, or to hyperacidity of the gastric contents.

Test if Maltose present.

It reduces Fehling's solution, but much less powerfully than dextrose = proportion being 65 : 100. (Remember this in estimating maltose quantitatively.)

Maltosazone crystals are characteristic, and are formed on heating a solution of phenyl-hydrazin with a fluid containing maltose for half an hour (plates).

MICROSCOPICAL EXAMINATION OF THE GASTRIC CONTENTS.

Fragments of the various articles of diet taken.

Many micro-organisms, *e.g.* :—

Tetrads of sarcinæ ventriculi (dilatation of stomach).
Torula cerevisiæ.
Bacteria.

RATE OF ABSORPTION FROM THE STOMACH.

Estimation.

Give patient capsule containing 0·1 gramme of iodide of potassium to swallow.

Test saliva at end of every minute for presence of iodine, thus :—

Have bibulous paper dipped in starch solution, and dried.
Moisten this with the saliva.
Add drop of strong nitric acid.
Blue colour = iodine present in saliva, showing that it has been absorbed from stomach.

EXAMINATION OF THE VOMIT.

Examine in same way as in "Chemical Examination of the Gastric Secretion".

Microscopically—Particles of various foods undergoing digestion.
Connective tissue.
Elastic fibres.
Muscle fibres.
Fat globules.

Starch granules.
Vegetable cells.
Yeast cells.

FIG. 15.—VOMIT, COMMON OBJECTS FOUND.

(*a*) Fat globules ; (*b*) Vegetable cells ; (*c*) Bacilli and micrococci ; (*d*) Leucocytes ; (*e*) Starch granules—partly digested ; (*f*) Yeast fungi ; (*g*) Epithelium ; (*h*) Sarcinæ ventriculi ; (*i*) muscle fibre.

Pathologically, we find :—

1. Leucocytes.
2. Red blood corpuscles, *e.g.* :—
   Acute gastritis.
   Gastric ulcer.
   Cancer of stomach.
3. Clots of blood.
   Gastric ulcer.
   Cancer of stomach.
4. Pigment masses—mahogany red in colour = conversion of oxyhæmoglobin into hæmatin by action of gastric juice.
5. Yeast cells—
   Dilatation of stomach.
   Cancer of stomach.

6. Sarcinæ ventriculi—Tetrads or wool packs.
   Dilatation of stomach.
   Cancer of stomach.
7. Bacilli } present in—Dilatation of stomach.
8. Micrococci } Cancer of stomach.
9. Mucus corpuscles—largely present.
   Acute and
   Chronic gastritis.

Characters of the Gastric Contents in Certain Diseases of the Stomach.

1. Acute Gastritis.—Vomited matters show
   Undigested food.
   Hydrochloric acid, absent or small in amount.
   Bile often present.
   Mucus increased.
   Bacteria numerous.
   Red blood corpuscles occasionally.
2. Chronic Gastric Catarrh.
   Much mucus.
   Yeast cells.
   Sarcinæ ventriculi.
3. Flatulent Dyspepsia.
   Acid smell.
   Hydrochloric acid, absent or small in amount.
   Lactic, acetic, or butyric acids present.
   Torulæ cerevisiæ.
   Sarcinæ ventriculi.

4. Acid Dyspepsia.
   Intensely acid.
   Hydrochloric acid increased in amount.
   Lactic acid present.
   (Saliva very alkaline.)
5. Atonic Dyspepsia.
   Hydrochloric acid very small in amount.
   Lactic acid present.
6. Gastric Ulcer.
   Hydrochloric acid in great excess.
   Blood often present—Dark red fluid, or clotted.
   Brown, like tea or "Coffee grounds" in appearance.
7. Cancer of Stomach.
   Grey, dark brown or chocolate in appearance.
   Hydrochloric acid absent, or in very small amount.
   Microscopically—Numerous fungi.
   Sarcinæ.
   Unchanged blood corpuscles.
   Cancer cells rarely present, and
   Cell nests form only reliable test.
8. Waxy Disease of Stomach.
   Hydrochloric acid absent usually.

DETECTION OF POISON IN THE VOMIT.

ACIDS.

1. Nitric Acid.

Vomit is

Yellowish in colour.

Very acid in reaction.

Detection—Mix vomit with water, boil and filter.

If acid, neutralise with caustic potash.

Evaporate = crystals of nitrate of potash.

Make a solution of these crystals, and

Test.

(1) Add 2 drops strong sulphuric acid.

Pour sulphate of iron solution on to surface =

Deep brown colour at junction of fluids.

(2) Heat crystal with strong sulphuric acid.

Add little brucia = blood-red colour.

2. Hydrochloric Acid.

Always due to introduction from without when found in great excess. Filter vomit, and test filtrate. (It is better to distil it almost to dryness, and use distillate.)

(1) Add carbonate of soda = evolution of carbonic acid gas.

(2) Add dioxide of manganese and heat = chlorine gas given off in pungent yellowish fumes.

(3) Add nitrate of silver solution = white precipitate.

Soluble in ammonia.

Insoluble in nitric acid.

3. Sulphuric Acid.

Vomit usually blackish.

Mix with distilled water, and shake for some time.

Filter and wash residue.

Evaporate filtrate to small bulk.

Add excess of alcohol and filter.

Dilute with water, and evaporate to drive off alcohol.

Tests. (1) Add barium nitrate = white precipitate.

Insoluble in nitric or hydrochloric acids.

(2) Add nitrate of lead = white precipitate.

4. Oxalic Acid.

Evaporate down the vomit.

Add alcohol, again evaporate.

Add water and filter.

Tests.

(*a*) Add chloride of calcium = white precipitate.

Microscopically = envelope crystals.

(*b*) Add acid solution of ferrous sulphate = lemon yellow colour.

Alkalis.

5. Ammonia.
   (1) Characteristic smell.
   (2) Hold glass rod moistened with hydrochloric acid near = white fumes of chloride of ammonium.
6. Caustic Potash or Soda.
   They render the vomit intensely alkaline.
   No reliable tests for them.
7. Chlorate of Potash.
   Tests. (1) Add acetic acid and boil.
   Filter and evaporate filtrate to small bulk = crystals of chlorate of potash separate.
   (2) To some of these crystals
   Add few drops strong hydrochloric acid = greenish yellow colour and fumes of chlorine given off.
   (3) Dissolve crystals in water.
   Add solution of indigo, and
   Little dilute sulphuric acid, and
   Hyposulphite of soda = blue becomes yellow.

Poisoning by Salts of the Metals.

8. Salts of Mercury.
   (*a*) Filter vomit—Take filtrate.
   Acidify with hydrochloric acid.

Add strips of zinc or brass wire.
Heat on water bath for an hour.
Wash strips with water, alcohol, ether, and then dry.
Place small pieces of these at bottom of sublimation or ordinary test tube.
Heat = metallic mercury sublimed and deposited on cold part of tube.

(1) Microscope shows this to consist of small globules.

(2) Add fragment of iodine to hot tube = red iodide of mercury formed.

(*b*) This process fails if much organic matter be present.
Remove it as follows :—
Strongly acidify with hydrochloric acid.
Add chlorate of potash.
Heat on water bath for long period till organic matter is destroyed. If not completely so,
Add more acid and chlorate of potash.
Then evaporate till no more chlorine comes off.
Dilute with water and filter.
Test filtrate.

(*a*) Add iodide of potash = yellow to red precipitate.
Soluble in excess.

(*b*) Add sulphuretted hydrogen = precipitate —yellow changing to brown and black.

(*c*) Add hydrochloric acid and copper foil = grey film of mercury on the foil.

9. Salts of Lead.

(*a*) If much organic matter be present, get rid of it by heating after having added hydrochloric acid and chlorate of potash.

Acidify and pass sulphuretted hydrogen through = black sulphide of lead precipitated.

Filter—Dissolve residue in nitric acid.

Tests. (1) Add sulphuric acid = white precipitate—sulphate of lead.

(2) Add chromate of potash = yellow precipitate.

(3) Add iodide of potash = yellow precipitate.

(*b*) Place a strip of magnesium in the vomit.

Lead is deposited on it, if present.

Dissolve this off with nitric acid, and apply above tests.

10. Salts of Copper.

(*a*) Vomit blue or green (verdigris) in colour.

Acidify with hydrochloric acid, and pass sulphuretted hydrogen through.

Filter off the sulphide of copper.

Dissolve this in nitric acid = blue solution.

Tests. (1) Add ammonia = whitish precipitate.

Dissolves to intensely blue colour.

(2) Add ferrocyanide of potash = mahogany red precipitate.

(*b*) Place a steel knife in the vomit.
= coating of metallic copper.

11. Phosphorus.

(*a*) Vomit is luminous in the dark.

(*b*) Characteristic odour of garlic.

(*c*) Acidify with sulphuric acid, and distil
= luminous vapour.

(*d*) Place pieces of sulphur in the vomit for some hours.
Remove and dry =
Luminous in dark, and give garlic odour.

12. Arsenic.

(1) Solid white arsenic detected by microscope = small octahedral crystals.
In solution—

(2) Reinsch's Test.
Filter liquid till nearly clear.
Add one-eighth of its volume of pure hydrochloric acid.
Boil in flask for twenty minutes.
Add strip of pure polished copper.
Dark grey film on foil = arsenic.
Remove foil, wash and dry; cut it into fragments.
Place these in sublimation tube.
Heat over flame = characteristic crystals deposited farther up tube as a white ring.

(1) Examine by microscope.

(2) If enough has sublimed, break tube; boil in water for some time, and apply liquid tests, *e.g.* :—

(α) Add ammonio-chloride of silver = yellow precipitate of arsenite of silver.

(β) Add sulphate of copper solution = deposit of Scheele's green.

(γ) Add sulphuretted hydrogen = yellow precipitate, soluble in ammonia.

13. Antimony.

Purify vomit as in preceding. Then apply tests.

(1) Reinsch gives a fine purple deposit on the foil.

(2) Acidulate with hydrochloric acid.
Place a drop on a sheet of platinum foil.
Stir with zinc rod = metallic stain = antimony.

(3) Wash this stain, and add
Sulphide of ammonia solution—one or two drops.
Orange red solution = antimony.

(4) Pour this solution into water = white precipitate of oxy-chloride.

POISONING BY ORGANIC PRODUCTS.

Alkaloids.

These are best separated by the *Stas-Otto Method.*

1. Dissolve the alkaloid by heating vomit for some time in flask with rectified spirit and a small quantity of tartaric or acetic acid (salts of the alkaloids being more soluble than the alkaloids themselves).

   Cool and filter to get rid of albumin, etc.
2. Evaporate filtrate to dryness.
3. Dissolve residue by adding slowly absolute alcohol till no further coagulation occurs.
4. Filter and evaporate to dryness.
5. Redissolve in a little water.

   If not clear, add more absolute alcohol, heat and filter, and again evaporate down. Do this till watery solution is clear.
6. Neutralise acidity with caustic potash, or ammonia.
7. Place in long tube, and shake up with twice its volume of ether, in which the alkaloid dissolves.
8. Remove this ethereal extract by a pipette, and place a few drops in several watch glasses.
9. On the ether evaporating, the alkaloid is left, and appropriate tests may now be applied.

General Characteristics of Alkaloids.

1. All are bitter (eserin excepted).
2. Add tannin = yellow or white precipitate.
3. With Meyer's reagent ($HgCl_2 + KI$) = abundant

white or yellow precipitate ; insoluble in water, or dilute acid.

4. Bichloride of platinum = yellowish-brown precipitate.
5. Metatungstic acid = flocculent white precipitate.

14. ATROPIN.

(*a*) Dissolve the alkaloid in acidulated water.
Test physiological action on rabbit's eye = pupil widely dilated.

(*b*) Dissolve some in fuming nitric acid, and dry.
Add alcoholic solution of caustic potash = violet becoming bright red in colour.

15. ACONITIN.

Test physiological—Numbing, tingling sensation on tongue.

16. STRYCHNIN.

(*a*) Intensely bitter.

(*b*) Add drop of sulphuric acid to alkaloid.
Add small quantity black oxide of manganese = play of colours—blue, purple, violet—ending in light red.

17. NICOTIN.

(*a*) Brownish oily fluid or brown mass is left by Stas' process.

(*b*) Dissolve in ether.
Add drop of ethereal solution of iodine = ruby red needles (require some hours to form).

18. COCAIN.

(*a*) Dilute solution of ferric chloride = yellow—Boil = red colour.

(*b*) Triturate with calomel = blackening on slightest moistening.

(*c*) Anæsthetic action on tongue, etc.

19. MORPHIN.

It is not dissolved by ether alone, so Stas' process is not applicable to it without modification.

Proceed to separate it as above described, and separate off the ether.

Shake up the watery fluid with warm amylic alcohol (in which morphia is soluble).

Separate the amylic solution, and evaporate to dryness = morphia.

Tests.

(*a*) Dissolve a little in weak hydrochloric acid.

Evaporate to dryness.

Add weak neutral perchloride of iron solution—2 drops.

= blue colour if morphia present.

(*b*) Add a drop of nitric acid = rich yellow colour.

(*c*) Add few drops of hydrochloric acid ; evaporate to dryness : redissolve in a few drops of water.

Add a few drops of starch paste, and evaporate to dryness.

Add drop of solution of iodic acid in water = blue colour.

20. LAUDANUM.

Test for the presence of morphia and meconic acid.

Filter and evaporate down the filtrate.

Add rectified spirit and acetic acid.

Heat and evaporate nearly to dryness.

Dissolve in water.

Add acetate of lead and filter.

Meconate of lead is left as residue on filter.

Acetate of morphia goes through in the filtrate.

MECONIC ACID.

Wash off the residue on the filter.

Add sulphuric acid or sulphuretted hydrogen to precipitate the lead.

Filter and test filtrate.

Add solution of perchloride of iron = rich red colour = meconic acid.

MORPHIN.

To the filtrate (of acetate of morphia) add sulphuretted hydrogen to remove excess of lead.

Filter.

Apply Stas' modified process to the filtrate.

HYDROCYANIC OR PRUSSIC ACID.

The vapour may be employed to give the reactions of this acid.

Into a small beaker place some of the stomach contents.

By means of a glass rod place a drop of the reagent on the under side of a watch glass, which is placed over the beaker as a cover.

Tests.

(*a*) On the under surface of the watch glass place a drop of caustic potash, and another of sulphate of

iron ($FeSO_4 + Fe_2(SO_4)_3$), and cover the beaker.

Drop becomes greenish brown.

Add drop of hydrochloric acid = intense (Prussian) blue.

(*b*) Drop of nitrate of silver on under side of watch glass = becomes white.

Insoluble in cold
Soluble in boiling } nitric acid.

(*c*) Drop of sulphide of ammonium on watch glass.

Expose to vapour: then dry = sulphocyanate of ammonium.

Moisten with perchloride of iron = brilliant red.

22. Nitro-Benzene—Oil of Bitter Almonds.

Distil gastric contents with little sulphuric acid.

Nitro-benzol distils over as oily drops, soluble in ether.

Add dilute hydrochloric acid and

Granulated zinc.

Neutralise with caustic potash = aniline.

Extract with ether.

Tests.

(*a*) Acidify this solution with hydrochloric acid.

Dip a pine wood shaving into it = deep yellow colour on wood.

(*b*) Place a drop of the oil in water.

Add a solution of chloride of lime = red colour.

. CARBOLIC ACID.

Filter the vomit (and distil if possible, using distillate for testing).

Tests.

(*a*) Add bromine water = yellow crystalline precipitate (tribromophenol).

(*b*) Add solution of perchloride of iron = dark violet colour.

. CHLOROFORM.

Tests.

(*a*) Dissolve piece of thymol in caustic potash.

Add it to the gastric fluid and heat.

Dark reddish violet colour = chloroform present.

(*b*) Add alcoholic solution of caustic potash.

Add drop of aniline = nauseating smell of phenylcarbylamine.

(*c*) The distillate reduces Fehling's copper solution.

. CHLORAL.

Tests.

(*a*) Add caustic potash solution to gastric fluid.

Place in beaker and cover up.

In short time = smell of chloroform = chloral present.

(*b*) Add sulphide of ammonium = yellow precipitate.

26. Alcohol.

Neutralise vomit, and distil it twice.

Apply to distillate these tests.

(*a*) Add little sulphuric acid.

Add bichromate of potash = green colour.
= smell of aldehyd.

(*b*) Add caustic potash.

Fragment of iodine.

Heat = smell of iodoform — yellow crystals.

27. Toxalbumins and Ptomaines.

Some of these may be separated by the Stas-Otto Method, or by some of its modifications; but these need not be described here, as they are too complicated for the ordinary clinical observer.

PANCREATIC SECRETION.

Naked Eye Characters.

Watery fluid.

Salt taste.

Specific gravity, 1030.

Chemical Characters.

Strongly alkaline.

Contains four ferments.

(1) Trypsin — a proteolytic ferment — changes proteids into peptones, and further into leucin and tyrosin.

(2) Amylopsin—Amylolytic ferment.
Acts on raw starch, changing it into dextrin and maltose.

(3) Steapsin—A fat-splitting ferment—splits fat into glycerine and fatty acid.

(4) Milk-curdling ferment.

Contains a proteid, coagulable by heat.

Mucin.

Microscopical Characters.

Few leucocytes.

Corpuscles—resembling salivary corpuscles—but smaller.

Chemical Reactions.

Coagulates when dropped into water, but these

Coagula soluble in chloride of sodium and in weak acids.

Heat = coagulation of the proteid.

Artificially cool = coagulation.

Coagulated by

Alcohol.

Strong mineral acids.

Tannic acid.

Metallic salts.

Products of Pancreatic Digestion.

Proteid is changed into—

Alkali albumin

Albumose, Peptone } later become { leucin, tyrosin } later { Indol, Phenol, Skatol } = results of putrefaction.

2. Starch is converted into—
   Maltose.
   Dextrin.
3. Fat is emulsified.
   Saponified.

Tests for Tyrosin and Leucin.

1. To some of the fluid add Millon's reagent.
   Filter off the precipitated proteids.
   Filtrate is pink in colour.
   Boil = red colour if tyrosin present.
2. Acidify and boil the fluid.
   Filter. Evaporate filtrate to small bulk.
   Microscope may show crystals of tyrosin and leucin.
3. Take some of filtrate from preceding (No. 2).
   Precipitate peptones by adding excess of absolute alcohol.
   Filter and evaporate to small bulk.
   Microscope may show great numbers of leucin balls.

BILIARY SECRETION.

Characters—Yellowish, reddish brown, or dark green in colour.
Transparent.
Specific gravity, 1005-10.
Neutral or faintly alkaline reaction.

Amount secreted—400-700 c.c. per diem.

Constituents—Mucin (chiefly nucleo-albumin).

Bile salts. { Taurocholate / Glycocholate } of sodium.
(The latter much in excess.)

Bile pigments—Bilirubin.
Biliverdin.

Fats and soaps.

Cholesterin.

Lecithin.

Urea.

Mineral matters—amongst which iron is always found.

Tests for Bile Acids (see "Urine").

Tests for bile pigments (see "Urine").

GALL STONES.

Composition—(1) Cholesterin (chiefly).
(2) Bile pigments (chiefly bilirubin).
(3) Carbonate of Lime.

Naked Eye Characters.

When single, are rounded, ovoid, or pyriform in shape.

When multiple are faceted.

Colour.

White, and may be transparent = cholesterin.

Yellowish green and opaque are also of cholesterin, along with bile pigments.

Structure.

1. Central nucleus—brownish black or green of—

(*a*) Biliary pigment and lime.
(*b*) Foreign body.
(*c*) Blood.
(*d*) Parasites.

2. Middle zone of concentric lamellæ of cholesterin arranged in radiating bundles.
3. External layer of calcium salts and bile pigment or of cholesterin.

Analysis.

1. Crush the stone to a fine powder.
2. Wash repeatedly with boiling water to remove bile.
3. Dry and extract repeatedly with a mixture of equal parts ether and alcohol to remove the cholesterin.
4. Treat residue with dilute hydrochloric acid. If carbonate of lime be present, effervescence will take place.

   Test residue for iron, copper, etc.
5. Wash residue thoroughly with water, then dry and boil with chloroform to extract bilirubin.
6. Evaporate this extract to dryness. Then treat with absolute alcohol (which extracts the pigment bilifuscin). Then treat with ether.
7. Treat residue with chloroform again to redissolve the bilirubin ; filter, evaporate down, and add alcohol when bilirubin is precipitated as an amorphous powder.

THE INTESTINAL SECRETION.

Intestinal Juice (Succus Entericus).

Characters.

Naked Eye—Pale yellow, turbid fluid.
Strongly alkaline in reaction.
Specific gravity, 1010.

Chemically—It contains—
Albumin.
Carbonate of soda.
"Invertin," a sugar-inverting ferment.

Actions—Has none on proteids.
Diastatic action converts starch into maltose.

On Sugars.

Cane changed into dextrose and levulose.
Milk sugar ,, ,, dextrose and galactose.
Maltose ,, ,, dextrose.

THE FÆCES.

Amount per diem—150-200 grammes (7 to 9 ounces), but varies with nature of diet.

Composition.

1. Undigested food.
   - Fats.
   - Carbohydrates. } if taken in excess.
   - Proteids.
2. Constituents of food difficult of digestion.
   - Mucin.
   - Keratin.
   - Elastin.
   - Cellulose.
   - Gums, resins, etc.
   - Uncooked starch.
   - Tendons.
   - Mineral matters.
3. Products of decomposition of food.
   - Indol, phenol, skatol.
   - Various acids, *e.g.* :—
     - Acetic.
     - Butyric.
     - Lactic.
     - Valerianic.
     - Malic.
     - Succinic.
   - Soaps of various kinds.
4. Biliary constituents.
   - Mucin.
   - Bile acids in small amount.
   - Lecithin.
   - Stercobilin (pigment resulting from bile pigment).

5. Epithelial cells, shed from alimentary tract.
6. Bacteria of all kinds.

Reaction = alkaline.

Colour.

Varies much in health, owing to nature of food.

Drugs taken internally give rise to varying coloration, *e.g.* :—

Black colour due to preparations of iron.
" " " " " " bismuth.
" " " " " " manganese.
" " " " " " charcoal.
Green " " " " " calomel.
Yellow rich " " " " " senna.
" " " " " " " rhubarb.
" " " " " " " santonin.

White stools, due to absence of bile pigment, always contain much fat and crystals of fatty acids.

Consistence.

Hard Firm Nodules = constipation as after long continued dry diet; chalk or magnesia mixtures.

Unformed Evacuations = much soft food.
Porridge.
Fruit.
Vegetables.

Watery = diarrhœa.
Enteritis.
Dysentery.
Cholera.

Abnormal Constituents (*Naked Eye*).

1. Mucus in large amount.
   Often in form of plugs or cylinders.
   Yellow or greenish in colour.
   As in
   Intestinal catarrh.
   Cancer of rectum.
2. Shreds of mucous membrane.
   Membranous enteritis.
3. Gall stones or intestinal concretions.
4. Pieces of cancer growths.
5. Cestode or nematode worms.

MICROSCOPICAL EXAMINATION.

Normal Constituents derived from undigested food, as
Muscle fibres.
Elastic fibres.
Connective tissue.
Unchanged starch granules.

Coagulated proteids.
Crystals of the fatty acids.
Mucus corpuscles.
Epithelial cells from alimentary tract. } Columnar, swollen up fusiform in shape, nucleus absent.
Cholesterin (always).
Mineral matters.

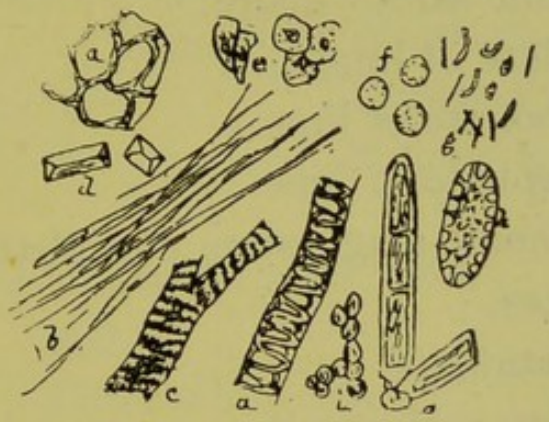


FIG. 16.—FÆCES.

(*a*) Vegetable cells; (*b*) Connective tissue; (*c*) Muscle fibre; (*d*) Triple phosphate crystals; (*e*) Epithelial cells; (*f*) Leucocytes; (*g*) Clostridium; (*h*) Diatom.

Microscopical Characters.

Abnormal Constituents.

1. Blood.
   - Clots or Isolated Corpuscles. } = Blood from lower part of intestinal tract.
   - Hæmatoidin pigment. } = Blood from upper part of digestive tract.
   - ,, crystals. } = Blood from upper part of digestive tract.
2. Pus corpuscles =
   - Ulceration of bowel.
   - Abscess burst into bowel.
   - Dysentery.
3. Epithelial cells increased greatly in number =
   - Catarrhal conditions of mucous membrane.

4. Cholesterin.
   Much increased.
   Not crystallised.
5. Crystals—
   Fatty acids.
   Charcot-Leyden (p. 13).
6. Inorganic salts—many.
   Oxalate of lime.
   Carbonate of lime.
   Phosphate of lime.
   Ammonio-magnesium phosphate, etc.
7. Parasites.
   Vegetable—
   Non-pathogenic.
   Pathogenic.
   Animal.

CHEMICAL EXAMINATION OF THE FÆCES.

1. Mucin—Always present.
   Forms basis of excretion—holds all together.
   Test—Stir up fæces with water.
   Add their own volume of lime water.
   Allow to stand some hours.
   Filter.
   To filtrate add acetic acid = precipitate.
   Increased
   Acute catarrh of intestines.
   Dysentery, etc.

2. ALBUMIN.

Test.

Acidify with acetic acid.
Stir up large quantity of water with fæces.
Filter several times.
Test filtrate for various proteids (*q. v.*).

Proteids—Absent in health.
Present in Diarrhœa.
Dysentery.
Enteric fever.

3. PEPTONE.

Test—Mix fæces with water.
Boil.
Filter while hot.
Allow filtrate to cool.
Test for albumin by adding acetic acid and ferrocyanide of potash.
If present, remove it by saturation with ammonium sulphate.
Test filtrate for peptone by biuret reaction, etc. (*q. v.*).

Occurrence.

Never present in health.
Present in Enteric fever.
Tubercular disease of intestines.
Dysentery.
Hepatic disease.

4. UREA.

Qualitative Test.

Add nitric acid, and examine by aid of microscope for nitrate of urea crystals.

Quantitative—(See "Urine").

5. Carbohydrates.

Starch—Detected by microscope, or
Add solution of iodine = deep blue.
Erythrodextrin = reddish colour with iodine solution.
Sugar = phenyl-hydrazin test (*q. v.*).

6. Bile Acids and Pigments.

Never present in health.

When present in large amount, they give their reactions.

Present in Catarrh of small intestine.
Enteric fever.

7. Fatty Acids.

Individual detection very difficult.

Formic.
Acetic.
Butyric.
Propionic.

8. Phenol.
Indol.
Skatol.
} Always present.

9. Fats.
Organic acids (non-volatile).
Cholesterin.
} Always present.

10. Pigments.

Urobilin (chief).

Test—Add water to fæces, shake up and filter.
Add little sulphuric acid and
Saturate with sulphate of ammonium.
Filter.
Wash residue with warm saturated solution of ammonium sulphate.
Extract with boiling alcoholic solution of ammonia.
Examine by spectroscope = characteristic absorption bands.

11. Hæmatin.

Derived from blood pigment.

Test —Teichmann's crystals (*q. v.*).
Spectroscope (*q. v.*).

12. Intestinal Gases.

Consist of—Carbonic acid.
Hydrogen.
Nitrogen.
Marsh gas.
Sulphuretted hydrogen.

13. Ptomaines.

Putrescin.
Cadaverin. } Normally present.

14. Ferments.

Diastase.
Invertin. } Normally present.

VEGETABLE PARASITES.

1. NON-PATHOGENIC.

(*a*) *Moulds.*

Oidium albicans—the only one of importance (see page 41).

(*b*) *Yeast.*

Yeast cells frequently present.

Single oval or round cells.

Groups of three or four, more usually.

(*c*) *Fission Fungi.*

Bacilli. } Very numerous. Occur as
Micrococci. }

(*a*) Bacterium termo (B. coli commune) in great abundance.

(*β*) Bacillus subtilis, as

Rods full of spores, or as

Threads with spores attached, or as

Groups of glassy spores alone.

(*γ*) Micrococci in zoogloœæ.

(*δ*) Clostridium butyricum.

Large round cells in strings (like beads) or clusters.

Staining Reaction for Fission Fungi.

Solution of iodine in iodide of potash stains the first three brownish colour, but the fourth a blue or violet colour.

2. PATHOGENIC FUNGI.

(*a*) *Bacillus of Enteric Fever.*

Short rod — 3 μ long (= $\frac{1}{3}$ diameter red blood corpuscle).

Often in threads.
Extremities rounded.
Spores often inside.
Flagella seen sometimes.

Method of Staining (*Lœffler*).

Make cover glass preparations (p. 16).

(1) Leave for from 5 to 10 minutes in solution of

{Concentrated alcoholic solution of methylene blue, 30 c.c.
Solution of caustic potash (1 in 10,000), 100 c.c.

(2) Wash for 5 or 10 seconds in solution of acetic acid ($\frac{1}{2}$ per cent.).

(3) Dehydrate in absolute alcohol.
Clear in oil of cloves.
Mount in Canada Balsam.

This bacillus has no specific stain.
Pure cultivations are therefore necessary for its full recognition.

In gelatine it grows rapidly.
Does not cause liquefaction.

(*b*) *Bacilli of Tuberculosis.*

Found in tubercular ulceration of bowels.
(*Fallacy*—If they only occur in small numbers, they may result from tubercular sputum swallowed.)
Detection—Proceed as for tubercular sputum (p. 17).

(*c*) *Bacilli of Cholera* (*Comma Bacillus*).

Short rod-like bacillus.
Thicker than tubercle bacillus.
Curved in form (comma-like).
Often joined in pairs—S-like.

FIG. 17.—COMMA BACILLI OF CHOLERA.

Stain in weak carbolo-fuchsin solution (p. 17), or by Gram's Method.

CULTIVATION.

Artificial Cultivation of these is required in order to arrive at correct diagnosis of Asiatic cholera.

Method of Cultivating Comma Bacillus (Cholera).

1. Place small quantity of alvine discharge in a vessel.
   Add an equal volume of alkaline meat broth.
   Keep at 40° C. for twelve hours.
   Bacilli multiply rapidly, and are found on surface.
   Make cover glass preparations of this.
   Stain with fuchsin, or methylene blue.
   Examine by microscope.

2. Plate cultivations on nutrient jelly may be made.
   They appear after 24 hours, as white colonies, with irregular sinuous outlines.
   Pale yellow or rose tint, like powdered glass.
   Gelatine soon liquefies.
3. If comma bacilli are found in the latter medium,
   Grow them deep in a tube of nutrient jelly.
   White colour appears along tract of needle.
   Funnel-shaped cavity is formed.
   Soon becomes like air-bubble.
   Jelly liquefies only at surface.
4. Grown on agar-agar.
   Grey slimy furrowed growths.
   No liquefaction.
5. May be cultivated in hanging drops.
   In 24 hours microscope shows—
   At centre of drop, swarms of motile bacteria.
   At periphery, spirilla—each with many convolutions.

(*d*) *Bacilli of Cholera Nostras.*

Resembles comma bacillus,
but longer,
broader.

Plate Cultivation—Colony round,
sharp edges,
brown in colour.
Gelatine soon liquefied.
Foul odour.

Deep Cultivation—Growth cylindrical.
Not funnel-shaped.

ANIMAL PARASITES.

I. Protozoa.

1. Sporozoa—Psorospermia.

Coccidia—Found in fæces and in liver.

Oval bodies.

Thin membrane enclosing

Granules arranged in groups.

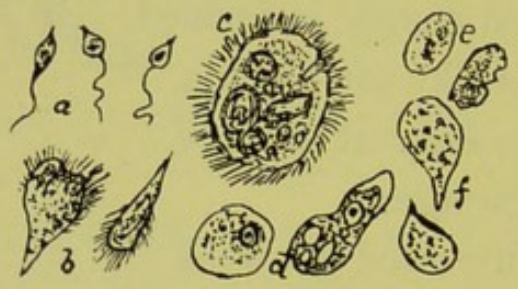


Fig. 18.—Rhizopods.

(*a*) Cercomonas intestinalis ; (*b*) Trichomonas intestinalis; (*c*) Paramœcium coli ; (*d*) Amœba coli ; (*e*) Monadines (dead) ; (*f*) Monadines (living).

2. Rhizopoda.

(*a*) Amœba coli—Large size.

(*b*) Monadines—Pear-shaped.

Long process to each.

Occur in fæces in

Enteric fever.

Phthisis.

3. Infusoria.

(*a*) Cercomonas intestinalis.

Pear-shaped body.

Eight hooklets.

Occurs in Diarrhœa.

Enteric fever.
Cholera.

(*b*) Trichomonas intestinalis.
Similar to preceding, but has
Ciliated disc at one extremity.

(*c*) Paramœcium coli.
Oval, 1 μ long.
Covered with cilia.

II. Platodes.

Class I.—Cestoidea.

1. (*a*) *Tœnia Solium.*
Length—6-10 feet.
Head —Square shape.
Size of small pin's head.
Four suckers.
Rostellum between these with
Double row of hooklets (compare with those from T. echinococcus).
Neck —Unsegmented—smooth.
One inch long.
Segments—(Proglottides).
Short near neck.
Become longer and more square-shaped farther down.
Uterus in each moderately branched.
Genital opening at border—at one or other side alternately.

Ovum—Oval.
Thick shell,
striated radially.
Embryo contained has six hooklets.

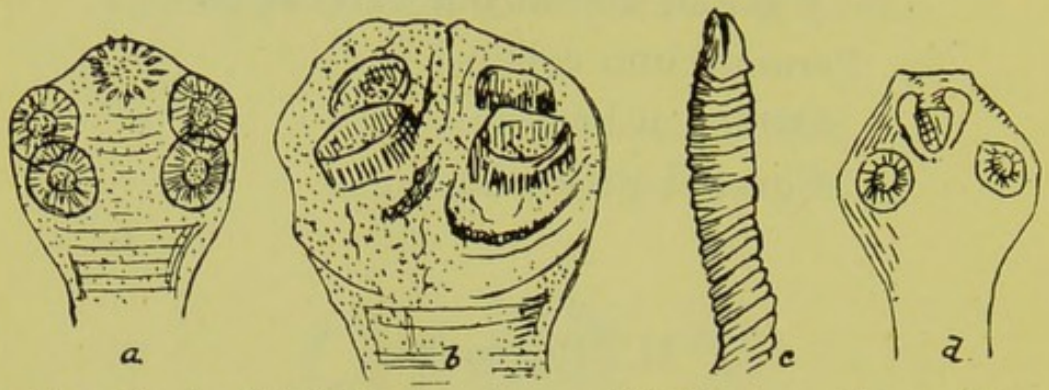


FIG. 19.—Head of (*a*) Tænia solium; (*b*) Tænia mediocanellata; (*c*) Bothriocephalus latus; (*d*) Tænia nana.

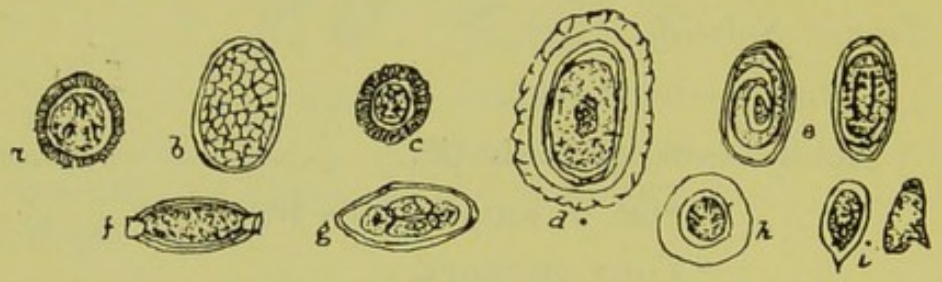


FIG. 20.—Eggs of (*a*) Tænia mediocanellata; (*b*) Bothriocephalus latus; (*c*) Tænia solium; (*d*) Ascaris lumbricoides; (*e*) Oxyuris vermicularis; (*f*) Tricocephalus dispar; (*g*) Anchylostomum duodenale; (*h*) Tænia nana; (*i*) Bilharzia hæmatobia.

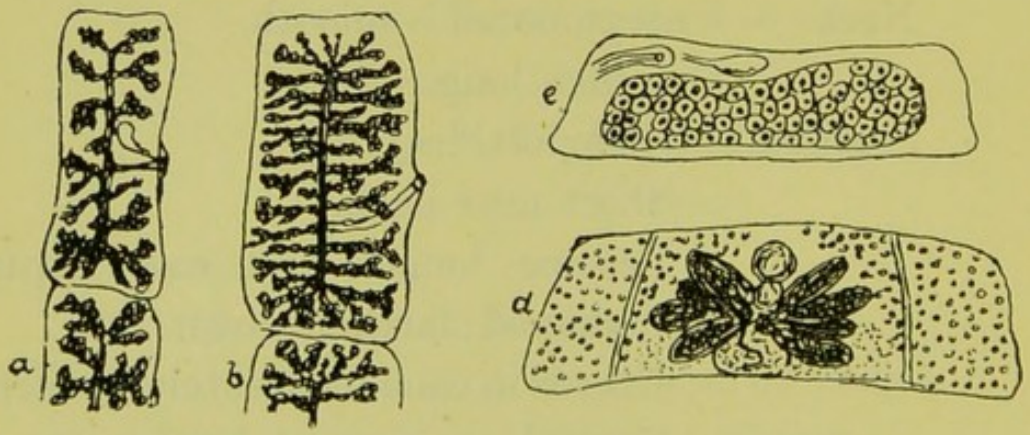


FIG. 21.—Proglottides of (*a*) Tænia solium; (*b*) Tænia mediocanellata (*c*) Tænia nana; (*d*) Bothriocephalus latus.

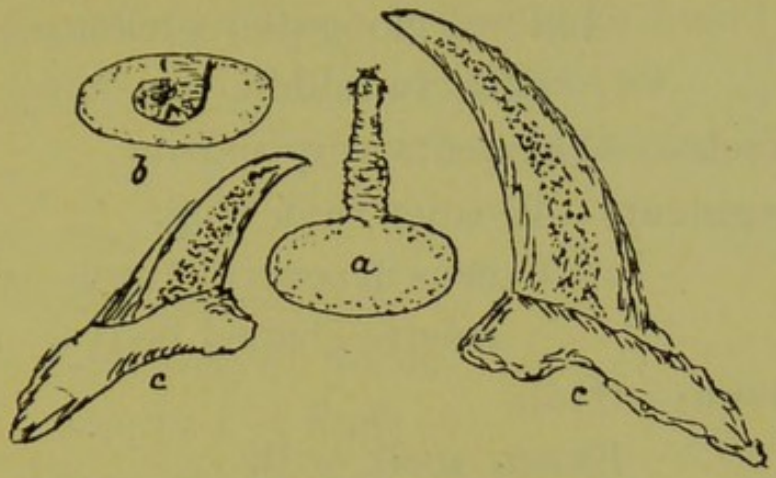


FIG. 22.—CYSTICERCUS CELLULOSÆ.

(*a*) Head protruded; (*b*) Head indrawn; (*c*) Hooks (× 350) (compare with size of Echinococci hooklets, Fig. 12).

(*b*) *Tænia Mediocanellata vel Saginata.*

Length—12-20 feet.

Head —Four dark suckers.
No rostellum.
No hooklets.

Neck —Unsegmented.

Segments—Each longer than broad.
Uterus much more branched than in T. solium.
Genital pore at lateral border of each segment.

Ovum—Oval.
Shell not so thick.
Embryo has no hooklets.

(*c*) *Bothriocephalus Latus.*

Length—15-25 feet.

Head —Oval.
Cleft.

Lateral elongated sucker on each side close to middle line.

Neck —Segments very narrow.

Segments—Broader than long.

Uterus in centre of each—resembling rosette-shaped body.

Ovum—Oval.

Brown shell, with

Operculum (lid).

(*d*) *Tænia Nana.*

Length—$\frac{1}{2}$-$\frac{3}{4}$ inch.

Head —Globular.

Four round suckers.

Rostellum (can be protruded).

Hooklets—twenty-four.

Neck —Unsegmented.

Body —Slender at first.

Soon increases in breadth.

Segments—Short.

Uterus oblong—full of eggs.

Ovum—Shell of double membrane.

Embryo has hooklets.

(*e*) *Tænia Cucumerina.*

Length—7-8 inches.

Head —Four suckers.

Rostellum (can be protruded).

Hooklets—sixty.

Neck —Finely segmented.

Segments—Much longer than broad.
Ovum —0·05 m.m. diameter.
Embryo has hooklets.

2. Trematodea.

(*a*) *Distoma hepaticum.*

Leaf-shaped worm.
Length —1 inch.
Breadth—$\frac{1}{2}$ inch.
Head—Small.
One sucker.
Body —Diffuse water vascular system.
Sucker on ventral aspect.
Uterus much convoluted.
Genital pore opens between the two suckers.
Ovum—Brown.
Shell of two layers.
Operculum.

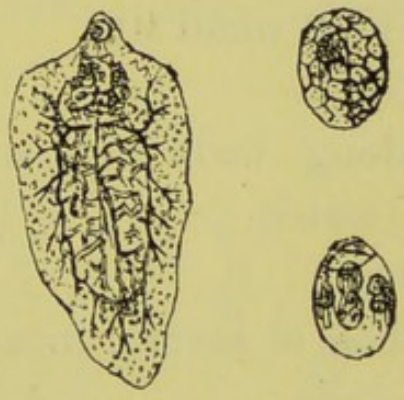


Fig. 23.—Distoma Hepaticum with Ova.

(*b*) *Distoma Lanceolatum.*

Lance-shaped – $\frac{3}{8}$ inch long.
Resembles preceding.
Ova contain the mature embryo.

CLASS II.—NEMATODEA, etc.

(*a*) *Ascaris Lumbricoides*—"Round Worm".

Resembles the earth worm.

Length—Male, 4-6 inches.
Female, 10-14 inches.

Head —Three lips.
Tactile papilla.
Teeth.

Ovum —Brown.
Round.
Tough shell covered by
Gelatinous layer.

(*b*) *Oxyuris Vermicularis*—"Thread Worm".

Resembles small pieces of white thread.

Length—Male, $\frac{1}{6}$-$\frac{1}{4}$ inch.
Female, $\frac{1}{3}$-$\frac{1}{2}$ inch.

Head —Three small lips.
Teeth.

Body —Along body two uteri extend backwards.

Ovum —Oval.
Shell of several membranes.

(*c*) *Anchylostoma Duodenale* (*Dochmius vel Strongylus Duodenalis*).

Length—Male, $\frac{1}{3}$-$\frac{1}{2}$ inch.

Head —Four claw-like hooks around mouth.
Two small teeth.

Tail of male ends in a pouch with three flaps.

Ovum —Oval.

Two or three daughter cells in each.

Note.—Ova are alone found in the fæces, so care has to be taken to discover them.

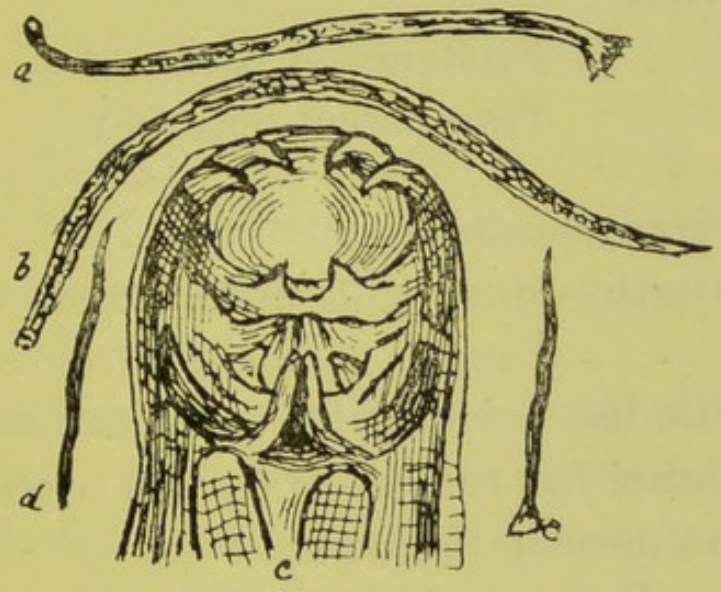


FIG. 24.—ANCHYLOSTOMA DUODENALE.

(*a*) Male (magnified); (*b*) Female (magnified); (*c*) Head showing hooks and teeth; (*d*) Female (twice natural size); (*e*) Male (twice natural size).

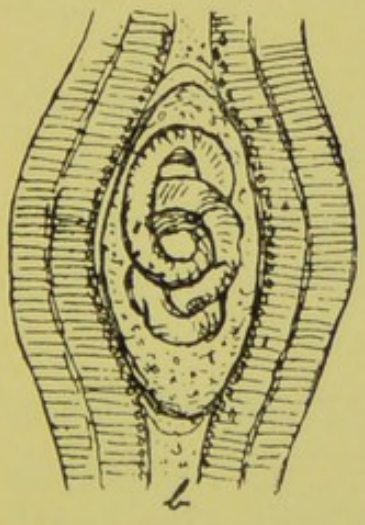


FIG. 25. TRICHINA SPIRALIS.
(*a*) Embrya.
(*b*) Encysted in muscle.

TRICHOCEPHALUS DISPAR (*a*) natural size; and OXYURIS VERMICULARIS (*b*) half natural size.

(*d*) *Trichocephalus Dispar*—"Whip Worm".

Length—Male, $1\frac{1}{2}$ inch.
Female, 2 inches.
Body —Short.
Long delicate process springs from one extremity.
Ovum —Oval.
Flattened at each end.
Transparent operculum.

(*e*) *Trichina Spiralis.*

Length—Male, $\frac{1}{20}$ inch.
Female, $\frac{1}{16}$ inch.
Male has four papillæ at one extremity.
Female has tubular ovary and uterus.
Ova develop in uterus.
Fully mature parasites are born.
Encapsuled in voluntary muscle—
Worm is rolled up spirally.
Enclosed in calcareous spindle-shaped envelope.

DISCHARGES FROM THE BOWELS IN CERTAIN DISEASES.

1. Acute Intestinal Catarrh.

Naked Eye Characters.

Evacuations fluid.
Foul smelling.
Much mucus (bile stained if there is catarrh of upper part of small intestine).
Yellowish brown in colour.
Undigested food present.

Chemical Characters.

Albumin present.
Mineral matter } increased excretion
Urea }

Microscopically.

Many leucocytes.
Much cylindrical epithelium.
Fungi—many.

2. Chronic Intestinal Catarrh.

As above.
Much bile-stained mucus.
Yellow mucus plugs.

3. Chronic Ulceration of Bowels.

(If in upper part of small intestine = usually no diarrhœa.)

In large intestine or rectum—

Naked Eye.

Copious diarrhœa.

Foul smell.

Pieces of mucous membrane (very diagnostic).

Small greyish nodules (of densely packed leucocytes).

Microscopically.

Blood corpuscles.

Pus corpuscles.

Aggregations of leucocytes.

4. Membranous Enteritis.

Naked Eye—Strings or tube-like structures evacuated at each straining with or without diarrhœa.

Membranes—Dirty white colour.
Length, 6—20 c.m.

Chemically—Chiefly mucus.
Alkalis cause liquefaction.

Microscopically.

Clear streaked ground substance.

Glistening fibrin threads.

Many degenerated columnar epithelial cells.

Many leucocytes.

Crystals of triple phosphate.

Cholesterin.

5. Enteric Fever.

Naked Eye—Copious diarrhœa.
Yellow colour (pea soup).
Oval sloughs of mucous membrane.

Chemically—Much mucus.
Albumin.
Much bile pigment.

Microscopically.

Leucocytes.
Epithelial cells, bile stained.
Crystals—Triple phosphate.
Carbonate of ammonia.
Blood or hæmatin may be present.
Many fungi.

Bacteriological examination (*q.v.*).

6. Dysentery.

Naked Eye—Watery.
Pinkish.
Very foul smelling—gangrenous odour.
Dark brown particles.
Much mucus, often appearing like frog spawn.
Mucus often blood or bile stained.
Blood often in spots or streaks in mucus.

Chemically—Mucus.
Serum albumin.
Peptone.

Microscopically.

Leucocytes.
Pus cells, many.

Much epithelium.
Blood in corpuscles or
Blood pigment.
Fungi.

7. Cholera.

Naked Eye—Rice water stools.
Semen-like odour only.
Greyish white in colour.
Particles — like swollen rice — suspended.

Chemically—Reaction, alkaline or neutral.
Specific gravity, 1006-13.
Much mucus.
Serum albumin.
No bile.
Leucin and tyrosin.
Indol present.
Nitrites always present.
(Test—Add dilute sulphuric acid = red colour.)

Microscopically.
Many leucocytes and red blood corpuscles.
Much swollen cylindrical epithelium.
"Comma bacillus," and many others.
Leucin and tyrosin.
Cultivation Methods (*q.v.*).

8. Acholic Stools.

Naked Eye—Hard consistence.
Very fœtid.

Chalky colour.
Much fat.

Chemically—No bilirubin or other bile pigments.
Crystals of fatty acids.

9. Gall Stones.

Cholesterin nearly always present.
Extract with boiling alcohol.
Then with alcoholic solution of potash.
Crystallise and examine.

Meconium.

This is the fæces of children newly born. Consists really of concentrated bile.

Naked Eye Characters.

Dark greenish brown or black in colour.
No putrefactive odour.
Viscid.
Acid reaction.

Chemically—Mucin.
Bile pigments (stercobilin absent).
Bile acids.
Cholesterin.
Fatty acids.

Microscopically.

Cylindrical epithelium.
Leucocytes (often stained green).
Fat globules.
Cholesterin.
Mineral matters—Triple phosphate chiefly.

EXAMINATION OF THE PRODUCTS OF INFLAMMATION.

PUS.

Naked Eye Characters.

Varieties.
- Thick yellow (*laudable pus*).
- Brownish red (from admixture with blood—*sanious pus*).
- Curdy pus.
- Watery pus.
- Putrid—Thin green or red in colour.

Specific gravity, 1030-1040.

Reaction alkaline (rarely acid ?).

Chemically.

Proteids present.
- Serum albumin.
- Serum globulin.
- Albumoses—usually alkali albumin.
- Much peptone.

Glucose. } Usually present.
Acetone. }

Glycogen—contained in leucocytes.

Fats.

Cholesterin.

Inorganic salts.

Does not coagulate spontaneously.

Microscopically.

Leucocytes in great abundance.

Living and contractile, but

Usually shrunken and dead.

Granular in appearance.

Three nuclei usually (rendered very evident by adding acetic acid).

May be very large with

Fatty particles.

Fat globules free.

Red blood corpuscles.

Crystals.

Hæmatoidin—Often found where there has been old extravasation.

Fatty Acids—Found in old abscesses.

Cholesterin—Present in chronic or septic abscess.

Triple Phosphate—Occurs along with decomposing pus.

Micro-Organisms.

(*a*) Micrococci found in Acute abscess.

Occur as Streptococci.

Diplococci.

Stain by Gram's method (p. 22).

(*b*) Specific Organisms.

(1) Tubercle Bacilli often detected (p. 21).

(2) Anthrax Bacilli.

May occur in pus of malignant pustule.
Microscopical characters (*q. v.*).
For thorough identification, artificial cultivation is necessary.

(3) Bacillus of Tetanus.

Make cover glass preparations.
Stain by Gram's method.
Bacillus appears as delicate rod.
Spore at one extremity frequently.

(4) Bacillus of Leprosy.

Stain as for tubercle bacilli (p. 17).
They stain much more readily.
Bacilli resemble tubercle bacilli.

(5) Bacillus of Influenza.

Stain by Lœffler's (p. 91), or Ziehl-Neelsen's methods (p. 17). (They do not stain by Gram's method.)
Exist as minute rods.

(6) Bacillus of Glanders.

Found in pus from Farcy buds.
Nasal discharge.
Stain by Lœffler's method (p. 91).
Each is a minute rod.
Spore at one extremity frequently.

(7) Actinomycosis.

Pus thin.
Small yellow granules visible.
Microscopically.
Each granule consists of :—

Dense mass of small pear-shaped bodies (Fig. 10).
Arranged radially.
Centre consists of dense felted network (seen by pressing down cover glass).
Each thread of network consists of a series of minute spheres connected by a delicate envelope.

TRANSUDATIONS.

1. Ordinary Non-Inflammatory Dropsical Fluid.

Naked Eye Characters.

Pale yellowish-green colour.
Reaction alkaline.
Specific gravity, 1010-1015.
Does not coagulate spontaneously.

Chemically.

Serum albumin.
Serum globulin.
Fibrinogen.
No peptone.
Sugar.
Urea.
Uric acid. } In small amount.
Mineral matters—Chiefly chloride of sodium.

Microscopically.

Few leucocytes, and

Red blood corpuscles.
Few degenerated epithelial cells.

Results from—

(1) Obstruction to flow of blood through heart or lungs; *e.g.*,
Obstructive valvular disease of heart.
Chronic lung diseases.

(2) Diseased conditions of the blood.
Bright's disease.
Anæmia.

(3) Inflammation of blood-vessels, allowing increased transudation.

2. Inflammatory Dropsy.

Naked Eye—Clear fluid.
Yellow colour.
Specific gravity, 1018-25.
Coagulates on standing.
Reaction, alkaline.

Chemically—Serum albumin. } In large amount.
Serum globulin. }
No peptone.
Sugar. }
Acetone. } Almost always present.
Uric acid. }

Microscopically.
Leucocytes in abundance.
Some red blood corpuscles.
Some epithelial cells.
Fat globules.
Micro-organisms.

Results from

All local inflammatory conditions.

3. Hæmorrhagic Exudations.

Colour—Pale or dark red.

Chemical composition as in preceding, but

More red blood corpuscles.

Examine for

Tubercle bacilli.

Cancer cells.

Colloid masses.

Cancer Cells.

Very large.

Irregular in size.

Lie in heaps.

Contain vacuoles—

One large nucleus (seldom several).

Fatty globules.

Hæmorrhagic exudation occurs in

Hæmorrhagic diathesis.

Tuberculosis.

New formations.

CONTENTS OF CYSTS.

1. Ovarian Cyst Fluid.

Naked Eye Characters—vary remarkably.

Clear—but usually turbid.

Yellow, green, or brown in colour.
Viscous (from presence of pseudo-mucin).
Specific gravity, 1020-1025.
Alkaline reaction.
Seldom coagulates spontaneously.

Chemically.

Much albumin, and
Metalbumin (the ropy substance formed during colloid degeneration, and which is not precipitated by acids).

Tests for metalbumin.

Add three times its volume of alcohol to the fluid.
Set aside for 24 hours.
Filter ; squeeze precipitate.
Shake up residue in water.
Again filter. Test filtrate.

(1) Boil = turbidity, but no precipitate.
(2) Add acetic acid = no precipitate.
(3) Add Millon's reagent and boil = bluish red colour.

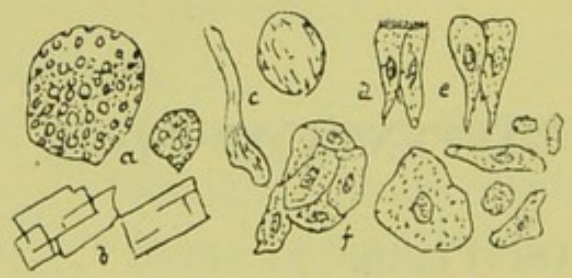


FIG. 26.—CONTENTS OF OVARIAN CYST.

(*a*) Epithelial cells, fattily degenerated ; (*b*) Cholesterin crystals ; (*c*) Colloid bodies ; (*d*) Ciliated epithelial cells ; (*e*) Columnar epithelial cells ; (*f*) Squamous epithelial cells.

(4) Strong sulphuric acid and acetic acid = violet colour.
(5) Boil with dilute sulphuric acid = reducing sugar formed.

Microscopically.

Red blood corpuscles.
Leucocytes.
Epithelium, Squamous. } Usually fattily degenerated.
Cubical. }
Ciliated. } Large granular "ovarian cells".
Cholesterin crystals frequently.
Blood pigment.

2. Parovarian Cyst.

Naked Eye—Clear watery fluid.
Specific gravity, low.
Chemically—Mucinoid substance absent.

3. Dermoid Cyst.

Naked Eye Characters.

Hair.
Nail.
Tooth.
Bone, etc.
Microscopically—The above.
Epithelium of all varieties.
Fat globules.
Hæmatoidin crystals.
Cholesterin.

4. Hydatid Cyst.

Naked Eye—Clear watery fluid.
Opalescent in some cases.
Reaction, alkaline or neutral.
Specific gravity, 1006-1010.

Chemically—Little or no albumin.
Glucose. } In small amount.
Urea. }
Mineral salts in large amount.
} *i.e.*, saline fluid.
Biliary constituents may be present.

Microscopically—Allow to stand for 24 hours in conical glass. Then examine sediment (Fig. 12).

Hooklets of echinococcus—
Small and deeply curved (compare with those of Tænia solium).

Hydatid membrane.
Portions show it to be
Composed of layers, which are
Transversely striated.

Scolices may be present—each with
Two rows of hooklets.
Four suckers.

Hæmatoidin crystals.

5. Pancreatic Cyst.

Naked Eye Characters.
Usually turbid.
May be bloody.
Specific gravity, 1010-12.
Reaction, alkaline.

Chemically.

Serum albumin.
Methæmoglobin (if blood present).
Cholesterin, plenty.
Test digestive action—
(*a*) Converts starch at once into maltose (p. 40).
(*b*) Digests albumin *without* presence of acid.
These actions do not take place in long standing cases of cyst formation.

6. Fluid in Hydronephrosis.

Naked Eye—Clear pale.
Watery fluid.
Specific gravity, 1009-15.

Chemically—Serum albumin. } In small amounts.
Serum globulin. }
Urea.
Uric acid.

Microscopically—Epithelium from renal tubules (of greatest importance).

7. Thyroid Cyst Fluid.

Naked Eye—Turbid.
Viscid.
Reddish or brown in colour.

Chemically—Serum albumin. } In large amount,
Serum globulin. } 7-8 per cent.
Colloid material.
Methæmoglobin.

Microscopically.

Degenerated red blood corpuscles.
Hæmatoidin crystals.
Cholesterin.

CEREBRO-SPINAL FLUID.

Naked Eye Characters.

Clear watery.
Reaction, neutral or faintly alkaline.
Specific gravity, 1007-8.

Chemically—Proteids in small amount. } Serum globulin. Albumoses.
No fibrinogen.
Substance having reducing action on copper solutions (pyrocatechin ?).
Mineral salts — chiefly chloride of sodium.

Note.—Repeated tappings increase the percentage of proteids.

SEMINAL FLUID.

Naked Eye Characters.

Whitish fluid.
Thick opaque.
Peculiar powerful odour.
Reaction, alkaline.

Chemical Characters—Serum albumin.
Serum globulin.
Many mineral salts.

FIG. 27.—SEMINAL FLUID.

(*a*) Spermatozoa ; (*b*) Böttcher's crystals ; (*c*) Amyloid corpuscles (prostatic) ; (*d*) Hyaline bodies ; (*e*) Squamous epithelial cells from urethra ; (*f*) Columnar epithelial cells ; (*g*) Testicle cells.

Microscopical Characters—Spermatozoa—
Long threads, each with
Conical head.
Rapid vibratile motion.
Length, 50-55 μ.
Epithelium—Squamous.
Columnar.
Finely granular "testicle cells".
Few leucocytes.
Lecithin corpuscles.
Corpora amylacea (from prostatic secretion).
Spermatic crystals (from prostatic secretion).

GONOCOCCI

Occur in heaps—small or large.
Frequently in pairs.

Each like a coffee-bean.
Often contained in pus cells or
epithelial cells.

FIG. 28.—GONOCOCCI.
Free and in pus cells.

Stain cover glass preparations (p. 16) in concentrated watery solution of methylene blue for 30 seconds.
Wash in water.
Dry thoroughly.
Mount in Canada Balsam.

VAGINAL SECRETION.

Naked Eye Characters.
Thin mucous fluid.
Reaction, acid.
Chemically—Mucin.
Microscopically—Few large leucocytes.
Large epithelial squamous cells.
Various fungi.

Trichomonas vaginalis—
10 μ long.
Oval in shape.
Long tail.
Three flagella.
Row of cilia.

MENSTRUAL SECRETION.

Microscopically—Many blood corpuscles.
Leucocytes.
Columnar epithelial cells (fattily degenerated) from cervical and uterine cavities.
Squamous epithelial plates from vagina.
Mucous corpuscles.

LOCHIAL DISCHARGE.

1. *Early*—Thin.
Red fluid.
Microscopically—Many red blood corpuscles.
Epithelial cells—
Columnar from uterus.
Squamous from vagina.
2. *Later*—Whiter in colour.
Leucocytes chiefly.
Epithelium.
Micro-organisms usually present.

CARCINOMA UTERI CERVICIS.

Reddish brown.
Watery discharge.

Microscopically.

Epithelium.
Fatty cells.
Fibrous stroma.
Alveoli with irregularly sized epithelial cells with large nuclei.

LACTEAL SECRETION.

Colostrum.

Colostrum present during pregnancy, and immediately after parturition.

Naked Eye Characters.

Thin turbid fluid.
More yellow in colour than ordinary milk.
Reaction, strongly alkaline.

Chemically.

Proteids in large amount, 7-8 per cent.
Serum albumin.
Serum globulin.
Casein (less than in pure milk), 2·7 per cent.
Fat, 4-5 per cent.
Mineral salts, 0·4-0·5 per cent.

Fig. 29.—Colostrum.

Microscopically.

"Colostrum corpuscles" arranged in groups = mammary gland cells fattily degenerated.

Few leucocytes.

Epithelial cells from galactoferous ducts.

After Parturition—Ordinary Milk.

"Colostrum corpuscles" gradually disappear.

Naked Eye Characters.

Thin.

Whitish fluid.

Slight creamy layer on standing.

Reaction, alkaline.

Daily secretion, 700-1000 c.c.

Specific gravity, 1030-2.

Chemically.

Serum albumin. } 3 per cent.
Casein. }

No serum globulin.

No peptone.

Nuclein present.

Fat, 3-4 per cent.

Milk sugar, 4-5 per cent.

Microscopically.

Fat globules of varying size.

Minute particles of casein and nuclein.

Micro-organisms.

Examine for tubercle bacilli by ordinary methods (p. 17).

Milk in Diseased Conditions of the Body.

1. Jaundice.

   Bile pigments. } Present in some cases.
   Bile acids. }

2. Bright's Disease.

   Serum albumin. } In far larger proportion.
   Casein. }

   Fat. } Much diminished.
   Milk sugar. }

3. Drugs Excreted in the Lacteal Secretion.

   Arsenic.
   Antimony.
   Lead.
   Zinc.
   Mercury.
   Iodine.
   Opium.

AMNIOTIC FLUID.

Naked Eye Characters.

Thin watery—may be slightly viscid
Greenish-yellow fluid.
Odour heavy.
Often mixed with meconium.
Specific gravity, 1007-11.
Alkaline reaction.

Chemically consists of—

Water.

Proteids—globulin.
Mucin.
Lactic acid.
Urea.
Grape sugar.
Mineral matters, chlorides and phosphates.
Creatinin.

CORPORA AMYLACEA.

Found in Pituitary, Pineal, Prostatic } glands, etc.

Tests. (1) Add solution of iodine = brown colour.

(2) Add iodine and sulphuric acid = blue colour.

CHALK STONES OR TOPHI IN GOUT.

White hard calcareous nodules.

Chemically. Crystals of urate of sodium—closely aggregated.

Microscopically. Crystals of urate of calcium in some cases.

PARASITES OF THE HAIR AND NAILS.

I. Moulds.

1. Achorion Schœnleinii (Favus).

Found as yellow honeycombed scabs with mousy odour on

Scalp —producing bald patches.
Nails—breaking them up.
Skin.

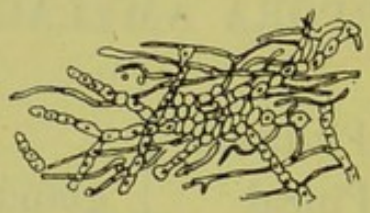


Fig. 30.—Achorion Schœnleinii.

Microscopically.

Tease particle of scab in alcohol, containing a little ammonia, and examine in glycerine.

Consists of—Epithelial cells.
Dense mycelium of short tubes.
Rows of conidia spores.

2. Trichophyton Tonsurans (Ringworm).

Occurs in the Scalp (Tinea tonsurans).
Beard (Tinea sycosis).
Skin (Tinea circinata).

Naked Eye Characters (T. tonsurans).

Bald patches.
Short broken hairs seen.

Ends of broken hairs split up—brush-like.
Diseased hairs become white on dropping chloroform on them.

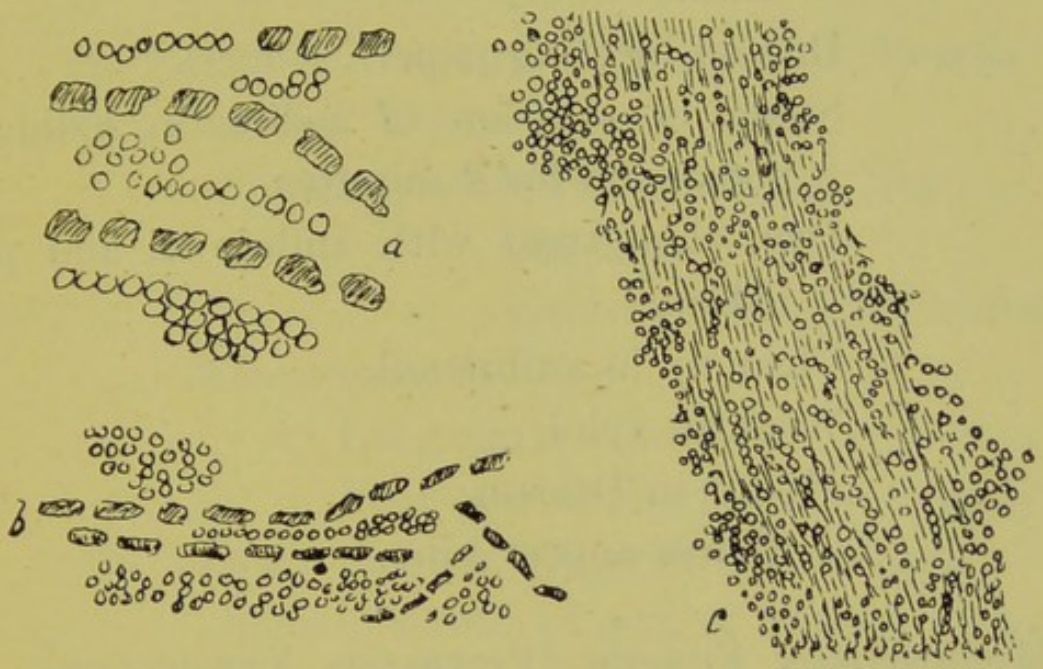


FIG. 31.—TINEA TONSURANS.

(*a*) Large spored fungus and mycelium; (*b*) Small spored fungus and mycelium; (*c*) Hair broken up by spores.

Microscopically.

Place the affected hairs in a drop of liquor potassii.
Seen to be opaque from spores inside.
Normal appearance of hair gone.
Surface of hair rough.
Pigment—not normal.
Free end ragged, bulbous, or fringed.
Packed with spores of three varieties, oval or round in form. { Large. Small.
Arranged in rows.
Not affected by ether.
Mycelium present.

Method of Staining.

Steep hairs for 1-2 minutes in 5 per cent. alcoholic solution of gentian-violet in aniline water.

Dry on blotting-paper.

Steep in solution of iodine in iodide of potassium for 2 minutes.

Dry, then treat with aniline oil and pure iodine.

Clear up in aniline oil.

Wash in xylol.

Mount in Balsam.

Spores appear blue.

3. Microsporon Furfur (Pityriasis Versicolor).

Occurs as—Yellowish-brown.
Scaly patches on
Skin of trunk.

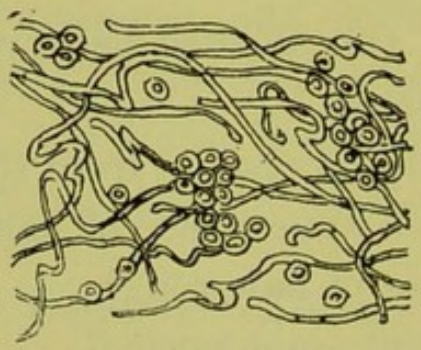


Fig. 32.—Microsporon Furfur.

Microscopically.

Place a few scales along with liquor potassii on a glass slide.

Squamous epithelial cells.

Abundant mycelial threads.

Spores arranged in groups—like grapes.

Each spore is larger than that seen in T. tonsurans.

II. External Animal Parasites or Epizoa.

(*a*) Demodex Folliculorum.

Found in sebaceous glands of Nose.

Cheeks.

External auditory meatus.

Microscopically.

Long narrow animal.

Four pair of short legs anteriorly.

(*b*) Acarus Scabiei (Sarcoptes Hominis).

Female found at end of tunnel, along with its eggs.

Just visible to naked eye as yellow oval body.

Microscopically.

Length, $\frac{1}{50}$ inch—male shorter.

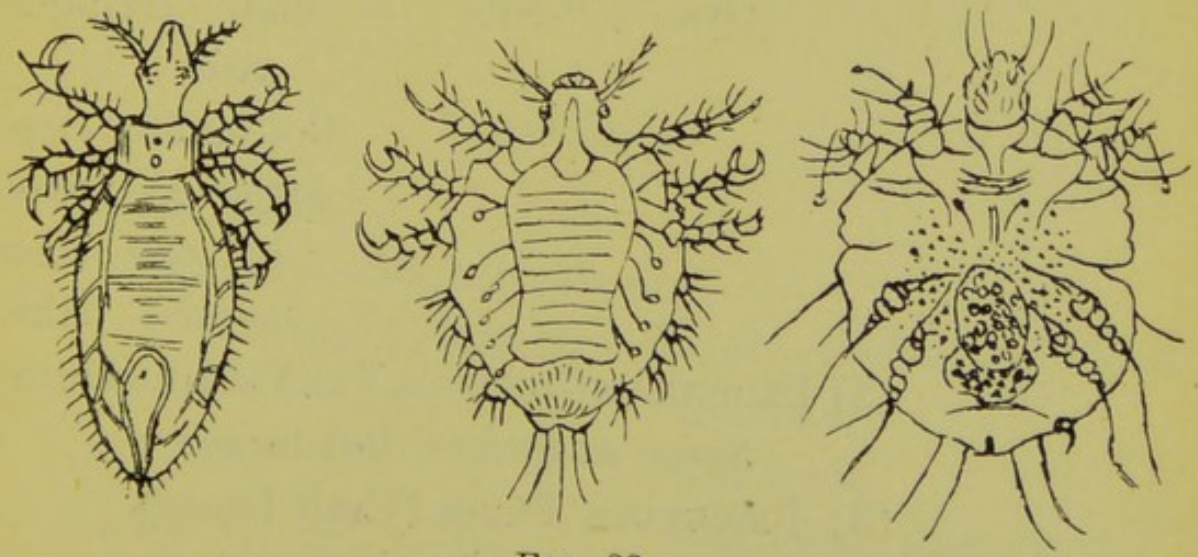


Fig. 33.

Pediculus Vestimentorum. Pediculus Pubis. Acarus Scabiei.

Head.
Four anterior limbs, each with sucker.
Four posterior limbs—
All pointed in female.
Two pointed, and two with suckers, in male.
Numerous bristles over body.
Ova often present.

(*c*) Pediculi (Lice).

(1) Pediculus Capitis.
Found in hair of scalp.
Head—mouth small, tubular, with sucker.
Body flat.
Transparent.
Segments distinct.
Legs—Three pairs.
Short.
Clawed.
Ova — "Nits" = small triangular cases.
Containing eggs.
Attached firmly by one corner to the hairs.

(2) Pediculus Corporis Vel Vestimentorum.
Same as former, but larger.

(3) Pediculus Pubis (Crab Louse).
Body is broader and shorter than preceding.

THE BLOOD.

General Composition.

Water,	77·99	per cent.
Solids of corpuscles,	14·01	,,
Serum albumin, Serum globulin,	6·94	,,
Fibrinogen,	0·22	,,
Extractives, Salts,	0·68	,,
Fat,	0·16	,,
Gases,	O, CO_2, N	

The Blood.

1. Consistence.

Normally—Slightly viscous.

Lessened viscosity = watery condition of blood.

Anæmia.

Chlorosis.

Pernicious anæmia.

Increased viscosity—Cholera.

Pneumonia.

2. Coagulation.

Normally it coagulates in from two to six minutes.

Delayed coagulation.

After taking neutral salts, as

Oxalates.

Citrates.

Alcohol.

After leech bites.

Rapid respiratory movements.

Anæmic conditions.

Febrile states.

Hastened coagulation.

Pneumonia.

Rheumatic Fever.

Calcium chloride taken internally.

Breathing mixture of carbonic acid and air.

No coagulation—Hæmophilia.

Estimation of Rate of Coagulation.

(1) Roughly.

Allow a little blood to flow into a watch-glass.

Pass a needle through this at intervals of thirty seconds.

Needle entangled in fibrin = coagulation commencing.

(2) Method more accurate.

Have a series of capillary tubes—all of 0·25 m.m. calibre.

Keep them at a constant temperature of 38° C.

Prick finger.

Allow blood to flow into each tube to depth of 5 c.m.

Replace in chamber at 38° C.

Ascertain condition of coagulation at succeeding intervals by blowing down the tubes.

Note when coagulation first takes place.

3. Colour.

Pale or pinkish = hæmoglobin reduced in amount.
- Anæmia.
- Chlorosis.
- Pernicious anæmia.
- Leucocythæmia.

Very bright red—as after
- Inhalation of oxygen.
- Carbonic oxide poisoning.

Dark venous colour = oxygenation defective.
- Chronic lung diseases.
- Heart disease with increased backward pressure.

4. Reaction.

Normally—Alkaline, due to
- Carbonate of sodium.
- Phosphate of sodium (Na_2HPO4).

Diminished alkalinity—as occurs in
- Fevers.
- Leucocythæmia.
- Pernicious anæmia.
- Uræmia.

Diabetes.
Carbonic acid poisoning.

Quantitative Estimation of Alkalinity.

Use glazed red litmus papers of known degrees of acidity.

Allow a drop of freshly-drawn blood to lie on one of these papers for ten seconds.

Wash off, and note reaction.

If blue distinct = greater alkalinity.

So take a paper containing more acid and place drop of blood on it.

Do this with successive papers of increasing acidity

Till no reaction (blue) is obtained.

Paper which gives the faintest reaction represents the degree of alkalinity of the blood.

5. Specific Gravity.

Normally—1060.

Diminished in (*a*) pregnancy.
(*b*) anæmia.
(*c*) starvation.
(*d*) ingestion of food.
(*e*) diminution of hæmoglobin.

Estimation of Specific Gravity.

(1) Series of test tubes required.

Fill each with mixture of glycerine and water in varying proportion, but so that the specific gravities range from 1035 to 1075.

Keep all at a temperature of 60° F.

Prick the finger.

Draw up the blood into a "dropping tube" (a tube fine at one extremity, expanded at the opposite end, and closed by an indiarubber cap).

Place the open end of this tube in the centre of one of the test tubes containing the glycerine and water.

Gently press the elastic cap, and a drop of blood escapes.

If it falls = specific gravity of mixture too low.

Place another drop in tube with higher specific gravity.

If it rises to surface = specific gravity of mixture too high.

When drop neither rises nor falls in a test tube, then

Specific gravity of mixture = that of the blood which is being examined.

(2) Another Method.

In vessel have mixture of chloroform and benzol.

Allow drop of blood to fall into this.

Alter specific gravity by adding one or other constituent

Till drop remains suspended in mixture.

Take specific gravity of mixture now = that of the blood.

6. Estimation of Red and White Blood Corpuscles.

(*a*) Hæmocytometer of Thoma and Zeiss easy to manipulate.

Consists of :—

(1) Glass slide containing cell of known depth ($\frac{1}{4000}$ m.m.).

Squares of known size engraved on floor of cell.

(2) Capillary pipette with bulbous enlargement at upper end containing a bead—Stem is marked at definite intervals.

Method.

Prick tip of finger with pricker.

Apply tip of capillary tube to exuding blood.

Allow blood to run in till at mark 0·5 or 1.

Wipe tip of pipette with soft cloth.

Suck into pipette a solution of common salt (3 per cent.) till it reaches the level marked 101.

Shake pipette thoroughly to mix blood and salt solution.

Blow out salt solution remaining in capillary part of tube.

Place a large drop of the mixture on the centre of the hollow cell on the slide.

Accurately place over the drop the prepared cover glass.

See that drop does not touch sides of cell at any point.

See that no air bubbles are included.

Set aside on level surface for ten minutes to allow corpuscles to settle.

Place slide under microscope.

Low Power first to see that no air bubbles are present.

Find scale, and fix slide.

High Power.

Count number of corpuscles in sixteen adjoining squares (each set of sixteen squares is divided off by double dark lines, and so is easily seen).

Greater accuracy got by counting several sets of sixteen. Divide the total number of corpuscles by the number of sets = average number to each set of sixteen.

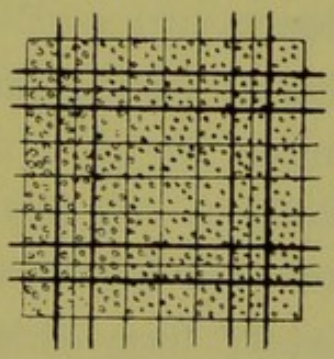


FIG. 34.—PART OF SCALE OF THOMA-ZEISS.
Apparatus, showing squares to be counted.

Calculation.

Multiply number of corpuscles in sixteen squares by 4000.

Multiply result by 200 if 0·5 m.m. blood taken, or by 100 if 1 m.m. blood taken.

Divide product by 16 =

Number of corpuscles per cubic millimetre of blood.

(*b*) *Gowers' Hæmocytometer.*

Frequently used ; not so easy to count the corpuscles, as the squares are larger.

Consists of :—

(1) Pipette with mark at level of 5 m.m.

(2) Another to hold 995 m.m.

(3) Small glass jar with stirring rod.

(4) Glass slide with cell, $\frac{1}{5}$ m.m. deep.

Diluting solution = Sulphate of soda, 104 grs.
Acetic acid, . . 1 dr.
Distilled water, . 4 ozs.

Method.

Measure by pipette 995 m.m. of the soda solution.

Place this in mixing jar.

Prick finger.

Allow blood to run into capillary pipette till at level of 5 c.m.m.

Immediately blow this into the soda solution.

Stir well.

Place a small drop of this in *centre* of cell.

Gently adjust cover glass, and fix with clips.

Set aside on level surface for ten minutes.

Then examine with microscope.

(The lines in the micrometer scale may be rendered more evident by rubbing in with

the finger tip a little graphite scraped from an ordinary writing pencil. Then dust off the surplus).

Calculation.

Count number of corpuscles in ten adjoining squares.

Multiply this number by ten thousand = number of corpuscles per cubic millimetre of blood.

Normal Number.

Five million per cubic millimetre in man.

Four and a half million per cubic millimetre in woman.

White Blood Corpuscles.

(*a*) Slightly raise the object glass out of focus.

Leucocytes then appear as brightly refracting white bodies.

(*b*) May be stained thus :—

Use the 3 per cent. salt solution or the sulphate of soda solution coloured with gentian violet.

Leucocytes take on the stain, but not the red blood corpuscles.

(*c*) Red blood corpuscles may be entirely dissolved by mixing the blood with ten parts solution of acetic acid (half per cent.).

Leucocytes are easily seen.

Remember this dilution in making the estimation.

Estimate the white blood corpuscles in the same way as the red.

Normal Number—6000 to 10,000 per cubic millimetre.

In children, 9500 per cubic millimetre.

NUMBER OF RED BLOOD CORPUSCLES.

Diminished (Oligocythæmia).

(1) Loss of blood.

(2) Anæmia, chlorosis.

May be two million per cubic millimetre, or less.

Increased.

(1) Natural condition—as to six and a half million per cubic millimetre.

(2) Plethoric condition.

NUMBER OF LEUCOCYTES.

Normally—One to six or seven hundred red blood corpuscles.

Increased (Leucocytosis).

(1) In health during digestion—greatest number, three to four hours after a meal—as 1 to 150 red corpuscles.

(2) Newly-born infant—
1 to 80 or 100.

(3) During pregnancy.

(4) In disease.
Leucocythæmia.

(5) Chlorosis.

(6) Pernicious Anæmia.
(7) Inflammation of lymphatic glands.
(8) Inflammatory exudations ;
e.g., croupous pneumonia.
(9) Chronic cachectic diseases.
(10) Septic diseases.
Puerperal septicæmia.
Erysipelas.
Diphtheria.
Osteomyelitis.
(11) Acute articular rheumatism.

7. Estimation of Hæmoglobin.

Hæmoglobinometer or Chromometer of Gowers usually used.

Consists of—

Two glass tubes of equal size.

(*a*) One filled with glycerine jelly so tinted with carmine that its colour is equal to that of normal blood diluted one hundred times.

(*b*) The other carries a graduated scale.

(*c*) Capillary pipette to hold 20 cubic millimetres of blood.

(*d*) Pricker and dropping bottle.

Method.

Place a few drops of distilled water into empty tube.

Prick finger.

Allow 20 cubic millimetres of blood to run into capillary tube.

Blow this into the distilled water in the graduated tube and mix.

Reduce colour by adding distilled water in drops till tint becomes same as that of standard jelly.

When so, number on scale at level of fluid = percentage oxyhæmoglobin present in the blood examined.

In *comparing the colour*, hold the two tubes against the window, and allow the diffuse white light to pass through them.

Relative Value of Corpuscle.

The value of each corpuscle relatively to the normal is expressed by a fraction got by estimating the number of corpuscles, and the amount of hæmoglobin present.

Example. Suppose these were 3,500,000 red blood corpuscles per cubic millimetre, and 60 per cent. of hæmoglobin in a specimen of blood.

If 100 represent the normal number, we have here only 70 corpuscles ($5 : 3{\cdot}5 :: 100 : x = 70$), so $\frac{60}{70} = \frac{6}{7}$ths of a normal corpuscle.

Hæmoglobin.

Diminished in

(1) Chlorosis.
(2) Leucocythæmia.
(3) Cirrhosis of liver and kidneys.
(4) Diabetes mellitus, etc.

8. Microscopical Examination of the Blood.

Method.

Thoroughly cleanse tip of finger by washing with turpentine, then ether, then solution of corrosive sublimate.

Prick finger.

Place small drop on slide by touching the exuding blood with the slide.

Place cover-glass immediately on, and examine.

Note.

(*a*) Colour of red blood corpuscles.
- Normal.
- Pale.
- Pigmented.

(*b*) Shape of red blood corpuscles.

(*c*) Formation of rouleaux.
- Rapidly.
- Slowly.
- Irregularly.

(*d*) Leucocytes.
- Size.
- Number of nuclei.
- Relative proportion to red corpuscles (roughly).

(*e*) Blood plates.
- Size.
- Number.

(*f*) Pigment granules.

(*g*) Micrococci, bacteria, spirilli.

(*a*) *Colour of red blood corpuscles.*

Paler in cases where hæmoglobin is diminished.

Pigmented.

(*b*) *Shape of red corpuscles.*

Often altered.

Flattened, less biconvex than normally ; *e.g.*, anæmia.

(1) Oval, pear-shaped, Star-shaped, Kidney-shaped, etc. } = Change in shape. Poikilocytosis.

(2) Small round bodies, containing hæmoglobin (may be buds separated from ordinary red blood corpuscles). } = Microcytes.

(3) Similar bodies—only larger than the ordinary red corpuscles. } = Megaloblasts.

(4) Nucleated red corpuscles, occur of

(*a*) Normal size—same as red blood corpuscle—

Nucleus centrally placed.

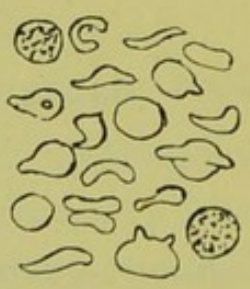


FIG. 35.—BLOOD IN POIKILOCYTOSIS.

(β) Large size — three or four times size of ordinary red corpuscle—

Nucleus usually eccentrically placed.

Poikilocytosis occurs in—

1. Leucocythæmia.
2. Waxy disease of internal organs.
3. Advanced anæmia or chlorosis.
4. Malignant disease.

(*c*) *Formation of Rouleaux.*

In some cases blood corpuscles do not tend to form rouleaux.

Corpuscles may remain isolated.

,, may form irregular clusters.

This occurs in Anæmia.

Increased rapidity of rouleaux formation.

In hyperinotic conditions of the blood.

Pneumonia.

Retarded Formation.

Anæmia.

Hæmophilia.

Hæmoglobinæmia.

(*d*) *Leucocytes*—may occur in various forms.

(1) Small—Lymphocytes.

Smaller than normal red corpuscle, 6 μ.

Nucleus single, but large.

(2) Large—Size of red corpuscle, 8-10 μ.
Hyaline cells free from granules.
Nucleus single—showing incipient division.

(3) Large finely granular, 8-9 μ.
Larger than red corpuscles.
Nuclei separate, or may be united.
Contractile processes seen.

(4) Coarsely granular = *eosinophilous cells* (oxyphile), 10-11 μ.
Strongly refracting granules conspicuous in cell substance.
Cover-glass preparations stained in eosin =

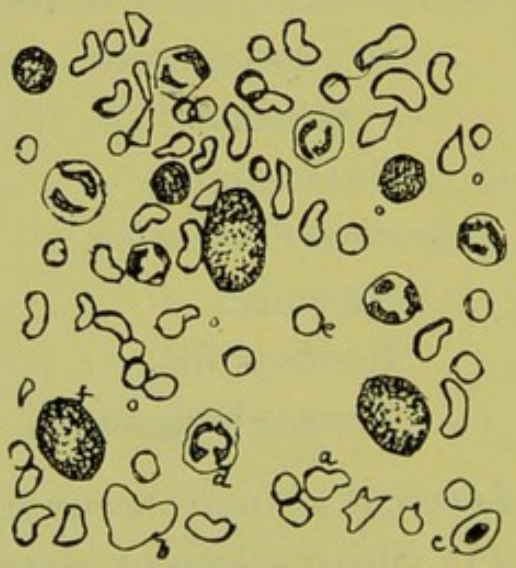


FIG. 36.—EOSINOPHILOUS CELLS IN LEUCOCYTHÆMIC BLOOD.

(*a*) Advanced poikilocytosis; (*b*) Megalocyte; (*c*) Megaloblast; (*d*) Polynucleated leucocyte; (*e*) Normal red blood corpuscle; (*f*) Eosinophilous cells.

Granules seize stain, and appear as

Shining red particles in the strawberry-red cell.

Horseshoe-shaped nucleus.

(5) Finely granular (basiphile), 7 μ.

Nucleus trilobed.

"Mast Cells" or Basiphilous Granules.

Stain easily in basic aniline dyes, as

Concentrated watery solution of methylene blue.

Granules—not so closely placed as in eosinophilous cells.

Not uniform in size in one cell.

Some globular—others elongated in shape.

Methods of Staining Mast Cells.

1. Leucocytes in a fresh preparation may be stained by running in by side of cover-glass a drop of weak eosin-hæmatoxylin stain.
2. Make two cover-glass films of the blood (p. 16). Dry them in incubator for some hours, or

(*a*) Fix them in absolute alcohol for one hour, or

(*b*) Fix them while still wet by placing them in saturated solution of corrosive sublimate, made with normal saline (0·7 per cent. NaCl), for 30 minutes.

Wash freely in water, and

Stain in concentrated solution of eosin in alcohol

For 30 minutes.
Wash in distilled water.
Stain in strong solution of methylene blue for some minutes.
Again wash in water.
Dry thoroughly, and mount in Balsam.

Red corpuscles are stained uniformly red.
White corpuscles only feebly tinged.
Eosinophilous granules stained very markedly.

3. Films prepared as above may be stained for 24 hours in mixture of

Eosin,
Nigrosin or Indulin, } of each 2 grammes.
Aurantia,
Glycerine, 30 ,,

Then wash in distilled water.
Dry and mount in Canada Balsam.

Red corpuscles stained orange colour.
Leucocytes—protoplasm stained dirty grey.
Nuclei stained darker.
Eosinophilous cells vivid red.

4. Ehrlich's Hæmatoxylin Eosin Solution.

Hæmatoxylin, 0·5 grammes.
Acetic acid, 2 ,,
Distilled water,
Alcohol, } of each 10 c.c.
Glycerine,
Add alum in excess.
Allow to stand exposed to sun for six weeks.
Then add one per cent. eosin.

Stain films for 24 hours.

Then wash in water ; dry and mount in Balsam.

Red corpuscles stain strawberry red.

Leucocytes remain colourless, their nuclei are dark.

Eosinophilous granules deep red.

Single nucleus of small lymphocytes almost black.

(*e*) *Blood plates* (*plaques—platelets*).

To see these blood must be "fixed" by Hayem's fluid.

Hayem's Fluid.

Common salt, one gramme.

Sulphate of sodium, 5 grammes.

Corrosive sublimate, $\frac{1}{2}$ gramme.

Distilled water, 200 c.c.

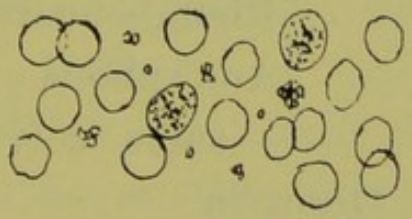


Fig. 37.—Blood Plates.

Method.

Having cleansed the finger tip thoroughly,

Place a drop of this solution on the finger.

Prick the finger through the fluid.
Exuding blood is at once fixed by the reagent.
Place drop on slide, cover and examine with high magnifying power.

Platelets occur
Normally as
Minute colourless bodies.
Single or in groups.
Each $1\frac{1}{2}$-3 μ. in diameter.
Increased in number.
Anæmia.
Pregnancy.

(*f*) *Pigment granules.*
Melanin usually—found in
Serum—floating free.
Enclosed in leucocytes.
Hæmatoidin crystals.
Small brick red.
Rhombohedral in shape.
Amorphous granules also of same colour.
Occur in
(1) Old blood extravasations.
(2) Aneurismal sacs.
(3) Corpora lutea.
Hæmatin crystals (Teichmann's crystals).
They indicate the presence of hæmoglobin.
Mahogany-brown in colour.

Oblique rhombic prisms.

Test—Dry the fluid (blood) on the slide.
Add a drop of glacial acetic acid, and a
Tiny crystal of common salt.
Heat gently.
Hæmoglobin present = hæmatin crystals seen by microscope.

(*g*) Micro-Organisms in the Blood.

Method of obtaining the blood.

Cleanse thoroughly the tip of one finger with soap and water and brush.
Wash with corrosive sublimate solution (1 to 1000).
Finally with alcohol and ether.
Prick finger deeply with sterilised needle.
Allow blood to flow.
Hold perfectly clean cover-glass by forceps.
Allow it to touch the blood as it flows.
Place another clean cover-glass immediately over the first, so getting fine film between the two.
Slide them apart.
Allow to dry under cover, or
Hold well above a bunsen flame.
When quite dry stain them.

Staining—

Place on film few drops strong watery solution of any basic aniline dye, or
Float cover-glass face downwards on stain in watch-glass.
Allow to stain for five minutes.
Remove and wash thoroughly in distilled water.
Examine at once, or
Dry thoroughly, and mount in Balsam for permanency.

Stains may be—
Methylene blue.
Methyl- or gentian-violet.
Bismarck brown.
Fuchsin, etc.

Gram's method may be employed.

In this method the stain is discharged from everything except the micro-organisms, which therefore are readily seen.

Stain prepared cover-glass in an alcoholic solution of gentian-violet in aniline oil water (p. 20).
Transfer to solution of iodine in iodide of potassium (iodine, 1 gramme; iodide of potassium, 2 grammes; distilled water, 300 c.c.).
Allow to remain in this two or three minutes.
Wash in absolute alcohol.
Mount in Canada Balsam.

Special Organisms.

Anthrax Bacilli.

Cover-glass preparations prepared as above described, show increased number of leucocytes.

Characteristic bacilli very numerous.

Each is short rod, 0·006-0·012 m.m. long.

Extremities slightly thickened.

Transverse segmentation may be present.

Fig. 38.—Bacillus Anthracis.
(*a*) Bacilli enclosed in leucocytes.

Bacilli of Tetanus.

Found arranged in groups or Threads.

Spore formation occasionally.

Bacilli of Tuberculosis.

Only found in blood in cases of Acute Miliary Tuberculosis.

Stain by Ziehl-Neelsen or Heneage Gibbe's stain (p. 17).

Bacilli of Glanders.

Appear as short rods—about 0·003 m.m. long.
Spores often seen at extremities.

Spirilli of Relapsing Fever (Spirochæta Obermeieri).

(1) If blood examined during attack
Fine spiral thread-like bodies seen,
Actively moving and causing
Peculiar vibratile motion in red blood corpuscles.
Each is in length about three times diameter of white blood corpuscle.
Melanin particles often present.

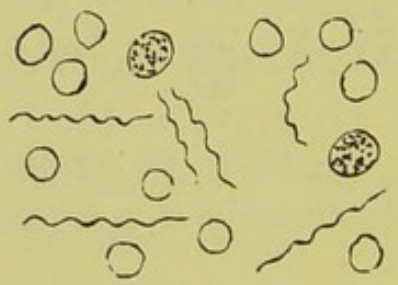


Fig. 39.—Spirilli of Relapsing Fever.

(2) During interval between attacks.
No spirilli present usually ; but
Many highly refractile bodies—probably spores.

Streptococci.

Stain cover glass preparations by Gram's method.

In most of the septic fevers the distinctive cocci are present in the blood as

Septic endocarditis.
Puerperal Fever.
Erysipelas.
Pneumonia.
Purpura.

Hæmatozoa.

1. Protozoa.

Characteristic types of this family found in blood of persons suffering from Malaria.

Hæmamœba Malaria found in tertian and quartan ague.

Lavarania Malaria present in anomalous forms.

Method of preparation.

Thoroughly cleanse tip of finger (*ut supra*).

Place on tip of finger a drop of a solution of methylene blue in normal saline (0·7 per cent.) solution—thoroughly sterilised.

Prick finger through drop.

Apply cover-glass to exuding blood mixed with stain.

Place this on slide, and examine with microscope.

Permanent preparations can be obtained by making

Cover-glass films.

Stain with methylene-blue-eosin solution.

TERTIAN AGUE.

During interval of attack—blood shows
Small motile bodies.
Each with one to three long delicate dark processes.

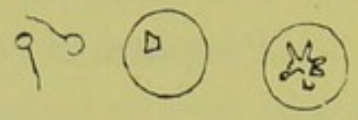


FIG. 40.—TERTIAN AGUE.
Forms of parasite as found free in blood or in red blood corpuscles shortly after a paroxysm.

Later—Parasite found inside red corpuscles.
Motile, but
Without processes.
Surrounded by melanin granules.

Still later—
Parasite in red blood corpuscles still, but
Larger,
Actively moving.
Several processes—
Hæmoglobin of these cells small in amount.
Therefore many red corpuscles appear pale.

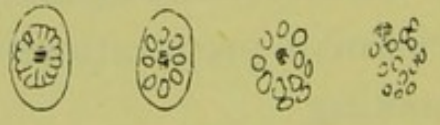


FIG. 41.—TERTIAN AGUE.
Segmentation of parasite.
Period—commencement of attack.

Later—

Pigment granules accumulate towards centre of plasmodium.

Each begins to divide into 15 or 20 segments.

Pyrexial attack on second day—

Red corpuscle now breaks down.

Results of segmentation of parasite escape into serum.

Pyrexial attack ensues—

(This new generation has taken two days to develop.)

When methylene blue has been used—the plasmodia are stained light blue, so are easily distinguished lying either outside or inside the red corpuscles.

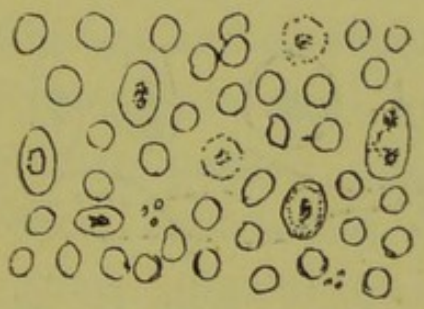


FIG. 42.—TERTIAN AGUE.
Appearance of blood at commencement of attack.

QUARTAN AGUE.

Stages of development very much the same as in tertian.

Three days elapse before segmentation is complete.

Each plasmodium breaks up into only six or twelve segments.

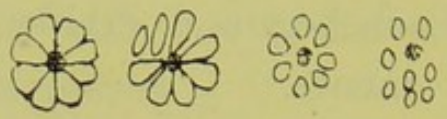


FIG. 43.—QUARTAN AGUE.
Process of segmentation.

IRREGULAR FORMS OF AGUE.

Plasmodium exists in this variety, as

Small round motile body, or

Larger, colourless and immobile amœba.

In other cases it appears as a

Crescentic or scaphoid body (Lavarania malariæ).

Other forms are oval, and possess long flagella.

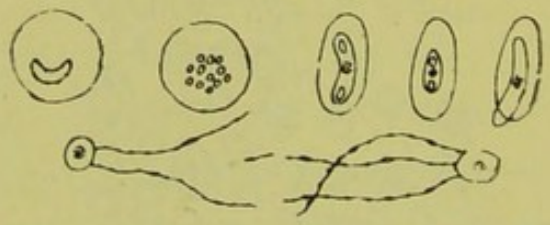


FIG. 44.—PARASITES OF ACYCLICAL FORMS OF AGUE.

2. VERMES.

FILARIA SANGUINIS HOMINIS (Nematode).

Present in blood chiefly during night, so examine it then.

Male, $1\frac{1}{4}$ inch long.

Transversely striated.

Very granular.

Larva, 0-34 m.m. long.

Enclosed in structureless sac, which is longer than worm itself.

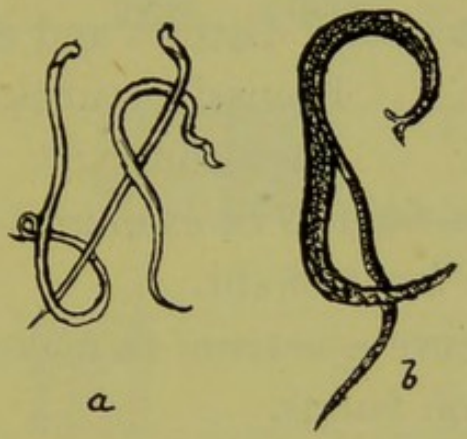


FIG. 45.—(*a*) FILARIA SANGUINIS HOMINIS.
(*b*) BILHARZIA HÆMATOBIA, male and female.

BILHARZIA VEL DISTOMA HÆMATOBIUM (Trematode).

Found in portal vein and its rootlets chiefly.

Male, 12-14 m.m. long.

Thicker and shorter than female.

Gynæphoric canal, in which female lies.

Suckers present (also in female).

Ova—small oval bodies, 0·12 m.m. long.

Sharp spine at apex or side of each.

SPECTROSCOPIC EXAMINATION OF BLOOD.

SPECTRUM ANALYSIS.

Precautions.

Small hand spectroscope usually used.

Direct it towards diffuse white light, as from clouds, and not towards the sun.

If artificial illumination be used, place small crystal of common salt in the flame to mark distinctly in the spectrum the sodium line.

First obtain distinct and clear spectrum by

Focussing tubes or

Narrowing slit.

Place fluid to be examined in tube, and hold in front of slit.

Observe spectrum to make out any absorption bands.

If fluid be too concentrated, dilute with distilled water till a clear spectrum is obtained.

(*a*) Oxyhæmoglobin.

With normal blood the spectrum shows two absorption bands, due to oxyhæmoglobin.

These are between the lines D and E of Fraunhofer.

That nearest D is more sharply defined, and narrower than the other near E.

(*b*) Reduced Hæmoglobin—spectrum.

One broad dark band.

Between D and E.

Overlapping D a little.

(*c*) Methæmoglobin.

This is a colouring matter of the blood.

Consists in a more intimate union of

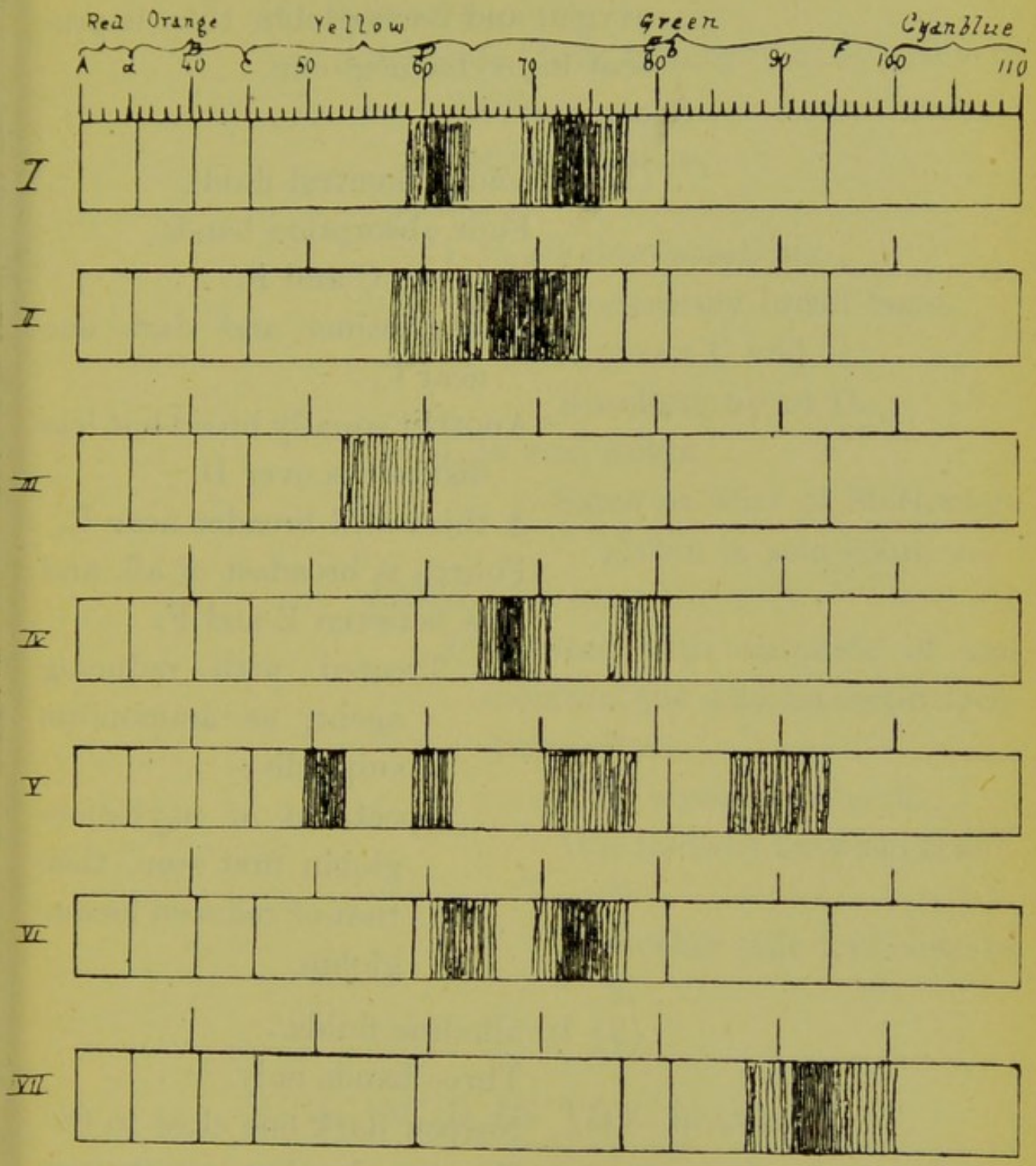


FIG. 46.—SPECTRA OF:

I. OXYHÆMOGLOBIN.
II. REDUCED HÆMOGLOBIN.
III. HÆMATIN IN ALKALINE SOLUTION.
IV. REDUCED HÆMATIN.
V. METHÆMOGLOBIN IN ACID AND NEUTRAL SOLUTIONS.
VI. CARBONIC ACID HÆMOGLOBIN.
VII. UROBILIN IN ACID SOLUTION.

oxygen and hæmoglobin than is present in oxyhæmoglobin.

Spectrum.

(1) In acid or neutral fluids.

Four absorption bands.

Between C and F.

Most distinct and dark one near C.

Another equally broad but less distinct is over D.

A third still broader near E.

Fourth is broadest of all, and is between E and F.

Treated with reducing agent, as ammonium sulphide—

Spectrum of oxyhæmoglobin first seen, then that of reduced hæmoglobin.

(2) In alkaline fluids.

Three bands only.

Narrow dark one close to C.

Two broader, but less distinct, between D and E.

Methæmoglobin occurs in the blood in

(1) Chlorate of potassium poisoning.

(2) Chlorate of sodium poisoning.

(3) Hæmaturia—some cases.

(4) HÆMATIN.

Separated from hæmoglobin by action of
Acids or
Strong alkalies.

Spectrum.

(1) In alkaline solutions.
Moderately broad band.
Between C and D.
Reaching up to D.

(2) In acid fluids.
Same as that of Methæmoglobin in acid solution.

Reduced hæmatin.

If treated with sulphide of ammonium, the acid hæmatin spectrum shows
Two absorption bands.
One midway between D and E.
The other pale and close to E.

URIC ACID IN THE BLOOD.

May be detected by Garrod's test.
Procure serum of blood by applying a small blister to the skin.
Place two drachms of this into flat glass dish.
Add two drops acetic acid.
Place a fine linen fibre in it.

Set aside till it becomes of the consistence of jelly.

If uric acid be in excess in the blood, crystals are seen by aid of the microscope clinging to the fibre.

Occurs in blood in

(1) Gout.
(2) Bright's disease.
(3) Croupous Pneumonia.
(4) Cardiac Diseases.
(5) Pleurisy.

UREA IN BLOOD.

Method of Estimation.

Take 50 c.c. blood.
100 c.c. absolute alcohol. } Mix.

Place in stoppered bottle for twenty-four hours.

Filter.

Wash residue well with absolute alcohol.

Evaporate alcoholic extract to dryness.

Redissolve residue in absolute alcohol.

Filter—Again evaporate filtrate to dryness.

Dissolve residue in water.

Estimate urea in it by Ureometer (*q. v.*).

GRAPE SUGAR IN BLOOD.

It is normally present in small amount in blood.

Methods of Estimation.

(1) Take two drachms of serum, got by applying blister to skin.
Add four times its volume of water.
Acidify with acetic acid, and
Boil to separate the proteids.
Filter.
Estimate sugar in filtrate by Fehling's method (*q. v.*).

(2) Another method.
Rub up two or more drachms of blood with solid sulphate of ammonium in a mortar (so precipitating all the proteids).
Filter.
Test filtrate for sugar by adding phenyl-hydrazin and heating (*q. v.*).

Increased in amount.
(1) Diabetes mellitus.
(2) Carcinoma (?).

FAT IN THE BLOOD—LIPÆMIA.

It is present in small amount normally.
When *increased* in amount, blood is
Pale.
Turbid.
Layer of fat collects on surface on standing.
Fat globules seen by aid of microscope.
Increased in amount.
(1) During digestion.
(2) Diabetes.

(3) Bright's disease.
(4) Chronic alcoholism.
(5) Injury to medulla of long bones.

BILE IN THE BLOOD—CHOLÆMIA.

Bile pigments or bile acids may be present.

Test for Bilirubin.

Obtain serum from blister, or by allowing blood to coagulate.

Heat it slowly to 70-80° C.

Coagulum forms, and if it be—

Whitish-yellow in colour = no bile pigment.

Greenish = bilirubin present as biliverdin.

ACETONE IN BLOOD—ACETONÆMIA.

Not present normally in blood.

Test—Shake up blood with ether.

Heat = distinctive smell.

(Other tests, see "Urine".)

Occurs in (1) Diabetes (?).
(2) Fevers.

CHANGES IN THE BLOOD IN CERTAIN DISEASES.

1. Primary Anæmia.

General and extreme diminution in total solid constituents.

Red corpuscles diminished in number (never extreme).

Red corpuscles diminished in size.

Show slight poikilocytosis.

White corpuscles diminished in number—but

Not relatively to red corpuscles.

Hæmoglobin diminished in amount.

May be extreme diminution.

2. Secondary Anæmia.

As that consequent on Phthisis.

Wasting diseases.

Carcinoma.

Red blood corpuscles diminished in number.

Marked poikilocytosis.

White corpuscles often considerably increased.

Hæmoglobin diminished.

3. Chlorosis.

Blood often pale in colour.

Specific gravity diminished.

Red blood corpuscles diminished in number.

Very pale.

Often extreme poikilocytosis.

Microcytes. } Often present.
Megaloblasts. }

White corpuscles diminished in number (not relatively to red).

Hæmoglobin diminished extremely—even to 20 per cent.

4. Hæmoglobinæmia.

If blood stands in conical glass vessel for 24 hours;

Serum is stained ruby-red in colour.

Red corpuscles do not tend to form rouleaux.

Poikilocytosis present.

"Phantom corpuscles" = pale colourless discs, numerous.

Occurrence.

(1) Acute infectious diseases.

Scarlatina.

Typhus.

(2) Malaria.

(3) Syphilis.

(4) Certain poisons.

Antipyrin, antifebrin, phenacetin.

Sulphonal.

Naphthol.

Hydrochloric acid.

5. Pernicious Anæmia.

Blood pale and watery in appearance.

Coagulation slow.

Feeble in degree.

Red blood corpuscles diminished extremely in number as to 500,000 per c.m.m.

Poikilocytosis marked.

Often much larger than normal (10-12 μ. = megaloblasts).

Microcytes also.

Nucleated red corpuscles sometimes seen.

White corpuscles not diminished.

Even increased sometimes.

Hæmoglobin diminished *absolutely* as to 12-15 per cent., but increased in relation to number of red corpuscles.

Blood plates few in number, and often absent.

Eosinophilous cells present.

6. Melanæmia.

Dark granules, or (more rarely) small masses of melanin seen

Floating in serum between corpuscles, or

Enclosed in leucocytes.

Occur in (1) Malaria.

(2) Relapsing Fever.

7. Leucocythæmia.

Blood pale and greasy in character.

Red blood corpuscles greatly diminished in number as to 2-3 millions per c.m.m.

Pale.

Mis-shapen (poikilocytosis).

Nucleated often.

Leucocytes increased enormously in number, as to proportion of one to three red corpuscles.

Large.
Small.
Giant-sized.

Contain hæmoglobin.
Mast cells present, easily stain with eosin in some cases.

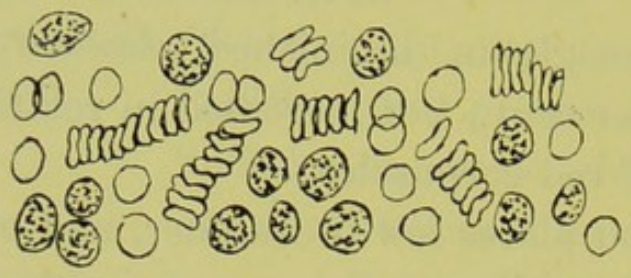


FIG. 47.—BLOOD IN LEUCOCYTHÆMIA.

Hæmoglobin greatly reduced.
Blood plates very numerous.
Crystals—oblong and shining (Charcot's).
Sometimes found in blood during life.
Always present after death.
Leucin.
Tyrosin.

8. CROUPOUS PNEUMONIA.
Leucocytes greatly increased—may be 60,000 per c.m.m.
This begins few hours after rigor.
Reaches height in 20 to 30 hours.
Chiefly multinucleated.
Eosinophilous cells—a few.

9. PSEUDO-LEUCOCYTHÆMIA.
Blood changes resemble much those of true leucocythæmia.

Red corpuscles greatly decreased as to $1\frac{1}{2}$ to 2 millions per c.m.m.
Leucocytes only slightly increased in number.
Hæmoglobin greatly diminished.

10. Typhus Abdominalis.

Leucocytes very few—1800 to 5000 per c.m.m.
Multinucleated chiefly.

11. Gout.

Uric acid always in excess during attack.
Oxalic acid present.

12. Rheumatic Fever.

Fibrin increased.

13. Hodgkin's Disease.

Red blood corpuscles diminished.
Rouleaux not well formed.

CHANGES IN THE BLOOD IN CERTAIN POISONS.

1. Carbonic Acid.

Blood remains fluid.
Dark purple colour.
When diluted gives spectrum of reduced hæmoglobin—a broad dark band between lines D and E (see "Spectra").

2. Carbonic Oxide.

Blood throughout body bright red in colour.

Spectrum—two bands between D and E.
Darker than in oxyhæmoglobin.
Placed nearer the violet end.

Combination of carbonic oxide with hæmoglobin cannot be reduced by sulphide of ammonium.

Add little sulphide of ammonium to the blood, and
Few drops of acetic acid = fine red colour produced.

Same reagents with normal blood = greyish green.

3. Sulphuretted Hydrogen.

Blood dark throughout body.
Dull green colour.
No special spectrum.

4. Chlorate of Potassium, Antifebrin, Nitrite of Amyl, as poisons = Methæmoglobin in blood (see "Spectra").

THE PULSE.

I. Pulse Rate.

Normal Frequency.

Adult male, 65-75.
Adult female, 70-80.
Children—varies with their age, 80-90.

(*a*) *Increased Frequency of Pulse Beat.*

(1) Fevers (except enteric, and occasionally meningitis).

(2) Great debility.
(3) Nervous diseases, as
Exophthalmic goitre.
Hysteria.
(4) Mitral regurgitation.
Occasionally also in aortic regurgitation.
(5) In infancy.

(*b*) *Diminished Pulse Rate.*
(1) Functional heart disease, as in
Jaundice.
Gout.
(2) Organic heart disease, as
Fatty degeneration (when resting).
Aortic stenosis.
(3) Some nervous diseases.
Migraine.
Meningitis.
(4) After crisis in fevers.
(5) Stimulation of cardio-inhibitory centre, as in intestinal troubles.

II. Rhythm of Pulse.

This may be studied in sphygmograms.

Intermittent Pulse—omission of a beat or beats.

Seen in (1) Nervous derangements.
(2) Weak ventricular contraction, as in
Fatty degeneration of heart.
Dilatation of heart.
Mitral disease.

III. Volume of Pulse.

(*a*) *Large.*

(1) Early stage of fevers.
(2) Atheroma of vessels (elasticity lessened).
(3) Hypertrophy of ventricle.
(4) Excitement of heart.
(5) Aortic regurgitation.

(*b*) *Small.*

(1) Total volume of blood in body reduced.
(2) Mitral disease —Regurgitation.
Stenosis.
(3) Aortic stenosis.
(4) Cardiac weakness, as in
Collapse,
Dilated heart,
Fatty, } degeneration of heart.
Fibroid, }

IV. Compressibility of Pulse—gauged by amount of pressure required to obliterate pulse below point of pressure.

High Tension.

(1) Chronic Bright's disease.
(2) Peritonitis.

Low Tension.

(1) Feeble action of heart.
(2) Relaxation of arteries.
(3) Mitral disease.
(4) Fevers.

V. Dicrotic Pulse—can be felt by finger.

Occurs in

(1) Low arterial tension.
(2) Relaxation of capillaries and smaller arterioles (vasomotor paralysis).
(3) Elasticity of arterial walls.
(4) Abrupt ventricular systole.
(5) Nearly every fever.

Hyperdicrotic Pulse—occurs in

(1) High fever with great exhaustion.
(2) General debility.

THE SPHYGMOGRAPH.

METHOD OF TAKING A SPHYGMOGRAM BY

1. MAREY'S INSTRUMENT.

Seat the person at a low table.

Place the forearm and hand on a double inclined plane (usually made up of the lid of the box).

Let the fingers be semiflexed and easy.

Mark out position of radial artery for some distance with a pencil.

Screw up clockwork of instrument.

Place pressure at zero mark.

Apply ivory pad accurately over the centre of the artery as it lies to the inner side of the styloid process of the radius.

Strap instrument firmly to arm.

Take strip of glazed paper and fit it to the slide which carries it, bending its edges over the frame.

Now remove it, and smoke it evenly over by holding it above a piece of burning camphor.

Again fix it in the carrying slide.

Apply slide with smoked paper to instrument.

Adjust writing point (by moving the screw) to centre of strip, and see that it moves freely.

Regulate pressure by the eccentric till the maximum amount of movement of the writing lever is obtained.

Set clockwork going, and take tracing.

Write on it, with a fine dry pen, or with a pin, name of patient, date, nature of disease, amount of pressure.

Varnish by dipping into vessel of photographic varnish, and allow to dry.

2. Dudgeon's Instrument.

Prepare instrument as above.

Mark out line of artery.

Support arm on book, and keep it steady.

Hold fingers easily open.

Slip retaining band over hand.

Place button exactly over the artery, the box resting above on the forearm.

Tighten band, and clamp it.

Apply pressure by screwing the milled head.

Insert smoked paper on right-hand side between roller and wheels.

See that pointer is making its maximum amount of movement.

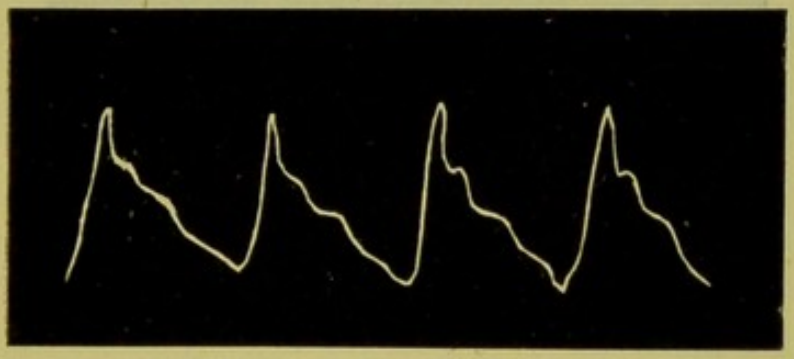
Set clockwork moving, and take tracing.

Finish as before.

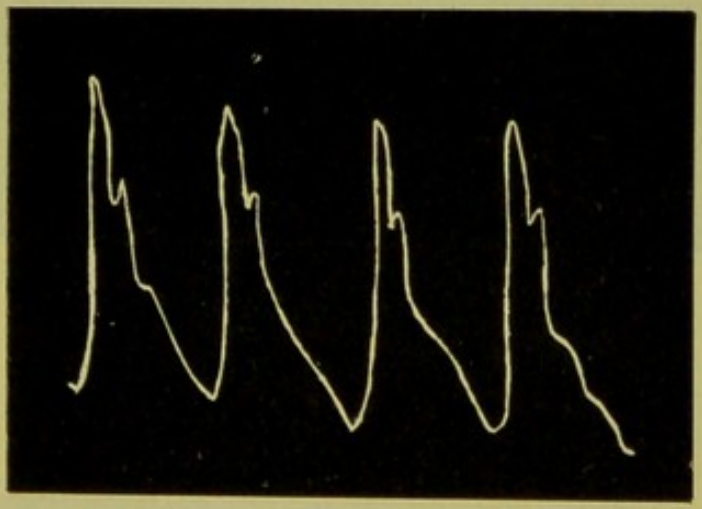
Note.—The movement of the artery is magnified fifty times.

Always wind up the clockwork anew before taking a tracing.

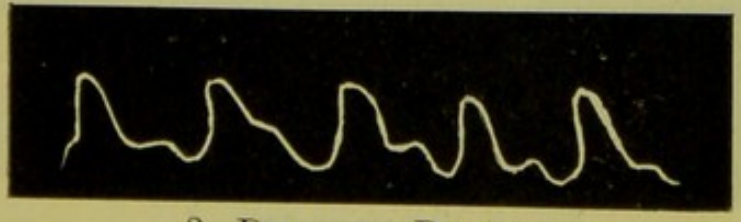
CHARACTERISTIC TRACINGS.



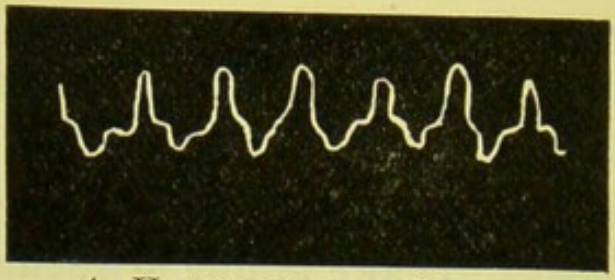
1. Normal Pulse Tracing.



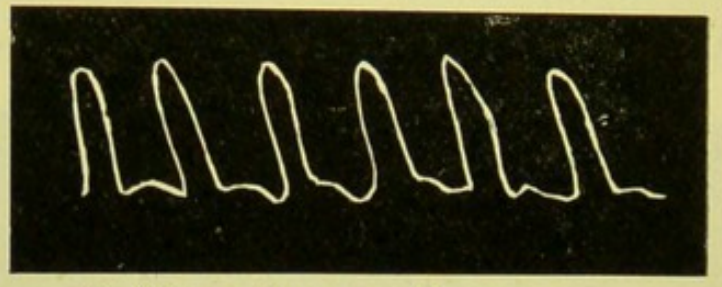
2. Aortic Regurgitation.



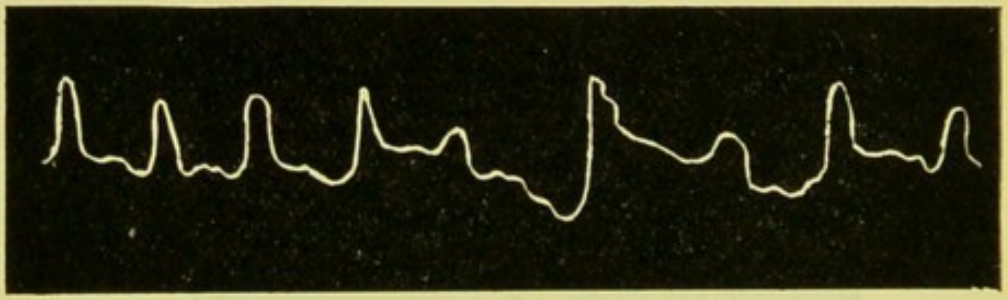
3. Dicrotic Pulse.



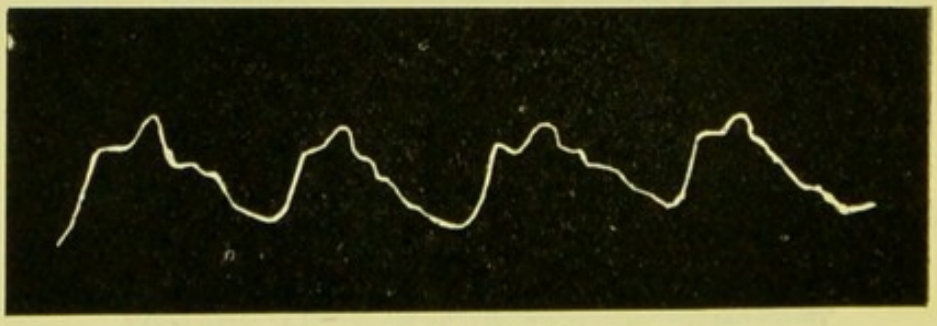
4. Hyperdicrotic Pulse.



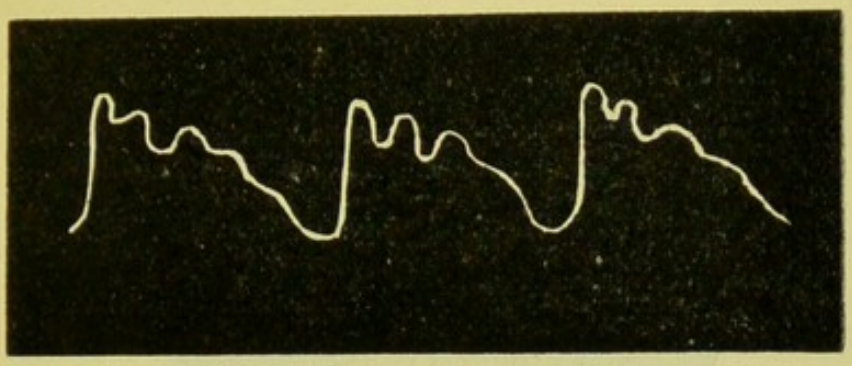
5. Weak Pulse. Monocrotic.
Artery almost empty during diastole.
Low tension pulse.



6. Mitral Regurgitation.
Irregular pulse.



7. Anacrotic Pulse.



8. Pulse of High Tension.
Tidal wave marked.

9. Intermittent Pulse.
One, two, or even three beats missed out—otherwise normal.

10. Pulsus Bigeminus.
Two beats together, then pause.

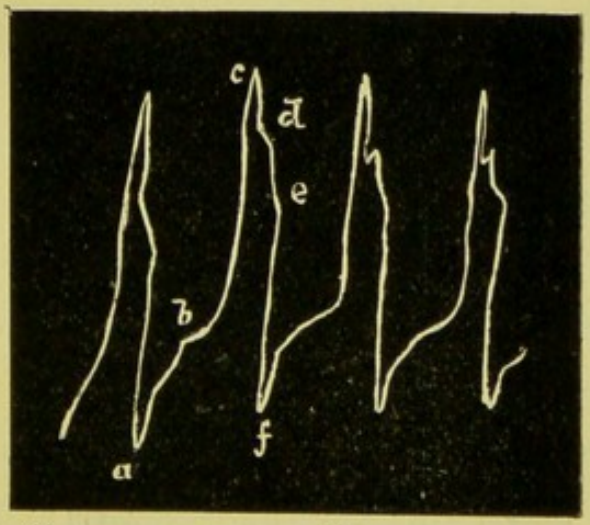
11. Pulsus Trigeminus.
Three beats together, then pause.

12. Hypertrophy of Left Ventricle.
Abrupt and high primary wave.

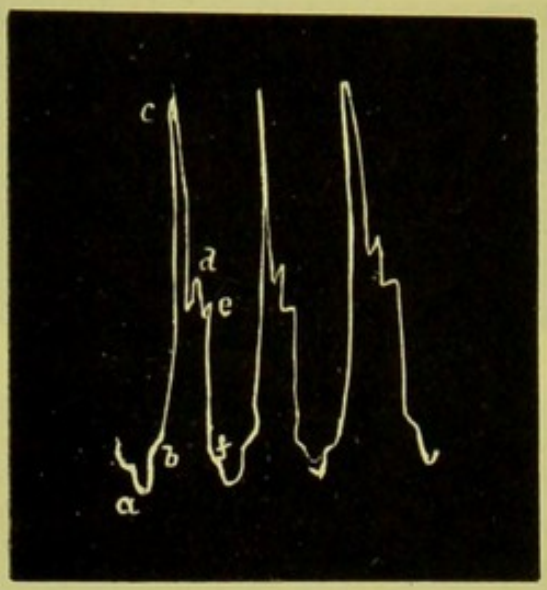
13. Pulsus Alternans.
Large and small beat alternately.

14. Aneurismal Pulse.
Very various. In extreme cases mere undulations represent pulse tracing.

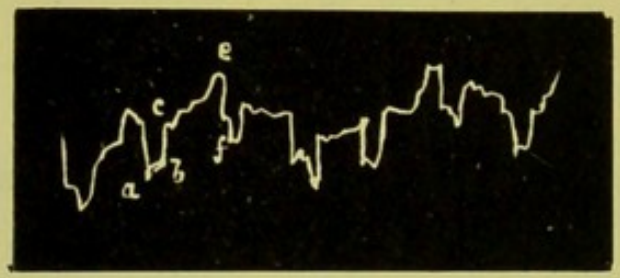
CARDIOGRAMS.



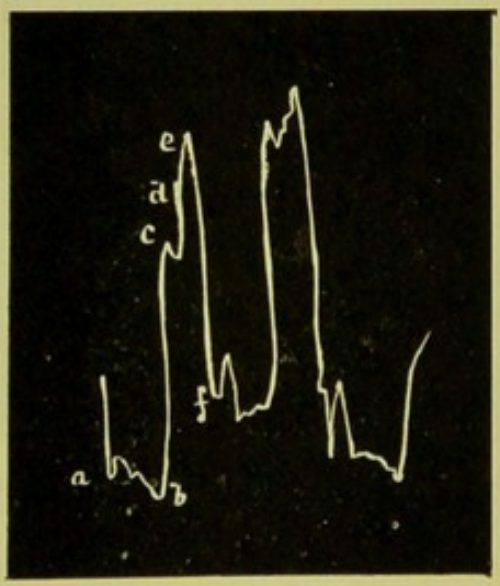
1. Cardiogram of Normal Heart.
a-b = contraction of auricles.
b-c = ventricular systole.
d = closure of aortic valves.
e = closure of pulmonary valves.
e-f = diastole of ventricles.



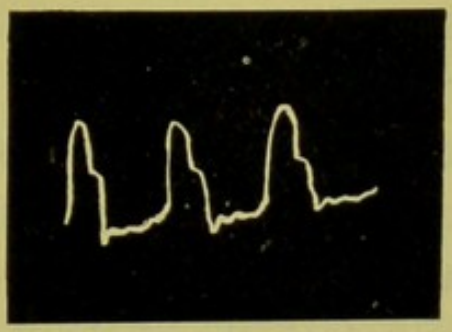
2. Hypertrophy and Dilatation of Left Ventricle.



3. Stenosis of Aortic Orifice.



4. Mitral Incompetence.



5. Mitral Stenosis.

BACTERIOLOGICAL EXAMINATION OF MICRO-ORGANISMS.

Glass flasks or test tubes containing sterilised nutrient media, plugged, ready for use, may be obtained at many instrument makers, or from a pathological laboratory.

Solid Nutrient Media are now almost alone used for cultivation.

(1) Human blood serum—

Used for cultivating

Tubercle bacilli.

Gonococci.

(2) Nutrient gelatine. { Peptone gelatine. Meat extract peptone gelatine.

Used for growing very many organisms.

(3) Agar-agar.

Method of Inoculation.

The flask or tube is held obliquely, and in an inverted position between the thumb and forefinger of the left hand, while the plug is removed and

held between the second and third fingers of the same hand (taking care to see that the lower surface of the plug is held downwards). With a platinum needle, which has been sterilised in a bunsen or spirit lamp flame, a particle of the fungus to be examined is detached and shoved by the needle into the gelatine. The plug is immediately inserted, and the whole placed in the incubator.

Plate Cultivations.

These are made by liquefying the infected gelatine or other nutrient medium, and pouring it on to a perfectly level sterilised glass plate. They are placed over damp blotting paper under sterilised glass jars.

The mode of growth of the fungus in colonies—the liquefaction and decomposition of the gelatine, etc., serve to indicate the specific organism. If more than one organism be present, they can be easily separated thus, and grown in tubes.

Hanging Drops.

On a perfectly clean cover-glass is placed a drop of sterilised broth, which has been inoculated with the organism. This is then inverted over a glass slide which has a hollow centre, and the edges of the drop are then examined by the microscope.

Evaporation is prevented by smearing the edges of the concavity with vaseline.

Sterilised Potato.

The growth of many pathogenic fungi on potatoes is most characteristic.

THE URINE.

Average Composition of Urine.

Amounts passed in 24 hours.

Water,	1500	grammes.
Total solids,	72	,,
Urea,	33·18	,,
Uric acid,	0·55	,,
Hippuric acid,	0·40	,,
Creatinin,	0·91	,,
Pigment and other organic substances,	10	,,
Sulphuric acid,	2·01	,,
Phosphoric acid,	3·16	,,
Chlorine,	7·50	,,
Ammonia,	0·77	,,
Potassium,	2·50	,,
Sodium,	11·09	,,
Calcium,	0·26	,,
Magnesium,	0·21	,,

General Directions for the Examination of Urine.

In the systematic examination of any specimen of urine observe—

1. Colour.
   (1) If very light = hydruria—
   Test for albumin (page 245).
   If very light or greenish = diabetes—
   Test for sugar (page 277).
   (2) Dark reddish brown = excessive amount of urates—examine deposit (*q. v.*).
   Dark reddish brown = blood—
   Test for this (p. 264).

2. Transparency.
   (1) Pale and cloudy urine = phosphates—test by adding acetic acid (p. 236).
   Pale and cloudy urine = suspended pus or bacteria—examine by microscope (p. 270).
   (2) Dark and turbid = urates—heat upper layer of urine in test tube when they dissolve.
   Dark and turbid = blood—test for this (p.264).

3. Specific Gravity.
   (1) Low = hydruria, 1010-15—test for albumin (p. 245).
   (2) High—above 1030 = diabetes—test for sugar (p. 277).

4. Reaction.
   (1) Alkaline—see if due to free or fixed alkali by drying paper (p. 195).
   Free = cystitis, etc.
   Fixed = dyspepsia.

(2) Highly acid = rheumatism, gout : note amount of urine *per diem* =

Test for sugar = diabetes.

5. Odour.

Strongly urinous = concentrated urine.

Ammoniacal = decomposition = cystitis (*q. v.*).

6. Test for Albumins Generally (see pages 245-50), by ferrocyanide test.

If present, differentiate

(*a*) Serum albumin (p. 251).

(*b*) Serum globulin (p. 254).

(*c*) Albumose (p. 256).

(*d*) Peptone (p. 257).

Remember fallacies due to taking of certain drugs (*q. v.*).

7. Test for Sugar—Haine's method (p. 279).
8. Test for Blood (p. 264).
9. Estimate Urea Quantitatively (p. 208).
10. Examine Deposit Microscopically (*q. v.*).

Examination of the Urine in Detail.

Summary.

Note (I.) Total amount excreted in 24 hours.

(II.) Physical characters.

(*a*) Colour.

(*b*) Transparency.

(*c*) Odour.

(*d*) Reaction.
(*e*) Specific Gravity.
(*f*) Deposit.

(III.) Chemical characters.

(*a*) Amount of urea, uric acid, and other nitrogenous substances.

(*b*) Presence of inorganic salts.
Chlorides.
Phosphates.
Sulphates.
Oxalates, etc.

(*c*) Presence of abnormal constituents.
Albumin.
Sugar.
Bile.
Blood, etc.

(IV.) Microscopical examination of deposit.

In the ward sideroom the specimen of urine has usually been taken from the total excretion of the preceding twenty-four hours. The result of our examination has reference, therefore, not to the day on which we make it, but to the preceding day. Suppose we are examining a specimen placed in the room to-day, then our results apply to yesterday's urine.

Average Sample.

To obtain a specimen of urine the whole excre-

tion per twenty-four hours is collected ; the quantity measured in a graduated glass vessel, and a specimen of this mixture is used for analysis.

Special Sample.

In certain abnormal conditions of the urine it may be necessary to examine freshly passed urine at various times during the day.

Rate of Secretion.

This varies during different periods of the day.

During sleep little is secreted.

During the day more abundant.

After meals very abundant.

I. Total Daily Excretion—varies greatly even in health.

Normally, 45-50 ounces.

1200-1500 c.c.

(*a*) Amount increased (Polyuria).

(1) After drinking much fluid.

(2) Lessened perspiration, *e.g.*, cold weather.

(3) Nervousness.

Hysteria.

Convulsions.

Tumours of the brain.

(4) Chronic renal disease.

Cirrhosis.

Waxy disease.

(5) Diabetes mellitus et insipidus.

(6) During convalescence.

(7) After certain drugs (diuretics), *e.g.*,
Digitalis.
Spiritus Ætheris Nitrosi.
Liquor Ammoniæ Acetatis, etc.

(*b*) Amount diminished (Oliguria).
(1) Profuse perspiration.
(2) Diarrhœa.
(3) Febrile conditions.
(4) Low blood pressure—heart disease.
(5) Hysteria.
(6) Acute Bright's disease.
Rarely in late stages of Chronic Bright.
(7) Certain drugs.
Opium.
Belladonna.
Cantharides.

(*c*) Suppressed (Anuria).
(1) Acute Bright's disease.
(2) Obstruction in urinary passages.
Urethral stricture.
Enlarged prostate.
Calculus in urethra.
(3) Destruction of kidney substance.
(4) Shock, collapse.
(5) Acute fevers.
Yellow fever.
Cholera.
(6) Profuse diarrhœa.
(7) Hysteria.

II. Physical Characters.

A. Colour.

In examining the colour, the urine should be in a tall cylindrical glass jar (urine glass). This should be placed in front of a window, and the colour judged of by looking through the urine; or the jar may be placed in front of a white surface, and opposite to the light. The colour cannot be determined by gas or lamp light.

Normal Colour—varies from

Pale straw yellow to *deep amber colour*, depending entirely on the amount of urine secreted.

Pale urine = dilute urine = excessive secretion
Dark urine = concentrated urine = scanty ,,
Abnormal colour = abnormal constituents.

(*a*) Pale urine seen—

(1) After free imbibition of liquids.
(2) Cold weather (perspiration slight).
(3) Anæmia (not pernicious).
(4) Hysteria.
Convulsions.
(5) Chronic Bright's disease.
Cirrhotic kidney.
Waxy ,,
(6) Diabetes mellitus et insipidus.

(*b*) Dark urine seen in

(1) Scanty secretion, as after
Active exercise.
Profuse perspiration.

Diarrhœa.
Acute fevers.
Renal congestion.
Pernicious anæmia.

(2) Presence of excessive amount of indican (*q.v.*), as in
Obstruction of bowels.
Diarrhœa.
Cancer of abdominal viscera.
Enteric fever.
Phthisis.

(3) Presence of abnormal constituents, *e.g.* :

(α) Blood.
Small quantity present = mere cloudy *smoky* appearance in urine.
Larger amounts = varying tints of red.

(β) Bile.
Yellowish brown to deep olive green.
Froth always yellowish green.

(γ) Hæmatin and methæmoglobin.
Brownish.

(δ) Melanin.
Brown or blackish.

(ε) Chyle.
Pinkish milky appearance.
Pellicle of fat on surface.

(ζ) Pus.

Milky turbidity.

(η) Indigo.

Dull blue.

(θ) Diabetes.

Greenish.

(ι) Certain drugs.

- Blackish or brown green:
  - Carbolic acid.
  - Creasote.
  - Resorcin.
  - Naphthalin.
- Yellowish brown or red:
  - Santonin.
  - Chrysophanic acid.
    - Rhubarb.
    - Senna.
  - Logwood.

Dark red—sulphonal.

Clear blood red—antipyrin.

Greenish yellow—juniper.

THE SIGNIFICANCE OF THE COLOUR OF URINE.

Colour.	Cause of Coloration.	Diseases in which such Urine occurs.
1. Nearly colourless.	Dilution or diminution of normal pigments.	Hysteria. Diabetes insipidus. Chronic Bright's disease.
2. Dark yellow to brown red.	Increase of normal pigments. Presence of pathological pigments.	Acute febrile conditions.
3. Milky.	Fat globules. Pus corpuscles.	Chyluria. Purulent disease of genito-urinary tract.
4. Orange.	Certain drugs.	Santonin. Chrysophanic acid (rhubarb).
5. Red.	Hæmoglobin. Certain drugs or foodstuffs.	Hæmorrhages into genito-urinary tract. Hæmoglobinuria. Logwood, madder.
6. Brown — to brown black.	Hæmatin.	Small hæmorrhages.
	Methæmoglobin.	Methæmoglobinuria.
	Melanin.	Melanotic sarcoma.
	Hydrochinon.	Carbolic acid poisoning.
7. Greenish yellow to black.	Bile pigments.	Jaundice.
8. Dirty green or blue.	Dark blue scum with blue deposit, due to excess of indigo-forming substances.	Cholera. Enteric fever.
9. Brown yellow to red brown.	Senna, rhubarb.	

Halliburton, p. 712.

B. Transparency.

Normally—Urine is quite transparent when passed. Deposits a mucous cloud after standing.

(1) Cloudy on being passed =
Mucus in large amount.
Pus.
Oil globules (*e.g.*, from catheter).
Bacteria.
Blood.

(2) Cloudy after standing some time = precipitation of
Urates.
Phosphates.

C. Odour.

(1) Urinous odour strong = urea percentage high usually.

(2) Ammoniacal = commencing decomposition (bacteria splitting up urea into carbonate of ammonia).

(3) Putrescent = decomposition = disease of bladder or kidneys.
Sulphuretted hydrogen smell from decomposition of proteids.

(4) Sweet mawkish = diabetes.

(5) Acetone = diabetic coma (?).

(6) Chloroform = diabetic coma.

(7) Certain foods give their odours to the urine, as
Asparagus.
Onions.
Garlic.

(8) Certain drugs also, as
Sandalwood oil.
Cubebs.
Valerian.
Asafœtida.
Turpentine—gives smell of sweet violets.

(9) Cystin in urine = sweetbriar smell.

D. Reaction.

Normally acid—due to acid salts—chief being acid phosphate of soda (NaH_2PO_4).

Variation in intensity of acidity.
At different periods of the day.
After certain foods.
,, ,, drugs.

Increase in acidity of urine on standing—
This goes on for two or three days, due to oxidation. There is a deposit of urates, uric acid, and oxalates.

Diminution in acidity—after this period, or from the first, in decomposing urines, *alkaline fermentation* ensues. This is due to fermentation (torula ureæ), with splitting up of urea into ammonia and carbonic acid gas.

Urine becomes turbid—due to presence of Ammonio-magnesium phosphate.

Calcium phosphate.
Ammonium urate.
Bacteria.

QUALITATIVE TESTS.

(1) *Acidity* = turns blue litmus paper red—degree of reddening may roughly show the degree of acidity.

Feeble ,, = blue hardly changed.

Strong ,, = well-marked red.

(2) *Alkalinity* = turns red litmus paper blue—degree of change may roughly show degree of alkalinity.

,, "temporary" = blue colour disappears as paper dries, due to carbonate of ammonia going off.

,, "permanent" = no change in paper on drying, due to non-volatile salts, *e.g.*, carbonates of soda or potash.

Amphoteric reaction (seldom seen) = urine turns
Blue litmus paper red.
Red ,, ,, blue.

QUANTITATIVE ESTIMATION OF THE ACIDITY.

Normally, total acidity of daily excretion = 1·5 to 2 grammes estimated as oxalic acid.

The acidity is usually estimated as oxalic acid.

Solutions required.

(1) Standard oxalic acid solution. This is made by dissolving 6·3 grammes pure oxalic acid in distilled water, and diluting to one litre : Ten c.c. of this solution therefore contain 0·063 gramme (63 milligrammes) of oxalic acid.

(2) Decinormal solution of caustic soda standardised, so that each c.c. must be equal to 0·0063 gram. oxalic acid.

To standardise it proceed as follows : Measure by a pipette 10 c.c. of the oxalic acid solution, and place it into a beaker. Add a few drops of tincture of litmus, which colours it red. In a burette have the caustic soda solution, and run it into the acid solution till it becomes blue. Read off the amount added. Suppose 7 c.c. have been used. Then 7 c.c. soda solution must be equal to 0·063 gram. oxalic acid. It is too strong, and must be diluted thus—700 c.c. soda solution are diluted to 1 litre, and now again we try, and so proceed till each c.c. of the soda solution is exactly neutralised by 1 c.c. oxalic acid solution.

Method. Place 10 c.c. urine in a beaker, and run into this from a burette the standard solution of caustic soda till a drop removed and placed on blue litmus paper no longer reddens it, or if placed on red litmus paper, no longer blues it.

Read off the amount, and the calculation is therefore easy, each c.c. soda solution being equal to 6·3 milligrammes oxalic acid, multiply the number of cubic centimetres used by 0·0063, and the result is the degree of acidity in 10 c.c. urine.

If expressed as acid phosphate of sodium (NaH_2PO_4), each c.c. of the standard soda solution is equal to 0·012 gram.

TABLE FOR CALCULATING ACIDITY OF URINE WHEN ESTIMATED AS OXALIC ACID.

Number of c.c. soda solution used to neutralise 10 c.c. urine.	Oxalic acid per cent. (per 100 c.c.).	Number of c.c. soda solution used to neutralise 10 c.c. urine.	Oxalic acid per cent. (per 100 c.c.).
1	0·063	3·8	0·2394
1·1	0·0693	3·9	0·2457
1·2	0·0756	4	0·2520
1·3	0·0819	4.1	0·2583
1·4	0·0882	4·2	0·2646
1·5	0·0946	4·3	0·2709
1·6	0·1008	4·4	0·2772
1·7	0·1071	4·5	0·2835
1·8	0·1134	4·6	0·2898
1·9	0·1197	4·7	0·2961
2	0·1260	4·8	0·3024
2·1	0·1323	4·9	0·3087
2·2	0·1386	5	0·3150
2·3	0·1449	5·5	0·3465
2·4	0·1512	6	0·3780
2·5	0·1575	6·5	0·4095
2·6	0·1638	7	0·4410
2·7	0·1701	7·5	0·4725
2·8	0·1764	8	0·5040
2·9	0·1827	8·5	0·5355
3	0·1890	9	0·5670
3·1	0·1953	9·5	0·5985
3·2	0·2016	10	0·6300
3·3	0·2079	10·5	0·6615
3·4	0·2142	11	0·6930
3·5	0·2205	11·5	0·7245
3·6	0·2268	12	0·7560
3·7	0·2331		

TABLE FOR ESTIMATING ACIDITY OF URINE WHEN ESTIMATED AS ACID PHOSPHATE OF SODIUM.

Number of c.c. soda solution used to neutralise 10 c.c. urine.	Acid sodium phosphate per cent. (per 100 c.c. urine).	Number of c.c. soda solution used to neutralise 10 c.c. urine.	Acid sodium phosphate per cent. (per 100 c.c. urine).
1	0·12	3·8	0·456
1·1	0·132	3·9	0·468
1·2	0·144	4	0·48
1·3	0·156	4·1	0·492
1·4	0·168	4·2	0·504
1·5	0·180	4·3	0·516
1·6	0·192	4·4	0·528
1·7	0·204	4·5	0·540
1·8	0·216	4·6	0·552
1·9	0·228	4·7	0·564
2	0·240	4·8	0·576
2·1	0·252	4·9	0·588
2·2	0·264	5	0·60
3·3	0·276	5·5	0·66
2·4	0·288	6	0·72
2·5	0·300	6·5	0·78
2·6	0·312	7	0·84
2·7	0·324	7·5	0·90
2·8	0·336	8	0·96
2·9	0·348	8·5	1·02
3	0·36	9	1·08
3·1	0·372	9·5	1·14
3·2	0·384	10	1·2
3·3	0·396	10·5	1·26
3·4	0·408	11	1·32
3·5	0·420	11·5	1·38
3·6	0·432	12	1·44
3·7	0·444		

Increased Acidity.

(1) Concentrated urines.

(2) After prolonged exercise.

(3) After flesh diet.

(4) Before ordinary meals ("acid wave").
(5) After taking acids.
(6) Acute fevers; rheumatic, scarlet, etc.
(7) Gout.
(8) Diabetes.
(9) Scurvy.
(10) Certain dyspepsias—may be an *absolute* increase.

Lessened Acidity or Alkalinity.

(1) Ammoniacal decomposition — putridity — cystitis, etc.
(2) Vegetable diet.
(3) Alkaline salts or organic acids.
(4) After ordinary meals ("alkaline wave"—maximum, 3-4 hours after food).
(5) Anæmia, simple and pernicious.
(6) Certain dyspepsias.

E. Specific Gravity.

Normally, 1017-20, but varies greatly according to amount of dissolved matters.

Estimation by Urinometer.

Place a quantity of urine sufficient to float the urinometer in a vessel a good deal wider than the instrument, so that it may not touch the sides at any point. Carefully immerse the urinometer (taking care not to let it drop in, as the glass bulb at the foot is easily broken), and allow it to come to rest. In reading the index, be careful to read it at the level of the lower edge

of the meniscus, formed by the urine and the glass stem, as this is the true water level.

Correction.

If the reading be taken before the urine has cooled down to the temperature at which the urinometer is graduated for use (and which is marked upon it), a correction is required, thus: Take the temperature; add 1° of specific gravity to that indicated by the instrument for each 7° of temperature F. above that from which the urinometer is graduated.

Deficient Quantity of Urine.

If there be not enough urine to float the urinometer, then dilute it with distilled water in definite proportions, and from this calculate the specific gravity. Thus — if we add as much water as there is urine, and the Sp. Gr. is found to be 1009, then the urine itself must have a Sp. Gr. of 1018.

Test each urinometer to see if it is correctly graduated by immersing it in distilled water at 60° F., when it should stand at 1000° on the scale.

High Specific Gravity.

(1) Concentrated urine.
(2) After much nitrogenous food.
(3) Urea, urates, uric acid in large amount.
(4) Acute Bright's disease.
(5) Diabetes mellitus.

Diminished Specific Gravity.

(1) Polyuria from drinking much fluid.

(2) Diabetes insipidus.

(3) Chronic Bright's disease.

Granular.

Waxy.

Note.—A sudden fall in specific gravity without a corresponding rise in the amount of urine passed (as happens in acute fevers or nephritis) is a grave symptom = failure of excretion of excrementitious salts.

TOTAL SOLIDS IN URINE.

Normally—total daily excretion = 50 gram. —$1\frac{1}{2}$ ounces.

Estimation.

Rough. (1) Multiply the last two figures of the specific gravity by 2, and the result shows grammes of total solids per 1000 c.c. (co-efficient of Trapp).

Example. Sp. Gr., 1015 = 30 grammes per litre. Total daily excretion of urine, 1600 c.c. $\therefore 30 \times 1{\cdot}6 = 48$ grammes.

(2) If specific gravity be above 1025, multiply the last two figures by 2·33 (co-efficient of Häser and Christison).

(3) If the last two figures of the specific

gravity be multiplied by the number of ounces of urine, the result gives the total solids per 24 hours in grains.

Example. Specific gravity, 1024. Amount of urine, 50 ounces. ∴ 24 × 50 = 1200 grains.

Exact. Into a platinum (or other) basin of known weight place 50 c.c. urine, and evaporate to dryness on a water bath. Then weigh ; when two successive weighings give the same result the operation is finished, subtract the weight of the basin, and the remainder is the total solids per 50 c.c. of urine.

TABLE FOR CALCULATING TOTAL SOLIDS FROM SPECIFIC GRAVITY (HÄSER'S CO-EFFICIENT).

Specific Gravity.	Grammes of Solids per 1000 c.c. Urine.
1011	25·63
1012	27·96
1013	30·29
1014	32·62
1015	34·95
1016	37·28
1017	39·61
1018	41·94

Specific Gravity.	Grammes of Solids per 1000 c.c. Urine.
1019	44·27
1020	46·60
1021	48·93
1022	51·26
1023	53·59
1024	55·92
1025	58·25
1026	60·58
1027	62·91
1028	65·24
1029	67·57
1030	69·90

Increase of Total Solids.

(1) Certain forms of dyspepsia.

(2) Increased excretion of urates.

Decrease of Total Solids.

(1) Mental depression.

(2) Certain kidney diseases.

Congestion.
Acute Bright's disease.
Chronic „ „ (sometimes).
Renal Inadequacy.

F. Deposits in Urine.

1. Coloured.

(*a*) Pink, brick red, orange, salmon coloured, vermilion, or dark brown granular deposit.

= amorphous urates.

Tests (α) Warm in test tube = dissolve.
(β) Urine acid.
(γ) Add acid = no change (compare phosphates).

(b) Red cayenne pepper grains at bottom and on sides of glass = uric acid.
Tests (1) Urine acid.
(2) Microscopic.

(c) Dirty brown, chocolate, or red deposit (specially if in clots) = blood.
Tests (α) Microscope.
(β) Guaiacum (p. 264).
(γ) Spectroscope (p. 266).

(d) Yellow = urate of sodium (rare).
Test (α) Urine acid.
(β) Microscope.

2. White or Colourless Deposits.

(a) Mucus = light cloud or denser deposit at bottom of vessel. Found in almost all urines on standing.
Tests (α) Moves freely about.
(β) Acetic acid (p. 260).

(b) White = earthy phosphates — often with scum on surface. Usually mixed with mucus.
Tests (α) Urine alkaline, neutral or feebly acid.
(β) Add acid = dissolves.
γ) Increased opacity on heating.

(*c*) Whitish-yellow tenacious deposit = pus.

Tests (*a*) Microscope.

(*β*) Decant urine, and to sediment add an equal volume of liquor potassii = great viscidity, so that vessel may be inverted without its escape.

(*d*) White undulating well-defined layer on surface of mucus, or as fine lines resembling scratches on sides of the glass = oxalate of lime.

Test—Microscope.

(*e*) White (usually with phosphatic) = urate of ammonium (rare).

Test—Microscope.

CHEMICAL EXAMINATION OF THE URINE.

The most important substances which are detected by chemical examination of the urine are :—

1. Urea.
2. Uric acid.
3. Hippuric Acid.
4. Creatinin.
5. Xanthin.
6. Acids.
7. Pigments.
8. Mineral matters.

UREA (CON_2H_4).

Urea is the chief product of proteid change which goes on in the living body.

It is freely soluble in water, so is *never* found as a deposit.

Carbonic acid and ammonia are both excretory products of the body, and so urea is closely allied to them. Urea can undergo hydration, as when acted upon by the *torula ureæ*, and then becomes carbonate of ammonia (alkaline decomposition of urine)—thus :—

$$CO\begin{cases}OH\\OH\end{cases} \qquad CO\begin{cases}NH_2\\NH_2\end{cases} + 2H_2O = CO\begin{cases}NH_4O\\NH_4O\end{cases}$$

carboxyl hydroxyl. — carbonic acid.

Carboxyl Amidogen. — Urea.

carbonate of ammonia.

Detection of Urea in any liquid.

(1) Evaporate down the liquid.
Add equal volume of nitric acid.
Crystals of nitrate of urea separate.
Microscope shows these as octahedra, hexagons, lozenges, or rhombic plates.

(2) Evaporate down the liquid.
Place a drop on a microscope slide.
Lay a cotton thread on this, and apply cover-glass.
Moisten end of thread with nitric acid.
Microscope shows hexagonal plates of nitrate of urea along the sides of the thread.

Daily Excretion.

Varies much with amount of nitrogenous food taken.

Forms 2-4 per cent. in urine.

Averages 30-40 grammes = 500 grains.

Forms nearly one-half of the total solids, and so may roughly be calculated from them.

Variations in Amount.

To determine the variations of urea excretion is, perhaps, the most important of clinical observations, as the degree of variation is an index of the amount of tissue change going on in the body.

Increased Excretion.

(*a*) After much nitrogenous food.
(*b*) Fevers, where great tissue waste goes on.
(*c*) Reaction stage of cholera.
(*d*) Copious drinking of water.
(*e*) Diabetes mellitus.

Hardly, if at all, increased after muscular exercise.

Diminished Excretion.

(*a*) Carbohydrate diet.
(*b*) During rest.
(*c*) Acute nephritis—a sudden diminution is of great clinical importance (as showing failure of renal excretion).

(*d*) Chronic renal diseases.
Uræmia.
(*e*) Chronic wasting diseases.
(*f*) Chronic alcoholism.
(*g*) Hepatic diseases.
(*h*) Algide stage of cholera.

Quantitative Estimation of the Urea Excreted.

The method usually employed is that of Hüfner.

This depends on the splitting up of urea by means of a solution of hypobromite or hypochlorite of sodium, and estimating the urea from the amount of nitrogen given off.

The reaction may be represented as follows :—

$$CON_2H_4 + 3NaBrO = 3NaBr + N_2 + CO_2 + 2H_2O.$$

(Urea.) (Hypobromite of Soda.) (Bromide of Soda.)

In practice one gramme urea gives off 371 c.c. of nitrogen (the carbonic acid is not estimated, as it is absorbed by the caustic soda solution).

Certain other nitrogenous substances in the urine, as kreatinin, uric acid, ammonia salts, etc., give up nitrogen when acted on by the hypobromite solution ; but, as the amount is so small, it may for practical purposes be overlooked.

Requisites.

(1) Solution of hypobromite of soda. This must be freshly prepared, and is made as follows:

Dissolve 100 grammes caustic soda in 250 c c. water, allow to cool, and add 25 c.c. of bromine (bromine is sold in tubes containing 25 c.c. These are broken inside a bottle containing the caustic soda solution to avoid escape of the fumes). There is free caustic soda in the solution after it is made, and so the carbonic acid liberated from the urea is at once combined to form the carbonate of soda, as already described.

(2) Burette graduated into cubic centimetres, and immersed in

(3) Glass cylinder of equal length containing water.

(4) Glass flask with indiarubber stopper, and with mark at height for indicating 15 c.c.

(5) Indiarubber tube connecting flask with graduated tube.

(6) Glass tube marked at height of 5 c.c.

(7) Basin of cold water in which to immerse flask.

Note.—If albumin be present in the urine, remove it by acidulating, boiling, and filtering. Then use the cooled filtrate for estimating the urea.

Method.

(*a*) Place 25 c.c. hypobromite solution in flask.

(*b*) Into tube (6) place 5 c.c. urine to be examined, and holding it by forceps, place it carefully into the flask containing the hypobromite solution, taking care that none of the urine is spilled amongst the soda solution.

(*c*) Now connect flask with burette by inserting the indiarubber cork which is connected to the top of the burette by means of an elastic tube.

(*d*) Level water in burette with that outside by sliding the burette up or down, or by opening clip at top of burette, if one is present. Read off the figure on the index at this level.

(*e*) Carefully incline the flask (4), so that the urine runs out of the tube (6), and mixes with the hypobromite solution. Shake them well together. Gas is evolved in great amount, and depresses the water in the burette.

(*f*) Place the flask in the basin of water, and leave all for 15 minutes.

(*g*) Now restore the water level by raising the burette, and again read off the figure on the index at this point.

(*h*) See how many cubic centimetres of gas have been evolved. Suppose in this case it has been 35 c.c. The number of cubic centimetres of nitrogen thus obtained was from

5 c.c. urine. If so, how many would have been evolved from the total urine excreted? Suppose 1600 c.c. urine have been passed in the 24 hours. Then

5 : 1600 : : 35 : x = 11200 c.c.,

but 371 c.c. of nitrogen are obtained from one gramme urea—so

371 : 11200 : : 1 : x = 30·18 grammes urea in 24 hours.

Practically not so much nitrogen is given off, and really only 354 c.c. N. are obtained from one gramme of urea.

If it be found that the urea exceeds 3%, then another estimation should be performed with urine diluted with its own volume of water—the result being multiplied by two.

Note.—In ordinary clinical work it is not necessary to make a correction in the volume of the gas for temperature and pressure. If it be required to make this correction employ this formula—

$V = \frac{vpT}{Pt}$ where V is the volume desired at 0° C. and 760 m.m. height of mercury; v = volume read off; P = pressure of 760 m.m. of mercury; p = atmospheric pressure of room; T = absolute temperature – 273° C.; t = temperature of room + 273° C. In the above case, sup-

pose barometer be 750 m.m., and temperature of room 15° C., then—

$$V = \frac{35 \times 750 \times 273}{760 \times 288} = 32{\cdot}7 \text{ c.c., so}$$

that the volume of nitrogen evolved from 5 c.c. urine in this case would have been (not 35 c.c.) but 32·7 c.c., and from the total urine excreted (1600 c.c.) 10464 c.c. Consequently the amount of urea excreted in 24 hours when corrected amounts to 28·2 grammes.

Gerrard's Apparatus for Estimation of Urea is very often used and is very easily manipulated. It gives the result as urea percentage.

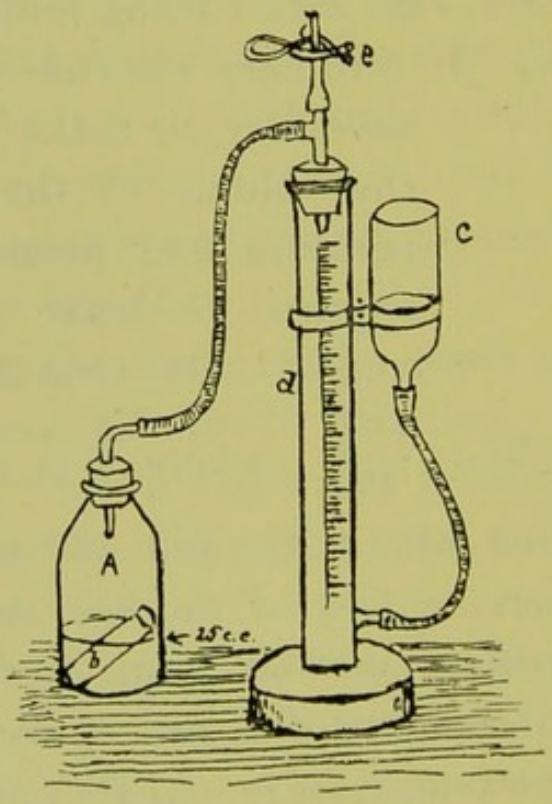


FIG. 48.—APPARATUS FOR ESTIMATION OF UREA.

The mode of using it is as follows :—

(1) Make the water level (at zero mark) in both tubes by sliding the small tube (*c*), which is attached by a clip to the graduated tube (*d*), up or down.

(2) Into the bottle (*A*) place 25 c.c. of freshly prepared hypobromite of soda solution.

(3) Into the small tube (*b*) place 5 c.c. of urine to be examined.

Take hold of it with a pair of forceps, and cautiously place it in the bottle (*A*) containing the hypobromite, not allowing them to mix in the slightest.

(4) Screw the indiarubber cork into the bottle (*A*), and so attach it to the graduated tube by the indiarubber tube which connects them. This disturbs the water level, so bring it back to zero by opening the clip (*e*) at the top of the graduated tube.

(5) See that all is air-tight. Now tilt the bottle, and thoroughly mix the urine with the hypobromite solution.

Place the bottle in a basin of cold water, and allow all to stand for 15 minutes.

(6) Bring the water in both tubes again to the same level by sliding the small one (*c*) down, and read off the percentage of urea.

From this it is easy to calculate the urea in the total urine excreted daily.

Example. Percentage of urea is 1·5. Total amount of urine, 1600 c.c. Then 100 : 1600 : : 1·5 : x = 24 grammes urea.

Expressed as Grains.

If it be required to express this as grains per ounce, the following table of equivalents which I have made up may be consulted.*

The total excretion of urea *per diem* is obtained by multiplying the number of grains per ounce by the number of ounces of urine passed in the twenty-four hours.

Example. The ureometer gives 1·5 per cent. urea. This is equal to 6·5 grains per ounce. The total excretion of urine was 50 ounces—so 6·5 × 50 = 325 grains urea *per diem*.

* A rough method of converting the percentage into grains per ounce is to multiply it by 4·4—*e.g.*, 1·5 per cent. = 6·6 grains per ounce.

Estimation of Urea.

Table of Equivalents.

Urea per cent.	=	Grains per ounce.	Urea per cent.	=	Grains per ounce.	Urea per cent.	=	Grains per ounce.
0·05	=	0·218	1·55	=	6·777	3·1	=	13·526
0·1	=	0·437	1·6	=	6·997	3·15	=	13·744
0·15	=	0·656	1·65	=	7·215	3·2	=	13·962
0·2	=	0·874	1·7	=	7·434	3·25	=	14·180
0·25	=	1·093	1·75	=	7·652	3·3	=	14·398
0·3	=	1·312	1·8	=	7·871	3·35	=	14·616
0·35	=	1·530	1·85	=	8·089	3·4	=	14·834
0·4	=	1·749	1·9	=	8·309	3·45	=	15·052
04·5	=	1·968	1·95	=	8·527	3·5	=	15·270
0·5	=	2·186	2	=	8·748	3·55	=	15·488
0·55	=	2·405	2·05	=	8·966	3·6	=	15·710
0·6	=	2·624	2·1	=	9·184	3·65	=	15·928
0·65	=	2·842	2·15	=	9·400	3·7	=	16·146
0·7	=	3·061	2·2	=	9·618	3·75	=	16·364
0·75	=	3·280	2·25	=	9·836	3·8	=	16·582
0·8	=	3·498	2·3	=	10·054	3·85	=	16·806
0·85	=	3·717	2·35	=	10·272	3·9	=	17·024
0·9	=	3·936	2·4	=	10·490	3·95	=	17·262
0·95	=	4·154	2·45	=	10·708	4	=	17·480
1	=	4·373	2·5	=	10·934	4·05	=	17·698
1·05	=	4·571	2·55	=	11·150	4·1	=	17·906
1·1	=	4·8	2·6	=	11·350	4·15	=	18·124
1·15	=	5·029	2·65	=	11·568	4·2	=	18·342
1·2	=	5·247	2·7	=	11·786	4·25	=	18·560
1·25	=	5·465	2·75	=	12·004	4·3	=	18·778
1·3	=	5·685	2·8	=	12·222	4·35	=	18·996
1·35	=	5·903	2·85	=	12·440	4·4	=	19·214
1·4	=	6·122	2·9	=	12·654	4·45	=	19·432
1·45	=	6·340	2·95	=	12·874	4·5	=	19·650
1·5	=	6·560	3·0	=	13·090	4·55	=	19·868
1·52	=	6·61	3·05	=	13·308			

The method of calculation is as follows: The ureometer gives it as grammes urea per 100 c.c. urine. Now there are 28·349 c.c. in one ounce. Suppose there has been 1·5 per cent. urea, 100

c.c. : 28·34 : : 1·5 per cent. urea : x = 0·425 grammes urea in one ounce. There are 15·4 grains in one gramme, so multiply 0·425 by 15·4 = 6·56 grains per ounce.

Ureometer of Doremus and Thursfield (manufactured by Southall) is also often used. It consists of a curved tube graduated at the upper part, so that each division is equal to 0·001 gramme urea in 1 c.c. of urine. The method of using it is to fill the curved tube up to the mark with the sodium hypobromite solution, then the bend and bulb are filled with water. One cubic centimetre of urine is introduced into the tube by means of a sucker pipette, which is curved at its end, so as to curve round the bend of the larger tube. As the urine rises through the hypobromite solution, the urea it contains is decomposed, and the nitrogen collects at the upper part of the tube. The percentage of urea is obtained by multiplying the amount of nitrogen so got by 100.

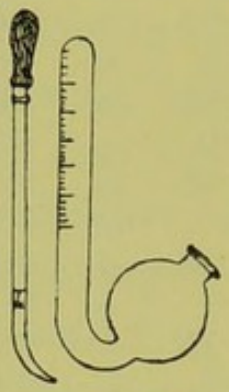


FIG. 49.—UREOMETER OF DOREMUS.

Liebig's Nitrate of Mercury process is still employed by many, though more troublesome, and not nearly so accurate as the hypobromite method.

URIC ACID ($C_5H_4N_4O_3$).

Normal daily excretion, 0·2-1 gramme.

Occurs in very acid urines.

„ as small reddish brown grains (cayenne pepper) on sides and bottom of vessel.

Microscopically.

Colour, pale yellow (almost always).

Reddish—if in large crystals.

Shape—very various.

Needles, lozenges, rosettes, spindles, cubes, cylinders, slabs, dumb-bells, balls, sheaves, etc.

Increased Amount.

(1) Deficiency of alkali in blood or urine.
(2) After much animal food.
(3) In febrile conditions.
(4) When action of skin is checked, *e.g.*, cold weather, extensive skin disease.
(5) Heart or lung disease obstructing circulation.
(6) Gout, after acute attack is over.
(7) Liver diseases.
(8) Blood diseases, *e.g.*, Scurvy.
Leucocythæmia.
Pernicious Anæmia.

Diminished Excretion.

(1) Vegetable diet.

(2) After certain drugs, salts of
Iodine, lithium, benzoic acid.

(3) Chronic kidney disease.

(4) Gout, before acute attack.

(5) Diabetes.

TESTS.

Qualitative.

(α) Microscope—characteristic crystals.

(β) Murexide test (also applicable to urates).

Evaporate *nearly* to dryness five drops of urine in a porcelain basin.

Add a drop of strong nitric acid, and heat to dryness = reddish brown deposit.

Allow to cool. Then hold it over the vapour of ammonia, or place a drop of liquid ammonia on it = deep red purple tint (a drop of caustic potash gives a violet tint, or, if used after the ammonia, a purple blue).

(γ) Garrod's Thread Test.

Evaporate 2 c.c. urine in a watch-glass to a small volume along with a few drops of glacial acetic acid, and one or two threads.

The microscope shows uric acid crystals on the sides of the thread.

(δ) Schiff's test.

Dissolve the crystals in a solution of carbonate of soda. Moisten a filter paper with nitrate of silver solution, and on adding a drop of

the alkaline solution a black spot of reduced silver appears.

Quantitative (Rough Method).

Heintz's Method.

Add 10 c.c. hydrochloric acid to 200 c.c. urine.
Shake and set aside for one or two days.
Then filter through filter paper of known weight.
Wash crystals on filter with distilled water.
Dry in warm chamber, and weigh till weight remains constant.
Deduct weight of filter paper = weight of uric acid in 200 c.c. urine.
(As all the uric acid is not precipitated by this method—add 0·0038 gram as uric acid for every 100 c.c. urine.)

URATES (LITHATES).

Two forms (1) Amorphous salts.
(2) Crystalline ,,

They form the commonest deposit which is found, and occur as—

Urate of soda (chiefly).
Urate of potash.
Ammonium and calcium urate in small amount.

(1) *Amorphous.*

Colour—Almost always coloured by urinary pigments.

Brick red—usually.
White.
Pink, vermilion—orange.
Purplish.

Deposition—Only occurs as urine cools.
If urine be heated they redissolve (compare phosphates).

Microscopically.
Amorphous yellow granules.

(2) *Crystalline Urates*—Seldom met with.

(*a*) Urate of sodium crystals.
Microscopically — Round yellowish red bodies with small projecting spines.
Occur (1) In gout—of serious import, as they may be precipitated in the renal tubules.
(2) Certain fevers.

(*b*) Urate of Ammonia—
Rarely found in fresh urine. Occurs along with phosphates in alkaline fermentation.
Microscopically—Dark brownish red spheres with projecting spines, or as dumb-bells (*q. v.*).

Deposit of Urates found in

(1) Fevers and inflammations.
(2) Disorders of digestion.
(3) Cold weather.
(4) Concentrated urine.
(5) Severe exercise.
(6) After much animal food.

Tests.

(1) Dissolve on heating.
(2) Acid added causes no change.
(3) Murexide test.
(4) Microscope.

Hippuric Acid.

Normal daily excretion, 0·3-1 gramme.

Occurs as hippurate of Sodium.

Tests.

Qualitative.

(1) Boil with few drops of nitric acid.
Heat to dryness.
Place in test tube, and heat = smell of oil of bitter almonds.

(2) Boil with hydrochloric acid (= splitting up of hippuric acid into benzoic acid and glycocine).
Add excess of caustic potash.
Add drop of dilute copper sulphate solution = deep blue colour, unchanged by boiling.

Quan'itative.

Evaporate 250 c.c. fresh urine to 25 c.c.
Mix to
Thick paste with powdered gypsum.
Acidify with acetic acid.
Extract with ether.
Evaporate off the ether.
Dissolve residue in hot water, and filter.
Crystals of hippuric acid crystallise out on cooling.
Weigh these = hippuric acid in 250 c.c. urine.

Increased Excretion.

(1) Vegetable diet.
(2) After taking benzoic acid or benzoates.
(3) Acute fevers.
(4) Chorea.
(5) Diabetes mellitus.
(6) Certain hepatic diseases.

Decreased.

Animal diet.

KREATININ.

It is derived from muscle waste, or from kreatin in animal food consumed.

Total Daily Excretion, $\frac{1}{2}$-1 gramme.

Crystallises in large colourless prisms.

TESTS.

Qualitative.

(1) Weyl's test.

Make a fresh dilute solution of nitroprusside of sodium of strength equal to a pale red colour.

Add a few drops of this to some urine, and

A weak solution of caustic potash drop by drop = ruby red colour if kreatinin be present.

Heated with glacial acetic acid, colour becomes green, and then blue.

(2) Jaffe's test.

Add solutions of picric acid (moderately strong), and caustic potash to the urine.

Heat this = fine red colour if kreatinin present.

(*Fallacy*—Acetone and grape sugar give a similar reaction—so test for these separately.)

(3) Take 250 c.c. urine and precipitate the phosphates by adding milk of lime and chloride of calcium in excess.

Filter and evaporate filtrate to small bulk.

Add 50 c.c. absolute alcohol.

Set aside for six hours.

Drop in 10-15 M. of an alcoholic solution of chloride of zinc.

In 36 hours

= deposit of kreatinin zinc chloride crystals, as rosettes or groups of fine needles.

Quantitative.

(1) The depth of colour produced in Weyl's test may roughly indicate the amount present.

(2) Take 250 c.c. urine, and proceed as in test No. 3.
Allow the crystals of kreatinin zinc chloride to precipitate for three days in the dark.
Collect on a weighed filter.
Wash residue with 90 per cent. alcohol.
Dry residue on filter, and weigh both.
Subtract weight of filter paper
= weight of kreatinin zinc chloride in 250 c.c. urine.
Calculation—100 parts of this salt correspond to 62·42 of kreatinin.

Increased Excretion.

(1) Nitrogenous animal diet.
(2) Febrile conditions.
(3) Diabetes mellitus.

Diminished Excretion.

(1) Vegetable diet.
(2) Wasting diseases.
(3) Chronic renal diseases.
(4) Anæmia.
(5) Tuberculosis, etc.
(6) Diabetes insipidus.
(7) During convalescence.

XANTHIN.

Occurs only in very small proportion in healthy urine.

May be found as waxy crystalline sediment, or in calculi (rarely).

Crystals—Lemon-shaped plates.

TESTS.

(1) Dissolve some of the crystals in nitric acid.
Evaporate to dryness.
Add drop of caustic potash, yellow becomes red.
Heat = reddish violet.

(2) May be obtained from the fluid from which kreatinin was precipitated (Test 3).
Add to this fluid ammonia and nitrate of silver = precipitate.
Redissolve this in nitric acid (sp. gr. 1·1).
Crystals of compound of hypoxanthin and silver nitrate form on cooling.
Filter these off.
Xanthin and nitrate of silver are in the filtrate.
Add ammonia in excess =

Xanthin precipitated.

(Remove the silver by adding sulphuretted hydrogen ; and, on again adding ammonia, xanthin is obtained in amorphous granules.)

HYPOXANTHIN.

This may be obtained from its combination with nitrate of silver (as was formed in the preceding test) by removing the silver by adding sulphuretted hydrogen. On adding ammonia to this nitrate of hypoxanthin, crystalline nodules of hypoxanthin are obtained.

URINARY PIGMENTS.

These are—Indican, Urobilin } chiefly.
Urohæmato-porphyrin, Uroerythrin } small amounts.

Indican

(Sulphindigotate of Sodium).

Normal daily excretion, 0·004-0·02 gramme.

Tests.

(1) Add 5 c.c. strong hydrochloric acid to 5 c.c. urine in test tube.
Heat =
Reddish to purplish violet colour, according to amount of indican present.

(2) *Jaffe's Test.*

The colour in the above test is deepened by adding a solution of chloride of calcium drop by drop. When maximum colour is reached, add equal volume chloroform, and shake.

On standing, the chloroform extract of indican falls to the bottom, and the depth of its colour may be taken as a rough quantitative test of the amount of indican present.

(If albumin be present in the urine, it must first be removed before applying this test.)

(3) *McMunn's Method.*

Boil together equal parts urine and hydrochloric acid with a few drops of nitric acid.

Allow to cool.

Shake up with chloroform = violet extract.

Examine this extract by spectroscope = spectrum, two moderately broad bands, one on either side of D.

Increased Excretion.

(1) All kinds of intestinal putrefaction, *e.g.* :—

Constipation.

Obstruction of bowels.

Enteric fever.

Dysentery.

Digestive disorders.

Septic peritonitis.

(2) After much animal food.

(3) Cancer of liver.

(4) Long-standing suppurations, empyema, etc.

(5) Tuberculosis.

(6) Cholera.

(7) Addison's disease.

(8) Certain drugs, creasote, turpentine.

Urobilin.

This is the normal colouring matter of urine.

When present in *large amount* ("urobilin jaundice"), the urine is very dark in colour, and gives a froth tinged with yellow (so resembling bile pigment).

TESTS.

(1) Add ammonia till urine is alkaline in reaction.
Filter.
Add few drops of chloride of zinc solution = rose colour with greenish fluorescence.

(2) Add chloroform to the urine, and shake.
Allow to settle, and decant off urine.
Add few drops of iodine solution, and then caustic potash = green fluorescence.

(3) Spectroscopic Test.
Decolorise urine by shaking up with ether.
(*a*) Acid urine shows absorption band in green and blue between *b* and F, and slightly beyond latter.
(*b*) Alkaline urine shows band midway between *b* and F.

Increased Excretion (Urobilinuria).

"Febrile Urobilin" is not quite the same as normal urobilin.

(1) Most fevers, specially septic fevers.
Enteric.
(2) Hæmorrhages, intracranial, or in other situations.
(3) Digestive disorders.
(4) Cirrhosis or congestion of liver.
(5) Scurvy.
(6) Addison's disease.
(7) Pernicious anæmia (very diagnostic).
(8) Broncho-pneumonia in children.

Urohæmato-porphyrinuria.

Appearance of Urine.

In a thin layer = brownish red colour.

In bulk = blackish in colour.

Tests (1) Unchanged by boiling.

(2) Albumin not necessarily present (so differing from hæmatinuria).

(3) Characteristic spectrum with four absorption bands.

Present in

(1) Acute rheumatism.

(2) Pneumonia.

(3) Measles.

(4) Enteric fever.

(5) Addison's disease.

(6) Inflammation of serous membranes.

Uroerythrin is the pigment of pink urates.

INORGANIC MATTERS IN NORMAL URINE.

There are present—

Salts of hydrochloric acid.

Sulphuric ,,

Phosphoric ,,

Carbonic ,, (carbonates).

Silicic ,, (silicates).

Nitric ,, (nitrates).

Nitrous ,, (nitrites).

I. Chlorides.

Hydrochloric acid is never free in urine.

It occurs united with sodium, and to a lesser extent with potassium, magnesium, and ammonium.

Chlorides are always in solution in urine.

Daily Excretion—10-15 grammes (140-200 grains).

Increased Excretion.

(1) After muscular exercise.
(2) „ taking much food or fluid.
(3) „ „ „ common salt.
(4) During absorption of exudations.
(5) Bright's disease.
(6) Diabetes insipidus.
(7) Ague.

Diminished.

(1) In all fevers (increased after crisis).
(2) Acute pneumonia (may be entirely absent).
(3) Dropsies—general or local.
(4) Chronic nephritis.
(5) Dyspepsia.
(6) Diarrhœa, enteric fever, cholera.
(7) Pleurisy.
(8) During the night.

Tests.

Qualitative.

(1) Evaporate a drop of urine on a glass slide.

Examine by microscope = characteristic crystals of chloride of sodium in cubes

and octahedra or rhombic plates (of chlorine and urea).

(2) Add few drops nitric acid to a little urine in a test tube.

Then add some nitrate of silver solution = copious white precipitate of chloride of silver.

Then add ammonia = precipitate redissolves.

Or add nitric acid = ,, no change.

(*Note.*—If albumin be present, it must first be removed by acidifying, boiling and filtering before applying this test. The nitric acid is first added to prevent the phosphates from precipitating the silver.)

Quantitative.

(1) The preceding test may be used as a rough method of estimating the amount of chlorides present. Add excess of nitrate of silver, so as to precipitate all the chlorine. Note the density of the coagulum.

If few chlorides be present = haziness only.

If no ,, ,, ,, = urine clear.

If many ,, ,, ,, = dense coagulum.

(2) Mohr's method.

A standard solution of nitrate of silver is made by dissolving 29·075 grammes pure nitrate of silver in a litre of distilled water. The silver in each cubic centimetre of this solution is exactly

reduced by ·006 gramme chlorine, or 0·01 gramme chloride of sodium. The "indicator" (for showing the end of the reduction) is a saturated neutral solution of chromate of potash, which, when acted on by silver salts, becomes bright red from the production of chromate of silver.

*Method.**

Remove any albumin by heating and filtration, or mucus by filtration alone. Take 10 c.c. of this urine and place in a porcelain basin with 100 c.c. distilled water, and a few drops of the chromate of potash solution.

Place this under a burette containing the standard nitrate of silver solution. Run the latter slowly into the dilute urine, stirring all the time, until a permanent reddish tint is produced. This marks the end of the process. Read off now the number of cubic centimetres of silver solution added. The silver first causes a reduction of all the chlorides, and it is only after they have all been reduced that the chromate of silver is formed, hence its use as an "indicator". The amount of silver in the number of cubic centimetres added has been required to precipitate the chlorine in 10 c.c. of urine, and so the total amount is easily obtained.

* To estimate the chlorides exactly, all the organic matter has to be got rid of by incineration, but the above method, in my experience, does sufficiently well for clinical purposes.

Example. Suppose 6 c.c. silver solution have been added. Each cubic centimetre is equal to 0·006 gramme chlorine, or 0·010 gramme NaCl, so 6 × ·006 = 0·036 gramme chlorine in 10 c.c. urine.

If total excretion of urine be 1400 c.c., then 10 : 1400 : : 0·036 : x = 5·04 grammes chlorine.

If expressed as chloride of sodium,

10 : 1400 : : 0·06 : x = 8·4 grammes chloride of sodium.

Notes (1) If urine be very highly coloured, it is not easy to tell when pink colour appears, so dilute the urine with distilled water.

(2) Subtract 1 c.c. from the total number added, as the urine contains substances which are more easily precipitated than the chromate.

II. Phosphoric Acid.

Found only as ortho-phosphates of the alkalies (soda and potash), and alkaline earthy metals (calcium and magnesium).

(*a*) Alkaline phosphates are always found in the urine and *always in solution*, as they are freely soluble. They occur as acid salts of sodium (chiefly) and potassium (NaH_2PO_4, and KH_2PO_4), and it is to

these salts that the normal acidity of the urine is due. Nearly three-quarters of the phosphoric acid is united to these alkalies.

(*b*) Insoluble or earthy phosphates are precipitated in alkaline urine. These are found as

(1) Phosphate of Calcium ($Ca_3(PO_4)_2$), which occurs in two forms.

(*a*) Amorphous granules, soluble at once on addition of acid (thus distinguishing them from amorphous urates, as does also the fact of the urine being alkaline).

(*β*) Stellar phosphate of lime—the stars being composed of aggregations of colourless needle-like crystals.

(2) Magnesium Phosphate ($Mg_3(PO_4)_2$) rarely occurs, and, when present, is usually associated with the calcium salt. It forms tablet-shaped crystals.

(3) Ammonio-magnesium, triple or feathery phosphate (NH_4MgPO_4, $6H_2O$) found in urine alkaline from presence of ammonia. It is, therefore, found in all decomposing urines, and often forms a shining pellicle on the surface of these urines.

It also occurs in two forms.

(α) Triangular prisms, knife-rests, or coffin-lid crystals.

(β) Feathery crystals (more rarely).

Acid phosphates (NaH_2PO_4, $Ca(H_2PO_4)_2$) usually present in acid urine.

Neutral phosphates (Na_2HPO_4, $MgHPO_4$) usually present in neutral urine.

Alkaline phosphates ($Ca_3(PO_4)_2$, $Mg_3(PO_4)_2$) sometimes present in alkaline urine.

Total daily excretion—2-4 grammes.

Increased Secretion.

(1) Many nervous diseases.
Chorea.
(2) After mental work.
(3) Muscular exertion.
(4) Copious drinking of water.
(5) Flesh diet.
(6) Bone diseases.
Rickets.
Osteomalachia.
(7) Early phthisis.
(8) Diabetes mellitus.
(9) Fevers.
(10) Leucocythæmia.
(11) True phosphaturia = phosphatic diabetes.

Diminished Excretion.

(1) Kidney diseases (constantly).
(2) Most acute diseases.

(3) Rheumatism.
(4) Gout.
(5) During pregnancy.
(6) Chronic cerebral disease.

TESTS.

Qualitative.

(1) Fill test tube half full of urine.
Heat upper layer of fluid = opacity from precipitated phosphates (owing to carbonic acid being driven off).
(2) Add acid = precipitate dissolves (compare urates).
(3) Add alkali to urine (as caustic potash) = precipitate of earthy phosphates.
(4) Add uranium nitrate = yellowish precipitate of phosphate of uranium, insoluble in acetic acid.

Quantitative—Solutions required.

(1) Standard solution of nitrate of uranium ($UrO_2(NO_3)_2$), of which each cubic centimetre is exactly reduced by five milligrammes of phosphoric acid (P_2O_5).*

* Dissolve 33 grammes yellow oxide of uranium in nitric acid solution (sp. gr. 1200). Add water to 1100 c.c., and standardise it against a solution of sodium phosphate of known strength, so that each c.c. is equal to 0·005 gramme phosphoric anhydride.

The solution of sodium phosphate, with which to standardise the uranium solution, is made by dissolving 10·085 grammes

(2) Solution of acetate of soda, containing free acetic acid (100 grammes acetate of soda; 100 c.c. pure acetic acid; distilled water to 1 litre).

(3) Solution of ferrocyanide of potash, as an indicator.

Method.

Place 50 c.c. urine in a porcelain basin.

Add 5 c.c. of the soda solution.

Test if urine is acid; if not, add acetic acid till it is.

Heat this by means of a spirit lamp.

Run in the standard uranium solution slowly from the burette till a drop of the mixture gives a distinct brown colour with a drop of the indicator on a slab.

If not, then add more of the uranium solution, and again test by the indicator. Go on doing this till the slightest trace of a brown appears. Then stop as the action is complete—the uranium has united with the whole of the phosphoric acid, and is now in excess, and can unite with the ferrocyanic acid. Keep the urine heated during the whole of the process. (The acetate of soda is used to combine with the nitric acid freed from the uranium, and acetic acid is thus

crystallised phosphate of soda in distilled water, and diluting to one litre. 50 c.c. of this contain 0·1 gramme of anhydrous phosphoric acid, or 2·5 c.c. = 0·005 gramme (P_2O_5).

liberated, and is necessary for the complete precipitation of the phosphoric acid.) Note the number of cubic centimetres of uranium solution used, and so calculate total excretion.

Example. Suppose 20 c.c. have been used. Each c.c. is equal to ·005 gramme phosphoric acid. So 20 × 5 = 100 milligrammes in 50 c.c. urine. If total excretion of urine be 1600, then 50 : 1600 : : 0·100 : x = 3·2 grammes phosphoric acid in 24 hours.

Tincture of cochineal may be used as an indicator also ; a few drops of it being added to the urine, and the titration stopped as soon as a greenish colour is produced (showing excess of uranium salt).

III. Sulphuric Acid.

Total daily excretion, 1·5-3 grammes.

The excretion of sulphates runs exactly parallel with that of urea.

Sulphuric acid is found in the urine united to the bases, sodium and potassium, as also in small amount to magnesium and calcium. These are all very soluble salts, so are never found as deposits.

It also occurs in the form of acid in the pigment indican, as also with phenol, skatol (ether-sulphonic bodies).

Increased Excretion.

(1) Fevers.

(2) Acute rheumatism.
(3) Pneumonia.
(4) Cerebral meningitis.
(5) Delirium tremens.
(6) Animal diet.
(7) After taking sulphur compounds.
(8) Increased tissue change.
(9) Prolonged exercise.

Lessened Excretion.

(1) Vegetable diet (usually).
(2) Chronic affections generally.
(3) Nephritis.
(4) Chlorosis.

TESTS.

Qualitative.

Acidulate with hydrochloric acid (to prevent precipitation of phosphates).

Add solution of barium nitrate

= white precipitate of barium sulphate—insoluble in acids.

Quantitative.

To estimate the sulphuric acid quantitatively, we require a standard

(1) Solution of barium chloride. This is made by dissolving 30·5 grammes of pure dried crystallised chloride of barium in distilled water, and diluting to one litre. One c.c. of this solution will exactly precipitate 0·01 gramme sulphuric anhydride (SO_3), or 0·01225 gramme sulphuric acid (H_2SO_4).

(2) We also dissolve 21·775 grammes pure sulphate of potash in distilled water, and make up to one litre. One c.c. of this solution precipitates exactly the same amounts of the hydrated and anhydrous acids.

(3) Pure hydrochloric acid.

Method.

In a beaker place 100 c.c. urine with 5 c.c. HCl, and, while boiling, run in from a burette placed above the beaker 6 to 8 c.c. of the barium chloride solution. Remove the lamp, and allow the precipitate to fall. If the fluid rapidly clears, run in another cubic centimetre, and heat again. Filter a few drops of this into a test tube, and to them add some of the barium solution from the burette. If a precipitate forms in the tube, it shows that we have not added enough to the urine in the beaker, so pour it back, and run in another c.c. from the burette. Filter a few drops, and test again, and repeat the process if necessary. Go on doing this till no precipitate falls in the test tube, on the addition of a few drops of the barium solution. When arrived at this stage, add a few drops of the sulphate of potash solution, when at most there should only be a slight cloudiness produced, showing that the barium is now in slight excess. If at the first trial we find that on adding a little of the barium solution to the filtrate in

the test tube, no opacity results, but that there is opacity produced on adding the sulphate of potash solution, then we have added too much barium solution to the urine, so the experiment must be repeated afresh.

Read off the number of centimetres used, and calculate the percentage of sulphuric acid.

Example. We have run in 15 c.c. of the barium solution before a slight cloudiness appeared on adding the potash solution to the filtered urine in the tube. Each c.c. was equal to 10 milligrammes sulphuric anhydride, therefore in the 100 c.c. urine there has been 0·15 gramme. If 1600 c.c. urine passed, then the excretion of sulphuric anhydride is 2·40 grammes. Calculated at sulphuric acid, this is 0·1837 gramme per 100 c.c. urine; and 2·94 grammes in 1600 c.c.

IV. Oxalic Acid.

Daily excretion, 0·02-1·5 grammes.

Never occurs free, but always as a salt of calcium and in solution.

Increased excretion of uric acid is usually associated with increased excretion of oxalic acid.

Increased Excretion.

(1) In certain disorders of digestion.
(2) Oxalic acid diathesis.
(3) Diabetes.
(4) Catarrh of urinary passages.

(5) After certain fruits or vegetables.

Rhubarb.
Cabbage.
Tomatoes.
Onions.
Turnips.

(6) Lumbago.

Quantitative estimation.

Take 500 c.c. urine.

Add chloride of lime solution and excess of ammonia.

A precipitate falls. Add a little acetic acid.

Oxalate of lime remains undissolved. Set aside for 24 hours.

Filter and wash residue.

Place filter with residue in hydrochloric acid and heat. This dissolves the oxalate of lime, but not uric acid.

Filter again, washing residue with dilute warm hydrochloric acid.

Add washings to filtrate, and neutralise with dilute ammonia.

Oxalate of lime crystals separate.

Collect on filter of known weight, dry and weigh.

Subtract weight of filter paper from total weight, and result is the oxalate of lime in 500 c.c. urine.

The oxalic acid present is easily calculated, as 100 parts oxalate of lime correspond to 70·31 parts oxalic acid.

LACTIC ACID.

Doubtful if it be a normal constituent of urine—probably not.

Said to occur in urine

(1) After severe muscular exertion.

(2) In diabetes.

(3) Phosphorus poisoning.

(4) Bone diseases.

Rickets.

Osteomalachia.

(5) Certain diseases of the liver.

ABNORMAL CONSTITUENTS IN URINE.

These are—

- **Proteids.**
  - Serum albumin.
  - Egg albumin.
  - Serum globulin.
  - Albumose.
    - Acid albumin.
    - Alkali albumin.
  - Peptone.
  - Propeptone.
  - Hetero-proteose.
  - Fibrin.
- **Blood.**
  - Blood corpuscles.
  - Hæmoglobin.
  - Methæmoglobin.
- **Bile.**
  - Bile pigments.
  - Bile acids.

Chyle—Fat.

Melanin.

- **Carbohydrates.**
  - Glucose.
  - Levulose.
  - Lactose.

Glycuronic acid.

Acetone.

Abnormal deposits.
Calculi.
Certain foods, or excess of.
Certain drugs.

PROTEIDS

("Albuminous Urine").

General Precautions.

Before testing for proteids, "prepare" the urine.

(1) If turbid, filter through bibulous paper.

(2) Note reaction, as acid or alkali albumin may be present.

(3) Should be rendered only *faintly* acid.

If very acid, it should be rendered less so by adding potash.

If alkaline, add a few drops of acetic acid.

Characters of Albuminous Urine.

There are no characters special to this abnormal urine; but

It froths easily.
Froth is very persistent.
Splashing sound on shaking the urine is often soft in character.

GENERAL TESTS FOR THE PRESENCE OF PROTEIDS IN URINE.

1. Acidification with Simple Heat.

Fill a test tube three-quarters full of urine; acidify it with one drop or two of acetic acid,

and heat the upper part of the fluid in a spirit lamp. As the boiling point is reached, the heated urine becomes opaque or cloudy, depending on the amount of proteid present. If in small amount there may be only a slight haze produced, and this is best seen by holding the tube against a dark background.

This test coagulates both serum albumin and serum globulin, but not the albumoses or peptones.

Precautions.

If the urine be insufficiently acidified, a precipitation of phosphates is often produced when it is boiled. This dissolves, however, at once on the addition of more acid; whereas, if it be due to proteids, the opacity is increased on addition of acids.

Acid and alkali albumins are uncoagulable by heat. In very alkaline urines serum albumin and serum globulin sometimes are changed into alkali albumins, and so are not precipitated by this test. On the other hand, when the urine is highly acid, or when excess of acetic or hydrochloric acids has been added, serum albumin may become acid albumin, and so fails to respond to this test.

If the precautions, however, as to the proper preliminary treatment of the urine be carried out, this test is, perhaps, the most reliable of all.

2. Cold Nitric Acid (Heller's Test).

Into a test tube place half an inch of the urine.

Pour in gently some strong nitric acid, allowing it to run down the side of the tube, and so form a layer below the urine. If proteid be present, at the line of contact a white cloud appears, which differs in density according to the amount of albumin present. If much proteid be present, the urine becomes almost solid.

Nitric acid coagulates serum albumin, serum globulin and albumoses, but not peptones.

Fallacies.

1. Urea may crystallise out as the nitrate of urea, and form a whitish layer, if much urea be present; but it is crystalline in appearance, and dissolves on heating.
2. Uric acid and urate give a similar appearance occasionally, but higher up in the urine itself, and not at the line of junction. These also dissolve on heating.
3. Resinous bodies (*e.g.*, copaiba, turpentine), when in the urine, give also a whitish line when nitric acid is added, but this also dissolves on heating.
4. Mucin causes a haziness higher up in the urine.

(*Note.*—A brown ring is often found at the junction of the two fluids. This is due to oxidation of chromogens in the urine. If

much indican be present it is violet or red in colour; and if bile be present the ring is greenish.)

3. Potassium Ferrocyanide Test (Pavy's Method Modified).

Into a test tube pour half a drachm of acetic acid, and about three times this quantity of a solution of ferrocyanide of potash, and mix.

Then add urine to about two-thirds the depth of the tube = pale greenish coagulum at junction, if proteid be present.

This coagulates all the proteids, with the exception of peptone.

It forms a very delicate test.

Gives no reaction with mucin, urates, phosphates, or vegetable alkaloids.

4. Picric Acid Test.

May be performed in two ways:—

(*a*) Contact method. Pour a concentrated watery solution of picric acid on to the surface of the urine in a test tube, and if proteid be present, a yellowish cloud appears at the junction.

(*b*) Fill the test tube half full of the picric acid solution, then fill it up with the urine. Invert the tube once or twice —cloudiness or copious yellow deposit forms according to the amount of proteid present.

Picric acid precipitates all the above-named proteids—*albumin, peptone, proteoses, mucin, and vegetable alkaloids*, but the deposit caused by albumoses and peptones disappears on heating, while with the other albumins it is increased.

Fallacy. If the patient be taking any of the alkaloids (quinine, morphine, or piperazine, etc.), picric acid causes their precipitation in the urine, but the coagulum due to these is soluble on heating.

Urates are also precipitated, but disappear on heating.

Phosphates also are precipitated.

The preceding are the most important clinical tests for proteids, though others, as corroborative tests, may be applied.

5. Nitric Acid and Heat Test.

Boil urine in test tube (albumin or phosphates may be precipitated).

Pour nitric acid down side.

= increased opacity if due to albumin.

= redissolves if due to phosphates.

This coagulates all the proteids, except peptone.

Fallacies (1) Acid albumin may be formed, and this is not coagulated.

(2) If uric acid be in excess, it may be precipitated.

(3) Certain resinous drugs are excreted by the urine, and are precipitated by this test. Alcohol redissolves them.

6. Millon's Test.

Reagent (one part mercury, two parts nitric acid; dissolve by gentle heat. Add two parts water).

This precipitates albumin, and, when boiled, the whole becomes brick red.

If only traces of proteid be present, no precipitate forms; only the red colour appearing.

7. Potassio-Mercuric Iodide Test (Tanret's Test).

Reagent—Mercuric chloride, 1·35 grammes; potassium iodide, 3·32 grammes; acetic acid, 20 c.c.; water, to 100 c.c. Employ as in Heller's test. It is very reliable.

It precipitates serum albumin, albumoses, peptone, bile acids, alkaloids.

Heated, the precipitate due to peptones, albumoses, and alkaloids redissolves.

8. Biuret Test.

Add one or two drops of caustic potash to the urine.

Then dilute copper sulphate solution in drops = green precipitate.

Redissolves if albumin be present—giving

Violet-coloured fluid with serum albumin, globulin, and albumose.

Pinkish red with peptone.

Precipitation and Estimation of the whole of the Proteids.

The whole of the proteids may be entirely removed from the urine, thus:—

(1) Add to the urine half its volume of common salt solution.

Then excess of tannic acid.

= precipitation of all proteids which may be filtered on a weighed filter. Wash frequently with water, and then hot alcohol, then dry and weigh.

(2) Take definite amount of urine.

Add five times its volume of alcohol.

Set aside for six hours.

Collect precipitate on weighed filter.

Wash with hot alcohol and ether.

Dry and weigh = total proteids in the volume of urine taken.

DIFFERENTIAL TESTS FOR PROTEIDS.

I. Serum Albumin.

Acidify and heat urine = precipitation (see page 245).

This may be serum albumin or serum globulin, or both.

Test for globulin.

If negative, then the proteid present is serum albumin.

Quantitative Estimation.

(1) Esbach's method.

(If serum globulin be present, it must first be got rid of—see below.)

Fill one of Esbach's albuminometer tubes with the urine up to the mark "U".

Then add the picric acid reagent up to "R".

(This reagent is made by dissolving 10 grammes picric acid, 20 grammes citric acid in hot water, and diluting, when cold, to one litre.)

Insert the indiarubber stopper, and invert the tube twice or thrice without shaking, and set aside.

Read off the amount in 24 hours. The result expresses grammes albumin per litre.

If, however, serum globulin has first been precipitated by adding sulphate of magnesia (see below), then the urine has so high a specific gravity, owing to the added salt, that several days must elapse before the amount is read off. Wait until the level does not change on two successive readings, each at an interval of 24 hours, and remember, in calculating, the dilution caused by adding the sulphate of magnesia, as, for example, 20 c.c. urine were saturated with the sulphate, and the volume is now 30 c.c. Therefore

20 : 30 : : amount of albumin : x.

Precautions.

(*a*) Render urine distinctly acid to begin with.

(*b*) If of high specific gravity, dilute urine twice with distilled water.

(*c*) If albumin be present in large amount (above 4 per 1000), then dilute the urine twice, thrice, or four times.

(*d*) If albumin be in very small amount (below 0·5 per 1000), then evaporate down the urine one-half or one-quarter its bulk before estimating by Esbach's method.

(2) If a balance be at hand, the albumin may be estimated gravimetrically.

Take a definite amount of urine, 50 or 100 c.c.

Heat in a beaker, and add dilute acetic acid in drops till flocculent precipitate falls.

Then boil and filter through filter paper of known weight.

Wash albumin on filter with water, alcohol, and ether.

Then dry and weigh.

Deduct weight of filter paper = weight of serum albumin in 50 or 100 c.c. urine.

Serum albumin found in urine.

(1) After too free indulgence in albuminous food ("physiological albuminuria").

(2) Increased blood pressure—

Heart disease.

Chronic lung disease.

Alcoholism, etc.

(3) After severe muscular exertion.
Tetanus.
Strychnia poisoning.
(4) Diseases of the kidney.
Nephritis, acute and chronic.
(5) Alteration in the blood.
Anæmia.
Cholera.
(6) Fevers.
(7) Suppuration in genito-urinary tract.
(8) Renal irritants, cantharides, carbolic acid, phosphorus.

Amount excreted—Usually forms 0·5 per cent. of urine, but may reach 2-3 per cent.

II. Serum Globulin—(Paraglobulin).

This is very often associated with serum albumin in urine, but the latter is usually much in excess.

Esbach's reagent precipitates both of these albumins, and in rough clinical work it is common to estimate them together as "albumin".

Tests.

Qualitative.

(1) If urine be acid, render it neutral, or faintly alkaline by adding liquor potassii.
Filter if turbid.
Allow a saturated solution of sulphate of magnesia to run slowly down side of tube, and below the urine.

= white woolly ring at junction if globulin be present.

This precipitate is easily dissolved by a solution of chloride of sodium.

(2) If globulin be present in large amount, it may be precipitated as a milky cloud on diluting the neutralised urine largely with water—globulin being insoluble in pure water.

This milkiness clears up on adding acetic acid.

Quantitative.

(*a*) If it be associated with serum albumin, estimate both together in one sample of urine by Esbach's method.

(*b*) In a second portion of urine precipitate the globulin by saturating it with powdered sulphate of magnesia. Filter this urine.

(*c*) Take this filtrate and estimate the serum albumin in it by Esbach's method, but allowing six or seven days to elapse before reading off the amount.

The difference between these two readings (*a* and *c*) gives the amount of serum globulin per 1000 parts urine.

Occurrence in Urine—Usually present along with serum albumin, but

It may be in larger amount than serum albumin in

(1) Lardaceous disease of the kidneys.
(2) Diabetes.

EGG ALBUMIN.

This gives the same reactions as serum albumin.

Differential Test.

Ether precipitates egg albumin, but not serum albumin.

III. ALBUMOSES OR ALBUMINATES.

These consist of (1) Acid albumin or syntonin.
(2) Alkali albumin.

They are, therefore, not present in neutral urine.

General Tests.

(1) Not coagulated by heat.
(2) Coagulated by nitric acid.
(3) ,, ,, picric acid.
(4) ,, ,, ferrocyanide of potash.

Differential Test.

They are *not* coagulated by heat and acetic acid.

If serum albumin or globulin be present likewise, get rid of them by adding acetic acid, boiling, and filtering.

Now test filtrate for acid or alkali albumin by ferrocyanide of potash, picric or nitric acid tests.

Neutralisation of the urine may cause a precipitate to fall.

This is soluble in excess of weak acid or alkali.

According to the original reaction of the urine,

this precipitate is either alkali or acid albumin.

Occur sometimes in urine in—

(1) Eruptive fevers.
Measles.
Scarlatina.

(2) Inflammation of bone.

IV. Peptones.

The presence of peptones in the urine is of great importance clinically in helping to elucidate doubtful cases. They occur in the renal excretion very generally in all suppurative diseases, phthisis, empyema, etc., where there is absorption of peptones derived from the breaking down of leucocytes.

Tests.

1. When present in large amount, they may give the—

Biuret reaction.

Add a drop or two of a weak solution of sulphate of copper and excess of caustic potash (Fehling's solution answers for both of these well) to half an inch of urine in a test tube = distinct reddish pink colour if peptones be present to a large extent. Other proteids give a violet colour when treated thus.

2. When present in small amount, the biuret reaction fails; or if it be doubtful whether it be deutero-proteose

Saturate a quantity of the urine with powdered sulphate of ammonia. This precipitates all proteids *except* peptones.

Filter and test filtrate for peptone by the following tests :—

(*a*) Add a solution of picric acid or Esbach's reagent.

A precipitate forms if peptone be present, which dissolves on heating, but reappears on cooling.

(*b*) Add nitric acid = no precipitate.
Now boil = deep yellow colour.

(*c*) Heat filtrate = no precipitate.

(*d*) Acetic acid and ferrocyanide of potash = no coagulation.

Occur frequently in the urine.

(1) Always found where any suppuration is going on in the body.

(2) Always found during absorption of inflammatory exudations (*pyogenic peptonuria*), *e.g.*, Empyema.
Resolution stage of pneumonia.

(3) Acute febrile attacks, exanthemata.

(4) Ulceration of bowels, peptones derived from digestion of food pass into blood.

(5) Inflammation of urinary mucous membrane.

(6) Severe scorbutus.

(7) Phosphorus poisoning.

(8) During the puerperium.

V. Propeptone or Hemialbumose.

This is a form of peptone less fully hydrated than peptone.

Said to occur tolerably frequently in urine.

Reactions for differentiation.

1. Add cold nitric acid = precipitate, soluble in excess.

   Precipitate dissolves on heating, but returns on cooling.

2. Intense pink colour with biuret reaction.
3. Add acetic acid and a few drops of ferrocyanide of poasth.

   = white precipitate = soluble in excess of ferrocyanide.

4. Add excess of acetic acid, then

   Equal volume of concentrated sulphate of soda solution.

   Boil = white precipitate.

5. Saturate with sulphate of ammonia = complete precipitation.

The last three reactions distinguish it from peptone.

VI. Hetero-Proteose.

Occasionally found in abnormal urine.

e.g., Preceding nephritis.

Osteomalachia.

Reactions.

(1) Add sulphate of ammonia or magnesium = precipitate.

(2) Heat urine, if alkaline = precipitate, soluble in dilute hydrochloric acid.

(3) Add nitric acid = precipitate, soluble on heating, but returns on cooling.

VII. Deutero-Proteose.

Reactions.

(1) Not precipitated by magnesium sulphate, ferrocyanide of potash or by boiling.

(2) Is precipitated by ammonium sulphate.

(3) „ „ brine along with cold nitric acid. This dissolves on heating and reappears on cooling.

MUCIN.

Normally present in urine, but may be in great amount in catarrh of genito-urinary passages.

Tests.

(1) Add lime water = dissolved easily.

(2) Add alcohol = precipitate,
Or acetic acid = precipitate,
Or dilute mineral acid = precipitate,
} soluble in lime water.

(3) Heat = no coagulation.

Note.—If present along with albumin, when Heller's test is applied the mucus cloud forms *above* that due to albumin.

FIBRINURIA.

Appears as "coagulable urine," or
as a sticky viscous sediment.

TESTS.

Filter off coagulum, and apply tests to it.

(1) Swells up in 1 per cent. solution of hydrochloric acid.

(2) Dissolved by action of pepsin.

(3) Dissolved in 1 per cent. carbonate of soda solution.

SUMMARY OF INVESTIGATIONS FOR PROTEIDS IN URINE.

1. Acidulate and boil.
   (*a*) If precipitate = serum albumin or globulin. Test for these.
   (*b*) If no precipitate = serum albumin or globulin absent.
2. Neutralise and saturate with sulphate of magnesia.
   (*a*) If precipitate = globulin or hetero-proteose present. Differentiate these.
   (*b*) If no precipitate = globulin or hetero-proteose absent.
3. Saturate with sulphate of ammonia, and filter. Test filtrate.
   (*a*) If biuret reaction = peptone present.
   (*b*) If no biuret reaction = peptone absent.

BLOOD.

I. Hæmoglobinuria = colouring matter of the blood (hæmoglobin) alone present in urine as—

- Oxyhæmoglobin.
- Reduced hæmoglobin.
- Methæmoglobin.
- Hæmatin (almost).

II. Hæmaturia = blood corpuscles in urine.

Colour—Varies according to amount of blood, or its pigment in the urine.

Small amount = mere smokiness.
= dirty turbidity (methæmoglobin present—specially if urine be acid).

Moderate amount = distinct reddish colour.

Large amount = bright red (if urine be alkaline).
= dark brown (usually methæmoglobin).

(*Note.*—Often on standing the upper layer in a dark urine containing blood, becomes bright in colour, owing to oxidation into oxyhæmoglobin.)

Deposit.

Colour varies.

Dark red—dark brown, or black.

CLOTS.

These often are found as a deposit.

Size and Shape.

Vary according to part of genito-urinary tract from whence they have come.

(1) From urethra = clots, small and elongated.
Come away before the urine on micturition.

Cause.

Acute urethritis, simple or specific.
New growths, etc.

(2) From bladder = clots, irregular in size and shape.
Come away towards end of micturition.
Urine alkaline.

Cause.

Vesical calculus.
Villous tumour of bladder.
Ulceration of bladder.

(3) From ureter or pelvis of kidney =
Worm-like in form.
Lighter in colour.
Come away with urine.

(4) From renal substance = not usually in clots.
Generally diffused through urine.
Do not tend to form sediment.

Microscopically—Blood casts present.

Causes.

(1) Acute Bright's disease.
(2) New growths in kidney.
(3) Renal calculus.

TESTS.

1. As blood contains serum albumin and globulin the urine gives the usual reactions for these proteids.

2. GUAIACUM TEST.

Place one inch urine in test tube.
Add two drops tincture of guaiacum (freshly prepared and made with rectified spirit).
Shake well.
Add ozonic ether or old turpentine—in volume as much as the urine.
= blue line at once produced at junction of fluids if much blood be present.
= if little blood present—
Shake up mixture. Then allow ether to rise to top.
= blue tint varying in intensity with amount of blood present.

Fallacies.

(*a*) Saliva gives a similar reaction, but is seldom present in sufficient amount in urine to give this reaction.

(*b*) Pus gives this reaction.

(*c*) Iodide of potash, in the urine of patients taking this drug, gives a blue colour, which, however, takes some time to show itself. With blood it appears at once.

3. Formation of Hæmin Crystals.

This is the only reliable *chemical* test.

Place a little of the urinary sediment on a microscope slide.

Evaporate to dryness.

Place a small crystal of chloride of sodium on it, and a cover-glass.

Place a drop of glacial acetic acid at edge of cover, and allow it to run in below.

Heat it slowly.

Examine by microscope.

= characteristic oblique rhombic prisms of dark reddish brown colour (Teichmann's crystals).

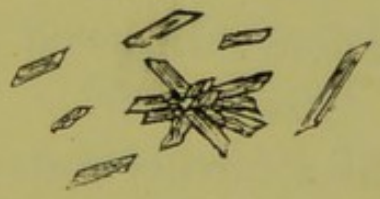


Fig. 50.—Hæmin Crystals.

They are *insoluble* in water, alcohol, ether.

Easily soluble in alkaline solutions.

4. Microscopic Examination.

Blood corpuscles present in hæmaturia.

Usually swollen up and spherical, or
Shrivelled, or with
Crenated edges.

"Phantom corpuscles" may alone be present.

Rouleaux formation seen in fragments of clot.

5. Spectroscopic Examination.

This is the most delicate test of all.

Use the small hand spectroscope.

If urine very dark, dilute with water.

Place some in narrow test tube, and hold before slit in spectroscope.

Oxyhæmoglobin = two dark absorption bands—

One of these narrow and definite towards red end.

The other broader, but less definite, and more towards the blue end.

These correspond to lines D and E of Fraunhofer.

As a further test.

Add a little sulphide of ammonia = reduced hæmoglobin formed.

Examine its spectrum—single hazy band between D and E (see below).

Notes (*a*) If urine be diluted too much,

the indistinct band fades away entirely.

(*b*) If small traces of blood be alone present, a larger layer of fluid must be employed. You may fill a test tube full of urine, and look down through it with the spectroscope.

Reduced Hæmoglobin.

Spectrum = one broad indistinct band placed intermediately between the two produced by oxyhæmoglobin.

Methæmoglobin.

In hæmoglobinuria this is the pigment usually present.

It also occurs in bloody urine of acid reaction, which has stood some time.

Spectrum.

(1) In acid or neutral urine.

= four bands. One very distinct between lines C and D. The other three, less distinct, occur in the yellow, green, and blue.

(2) In alkaline urine = three bands only.

One narrow and distinct close to D.

Two less distinct between D and E.

This pigment is present always in paroxysmal hæmatinuria.

Urine is brownish or black in colour.

Blood Corpuscles in the Urine—Hæmaturia—seen in—

(1) Inflammation or ulceration of urethra, bladder, ureter or pelvis of kidney.

(2) Cancer of bladder or kidney.

(3) Diseases of the kidney.
Tubercular disease.
Cystic disease.
Acute inflammation.

(4) Calculus in kidney substance.
Pelvis of kidney.
Ureter.
Bladder.
Urethra.
} Pus cells are always present also.

(5) Blood diseases, Purpura hæmorrhagica.
Scorbutus.

(6) Parasite—Bilharzia hæmatobia.

(7) Certain drugs, Cantharides.
Turpentine.

Blood Pigment in the Urine—Hæmoglobinuria.

(1) Paroxysmal hæmoglobinuria.

(2) Malaria.

(3) Certain poisons—*e.g.*: chlorate of potash; carbolic, hydrochloric, sulphuric acids; phosphorus; arseniuretted hydrogen.

(4) Acute infectious fevers, pyæmia, typhus.

(5) Transfusion.
(6) Sunstroke.
(7) Burns.
(8) Scurvy.
(9) Jaundice.
(10) Fat embolism.

CHYLURIA.

Characters of Urine.

Milky.
Pink in colour frequently.
Fibrinous coagula deposited.
May gelatinise throughout.

Albumin present as { Serum albumin. / Serum globulin. / Peptone.

Microscopically.

Fat globules.
Red blood corpuscles.
Leucocytes.
Embryos of the *filaria sanguinis hominis.*

MELANURIA.

Melanin is sometimes excreted in the urine of persons suffering from melanotic cancer. The urine may be normal in appearance, or more rarely black granules are suspended in it; but it darkens on exposure to air.

TESTS.

1. It becomes intensely black on the addition of an oxidising agent (sulphuric acid).
2. Add a few drops of solution of perchloride of iron to some urine, when it becomes grey if melanin be present. If more of the reagent be added, a coloured precipitate is formed which redissolves in excess of the iron solution.
3. To the urine add some bromine water, which causes a yellow precipitate to form, and which gradually blackens.

MICRO-ORGANISMS.

Frequently present in urine, and give to it a turbid appearance.

The opacity does not settle down, but remains diffused throughout.

The reaction is usually alkaline or neutral.

BILE IN URINE--CHOLURIA.

Colour of Urine.

This varies with amount of bile pigment present from dark yellow to olive green, brownish green, or porter colour.

It froths somewhat easily, and the froth always shows the colour well.

The urine leaves a yellow stain on paper or linen.

It is usually transparent.

Bile consists of bile pigments and bile acids. { Either or both may exist in urine.

BILE PIGMENTS are recognised by the play of colours which they give when oxidised.

Tests.

1. Gmelin's. Place a few drops of urine on a white porcelain slab. Close to the urine place a drop or two of fuming nitric acid. Allow them to mix slowly, and note if there is a play of colours.

   The first and *most characteristic* which appears *is green* (due to the production of biliverdin—this colour is the important one to observe); then a blue colour (bilicyanin) is produced; which then changes to yellowish red (choletelin). Then all colour disappears.

   (*Note.*—Strong nitric acid gives a pinkish red colour when mixed with high-coloured urines.)

2. Dip blotting or bibulous paper into the urine, and allow it to dry. Then allow a drop of nitric acid to fall on it, when rings of colour are produced if bile pigments be present.

3. The urine may be placed in a test tube or Y-shaped glass, and nitric acid poured down the side, so as to form a layer.

4. On to the surface of a little tincture of iodine in a test tube run a little urine, when a bright green colour is formed at the junction if bile pigments be present (Marechal's test).

BILE ACIDS (Taurocholic and Glycocholic Acids).

Clinical tests are not very accurate.

Tests.

1. Pettenkofer's.

   Place a little urine in a test glass.

   Add a few drops of syrup, and mix.

   Pour down by the side a little sulphuric acid.

   = a violet colour if acid be present.

   This test only acts if the acids be present in large amount.

2. Dip bibulous paper in the mixture of syrup and urine, and allow it to dry. Then allow a drop of strong sulphuric acid to fall, and a violet circle appears if bile acid be present.

3. A ready test is that of Francis.

   To 30 grains of warm dry glucose add half an ounce of strong sulphuric acid. The resulting straw-coloured fluid must be kept in a stoppered bottle in the dark.

   Method.

   Place half-inch of the reagent in a test tube.

   Pour slowly on to the surface the urine.

= a purple line is formed if acid be present.

4. Hay's Test.

Sprinkle sublimed sulphur over surface of urine.

= sinks if bile salts be present, as they lower the surface tension.

5. Oliver's Test.

The bile salts have the property of precipitating proteids from their solutions, and the converse of this may be employed as a test for bile acids.

Method. On to the surface of the jaundiced urine run a layer of albuminous urine (which has been acidified with citric or acetic acid), or an acidified solution of peptone = a white band of coagulated albumin appears at the junction if bile acids be present.

Quantitative Estimation.

Oliver's Test Solution.

Powdered peptone (Savory and Moore's) half a drachm.

Salicylic acid, 4 grains.

Acetic acid, half drachm.

Distilled water to 8 ounces.

Filter repeatedly till transparent.

Method. Filter urine till clear.

Acidify and reduce specific gravity to 1008.

Place a drachm of the above test solution in a test tube.

Add 20 drops of the urine =

If bile acids be present in small amount, a slight milkiness results in a short time.

If bile acids be present in excess — the milkiness appears at once, and becomes denser the larger the amount of bile acids present.

Standard milkiness got by adding equal parts test fluid and normal urine (of specific gravity reduced to 1008).

If more than 60 minims of any urine are required to be added to the drachm of test solution to bring it up to the standard milkiness, that urine does *not* contain excess of bile acids.

DR. OLIVER'S STANDARD TABLE.

Urine.		Percentage Increase of Bile Salts over the Normal.
Minims.	Drops.	
1	2	6000
2	4	3000
3	6	2000
4	8	1500
5	10	1200
10	20	600
15	30	400
20	40	300
25	50	240
30	60	100
35	70	83
40	80	66
45	90	50

Occurrence of Bile Pigments and Acids in Urine.

(1) Obstruction of common bile duct.

(2) Generally, in all forms of jaundice; hæmatogenic or otherwise.

(3) Febrile conditions.

(4) Phosphorus poisoning.

(5) Hæmoglobinuria, Scorbutus, Leucocythæmia.

(6) Bile salts occur, apart from bile pigments, in Hepatic diseases, *e.g.*, Cirrhosis.
Waxy disease.

Note.—In long-continued jaundice bile acids are usually absent.

SUGAR IN URINE

(Glycosuria).

The sugar is almost always present as grape sugar (glucose or dextrose).

Urine is excessive in amount.

Pale in colour.

Daily excretion of sugar in diabetes mellitus—80-100 grammes, forming 2-10 per cent. of the urine.

Presence of Sugar in Urine.

(1) Traces sometimes found in healthy urine.

(2) In many fevers, Scarlatina.
Enteric fever.
Typhus.
Cholera, etc.

(3) Certain nervous diseases, *e.g.* :—
After epileptic fits.
Lesions of floor of 4th ventricle.
Asthma.
Pertussis.

(4) Certain hepatic diseases ; cirrhosis.

(5) Gouty conditions.

(6) Certain diseases of the pancreas.

(7) After ingestion of excess of carbohydrate food.

(8) Persistent in diabetes mellitus.

((9) Certain drugs or poisons.

These are eliminated by the urine, and give origin to "glycuronic acid," which reduces Fehling's solution. *E.g.*, morphia, chloroform, ether, salicylic acid, turpentine, nitrite of amyl, hydrocyanic acid.)

TESTS.

Qualitative.

(1) High specific gravity (above 1030) along with pale colour.

(2) Sweetish odour.

(3) MOORE'S TEST.

Mix equal volumes of urine and liquor potassii.

Fill test tube three parts full of this, and boil upper layer.

If glucose present = golden yellow to brown colour.

(Not reliable, as when there is much mucus present, it becomes dark when treated thus.)

(4) TROMMER'S TEST.

Add one or two drops of weak copper sulphate solution to a little urine in a test tube.

Add a quantity of liquor potassii equal in volume to the urine =

Blue precipitate. Shake.

Glucose present = precipitate redissolves.

Heat (do not boil) = yellow precipitate (hydrated oxide), which becomes red (suboxide of copper).

Blue colour fades.

Fallacies.

(*a*) Many nitrogenous matters present in urine have a reducing action on cupric oxide, *e.g.*, uric acid, hippuric acid, kreatinin, mucin, glycuronic acid, as also

(*b*) Certain drugs eliminated by the urine, as, benzoic and salicylic, chloral, glycerine, turpentine, copaiba, etc.

(5) Fehling's Test.

Fill test tube one inch with freshly made Fehling's reagent (*q.v.*).

Boil to see that no reduction of copper takes place.

If not, add suspected urine drop by drop.

Keep fluid boiling = yellow precipitate at once, and red later if glucose present.

Note.—Never add more than an equal volume of urine to the test solution; as, when more is necessary, the urine contains no sugar.

Fallacies—Same as under Trommer's test.

(6) HAINE'S TEST.

Reagent.

Pure sulphate of copper, 30 grains. } Dissolve.
Distilled water, half ounce. }
Add pure glycerine, half ounce. Mix.
Add liquor potassii, 5 ounces.
This solution keeps good any length of time.

Method.

Boil one drachm of this in test tube.
Add few drops of suspected urine (never more than eight).
Gently boil = large yellowish red precipitate = glucose.

(7) PAVY'S TEST.

Consists merely of Fehling's solution, to which ammonia has been added.
Boil a drachm of the reagent.
Add the suspected urine = blue colour disappears if glucose present.

(8) PENZOLDT-RUBNER TEST—Very accurate.

To a little urine in test tube add few drops of the basic subacetate of lead solution.
Add few drops of ammonia.
Warm = red precipitate = glucose.

(9) PICRIC ACID TEST (Johnson's).

Place equal volumes picric acid solution and urine into test tube.

Add quarter volume caustic potash solution.

Boil upper layer of fluid = very dark red (picramic acid) = glucose.

(10) Fermentation Test.

This is the best test for distinguishing sugar from those other bodies which reduce copper salts.

Fill two test tubes of similar capacity two-thirds with mercury.

Fill one to the top with the urine to be examined.

Fill the other with healthy urine.

To each add a little tartaric acid and a small piece of well-washed yeast.

Close the tubes with the thumb, and invert them over mercury.

Glucose present = fermentation.

Carbonic acid collects at upper part of tube.

Healthy urine undergoes a like fermentation, but to a very small extent, so the second tube is used merely for comparison.

(11) Von Jaksch's Test.

Useful in determining the presence of minute quantities of glucose in any fluid.

Reagent.

Dissolve 2 parts of phenylhydrazin hydrochlorate, and 3 parts acetate of sodium in 6-8 c.c. urine in a test tube.

If the salts do not dissolve, add a little water, and warm.

Place the test tube in boiling water for 30 minutes.

Then cool in cold water = yellow deposit if sugar present.

FIG. 51.—PHENYL-GLUCOSAZON CRYSTALS.

Microscopically.

Crystals are composed of yellow needles, isolated or in stars, and consist of phenyl-glucosazon.

It is better to remove proteids from urine previously.

Quantitative Estimation of Sugar.

1. Very roughly.

The amount of sugar present in the urine may be calculated from the specific gravity (when the daily excretion exceeds 150 ounces). Each degree above 1000 being

nearly equal to 1 grain sugar per ounce, thus specific gravity 1030 = 30 grains sugar per ounce.

2. Prepare the urine by removing any serum albumin or globulin it may contain by acidifying, boiling, and filtering.

If urine be diabetic, dilute it ten or twenty times its volume with water.

FEHLING'S TEST.

The solution is made by dissolving (*a*) 17·32 grammes of sulphate of copper in 250 c.c. of distilled water, and adding it to (*b*) 87·5 grammes of neutral potassium tartrate dissolved in 250 c.c. of caustic soda solution (which has a specific gravity of 1·12 = about 35 grammes caustic soda).

a and *b* should be kept in separate bottles, and mixed as required in exactly equal volumes.

This solution is standardised, so that the copper in 10 c.c. of it is exactly reduced by 0·05 gramme of glucose.

Method.

Place 10 c.c. of Fehling's solution with 40 c.c. of water in a porcelain basin, and boil it by means of a Bunsen burner or spirit lamp.

Take 10 c.c. urine and dilute it to 100 c.c. with water. Fill a burette with this. Run this into the boiling Fehling's solution

quickly at first, but slowly as the copper becomes reduced, stirring all the time. Do this till all the blue or purplish colour is gone, and till the fluid is only yellowish in tint. This is best observed by removing the lamp, and allowing the copper to fall. Then tilt up the basin a little, and look at the layer of fluid above the copper deposit.*

(If the basin be left exposed after all the copper is reduced, the fluid soon becomes blue again, owing to the hydration of the copper. Do not mistake this for insufficient reduction.)

Now note how many cubic centimetres of dilute urine have been used, and calculate the amount of sugar present.

Example. If 80 c.c. of dilute urine have been required to reduce all the copper in the 10 c.c. Fehling's solution, then 80 c.c. dilute urine contain 0·05 gramme glucose = 8 c.c. pure urine contain 0·05 gramme glucose. How much is this per cent. ?

* If in doubt as to whether all colour has gone, filter a small quantity. On a porcelain slab have a drop of ferrocyanide of potassium acidified with acetic acid. Mix the latter with a drop of the clear filtrate. If a brown colour is produced, then all the copper has not been reduced, so more of the diluted urine requires to be added, but if no colour is produced on the slab, then all the copper has been reduced, so repeat the whole experiment anew, but allow less urine to run into the Fehling's solution.

8 : 100 : : 0·05 : x = 0·625 gramme glucose.

The total daily excretion is easily obtained by multiplying this result by the number of hundreds of cubic centimetres of urine passed. Thus if 1600 c.c. were the amount, then 0·625 × 16 = 10 grammes glucose daily.

The following tables which I have prepared will save the student a great deal of time :—

Table showing the equivalence of grammes per cent. of sugar in grains per ounce of urine.

Grammes per cent.	= Grains per ounce.	Grammes per cent.	= Grains per ounce.
0·05	= 0·218	1·5	= 6·561
0·1	= 0·437	1·6	= 7·00
0·15	= 0·656	1·7	= 7·437
0·2	= 0·8746	1·8	= 7·874
0·25	= 1·093	1·9	= 8·311
0·3	= 1·312	2	= 8·750
0·35	= 1·530	2·5	= 10·936
0·4	= 1·749	3	= 13·125
0·45	= 1·968	3·5	= 15·311
0·5	= 2·186	4	= 17·500
0·55	= 2·406	4·5	= 19·686
0·6	= 2·624	5	= 21·872
0·65	= 2·843	5·5	= 24·058
0·7	= 3·062	6	= 26·250
0·75	= 3·280	6·25	= 27·343
0·8	= 3·498	6·5	= 28·436
0·85	= 3·717	7	= 30·622
0·9	= 3·937	7·5	= 32·808
0·95	= 4·156	8	= 34·994
1·0	= 4·375	8·5	= 37·183
1·1	= 4·8	9	= 39·370
1·2	= 5·25	9·5	= 41·558
1·3	= 5·70	10	= 43·750
1·4	= 6·125		

Table showing number of grains of glucose present in each ounce of urine, when the following amounts of *pure* urine have been required to completely reduce the copper in 10 c.c. of standard Fehling's solution. (In practice the urine is diluted ten times, therefore $\frac{1}{10}$th of the amount necessary = pure urine.)

Amount of Urine used	= Grains per ounce.
0·1 c.c.	= 218·867
0·2 ,,	= 109·335
0·25 ,,	= 87·472
0·3 ,,	= 72·890
0·4 ,,	= 54·668
0·5 ,,	= 43·736
0·6 ,,	= 36·458
0·65 ,,	= 33·654
0·7 ,,	= 31·5
0·75 ,,	= 29·140
0·8 ,,	= 27·344
0·85 ,,	= 25·735
0·9 ,,	= 24·295
0·95 ,,	= 23·0
1 ,,	= 21·886
1·1 ,,	= 19·886
1·15 ,,	= 19
1·2 ,,	= 18·229
1·25 ,,	= 17·494
1·3 ,,	= 16·827
1·35 ,,	= 16·2
1·4 ,,	= 15·75
1·45 ,,	= 15·07
1·5 ,,	= 14·578
1·55 ,,	= 14·119
1·6 ,,	= 13·677
1·65 ,,	= 13·22
1·7 ,,	= 12·867
1·75 ,,	= 12·495
1·8 ,,	= 12·147
1·85 ,,	= 11·824
1·9 ,,	= 11·508
1·95 ,,	= 11·218
2 ,,	= 10·897
2·05 c.c.	= 10·607
2·1 ,,	= 10·416
2·2 ,,	= 9·939
2·25 ,,	= 9·719
2·3 ,,	= 9·507
2·4 ,,	= 9·114
2·5 ,,	= 8·746
2·6 ,,	= 8·410
2·7 ,,	= 8·098
2·75 ,,	= 7·949
2·8 ,,	= 7·875
2·9 ,,	= 7·540
3 ,,	= 7·289
3·25 ,,	= 6·728
3·5 ,,	= 6·245
3·6 ,,	= 6·074
3·7 ,,	= 5·910
3·75 ,,	= 5·803
3·9 ,,	= 5·609
4 ,,	= 5·448
4·25 ,,	= 5·145
4·5 ,,	= 4·859
4·6 ,,	= 4·753
4·7 ,,	= 4·652
4·75 ,,	= 4·603
4·9 ,,	= 4·462
5 ,,	= 4·373
5·25 ,,	= 4·165
5·5 ,,	= 3·975
5·75 ,,	= 3·806
6 ,,	= 3·645
6·25 ,,	= 3·498
6·5 ,,	= 3·364
6·75 ,,	= 3·238

Amount of Urine used	= Grains per ounce.	Amount of Urine used	= Grains per ounce.
7 c.c.	= 3·124	10 c.c.	= 2·188
7·25 ,,	= 3·016	11 ,,	= 1·988
7·5 ,,	= 2·905	12 ,,	= 1·822
7·75 ,,	= 2·821	13 ,,	= 1·682
8 ,,	= 2·723	14 ,,	= 1·562
8·25 ,,	= 2·650	15 ,,	= 1·454
8·5 ,,	= 2·572	16 ,,	= 1·364
8·75 ,,	= 2·499	17 ,,	= 1·286
9 ,,	= 2·429	18 ,,	= 1·215
9·25 ,,	= 2·364	19 ,,	= 1·150
9·5 ,,	= 2·302	20 ,,	= 1·093
9·75 ,,	= 2·242		

Example. Suppose 20 c.c. of urine, diluted ten times with water, have been required to reduce entirely the copper from 10 c.c. of Fehling's solution. Consulting the table, we find that when 2 c.c. of pure urine require to be used, it is equal to 10·897 grains per ounce. Multiply this by the total daily excretion of urine in ounces, and the result is the excretion of glucose per 24 hours, *e.g.*, here 10·897 × 200 = 2179·4 grains.

Table showing per cent. of sugar present in the urine, when the following amounts of *pure* urine have been required to completely reduce the copper in 10 c.c. of standard Fehling's solution.

Amount of Urine used	= Grammes of Sugar per cent.	Amount of Urine used	= Grammes of Sugar per cent.
0·1 c.c.	= 50	1·25 c.c.	= 4
0·2 ,,	= 25	1·3 ,,	= 3·8
0·25 ,,	= 20	1·4 ,,	= 3·57
0·3 ,,	= 16·6	1·5 ,,	= 3·33
0·4 ,,	= 12·5	1·6 ,,	= 3·12
0·5 ,,	= 10	1·7 ,,	= 2·94
0·6 ,,	= 8·33	1·75 ,,	= 2·85
0·7 ,,	= 7·14	1·8 ,,	= 2·77
0·75 ,,	= 6·6	1·9 ,,	= 2·63
0·8 ,,	= 6·25	2 ,,	= 2·5
0·9 ,,	= 5·55	2·1 ,,	= 2·39
1 ,,	= 5	2·2 ,,	= 2·27
1·1 ,,	= 4·54	2·25 ,,	= 2·22
1·2 ,,	= 4·17	2·3 ,,	= 2·17

Amount of Urine used	=	Grammes of Sugar per cent.
2·4 c.c.	=	2·08
2·5 ,,	=	2
2·6 ,,	=	1·92
2·7 ,,	=	1·85
2·75 ,,	=	1·81
2·8 ,,	=	1·78
2·9 ,,	=	1·72
3 ,,	=	1·66
3·25 ,,	=	1·53
3·5 ,,	=	1·42
3·6 ,,	=	1·38
3·7 ,,	=	1·35
3·75 ,,	=	1·33
3·9 ,,	=	1·28
4 ,,	=	1·25
4·25 ,,	=	1·17
4·5 ,,	=	1·11
4·6 ,,	=	1·08
4·7 ,,	=	1·06
4·75 ,,	=	1·05
4·9 ,,	=	1·02
5 ,,	=	1
5·25 ,,	=	0·95
5·5 ,,	=	0·9
5·75 ,,	=	0·87
6 ,,	=	0·83
6·25 ,,	=	0·8
6·5 ,,	=	0·76
6·75 ,,	=	0·73
7 ,,	=	0·71

Amount of Urine used	=	Grammes of Sugar per cent.
7·25 c.c.	=	0·68
7·5 ,,	=	0·66
7·75 ,,	=	0·64
8 ,,	=	0·625
8·25 ,,	=	0·606
8·5 ,,	=	0·58
8·75 ,,	=	0·57
9 ,,	=	0·55
9·25 ,,	=	0·54
9·5 ,,	=	0·52
9·75 ,,	=	0·51
10 ,,	=	0·5
10·5 ,,	=	0·47
11 ,,	=	0·45
11·5 ,,	=	0·43
12 ,,	=	0·416
12·5 ,,	=	0·4
13 ,,	=	0·38
14 ,,	=	0·36
15 ,,	=	0·33
16 ,,	=	0·31
17 ,,	=	0·29
18 ,,	=	0·27
19 ,,	=	0·26
20 ,,	=	0·25
25 ,,	=	0·2
30 ,,	=	0·16
35 ,,	=	0·14
40 ,,	=	0·125
50 ,,	=	0·10

Saccharometer of Carwardine.

Fairly accurate and easy of application.

No calculations are necessary, the percentage of sugar present in the urine being read off at once.

Apparatus consists of—

(1) A measure for the Fehling's solution.

(2) A test tube in which to boil the Fehling's solution.

(3) A graduated pipette from which the diluted urine is run.

Method.

A definite amount of Fehling's solution is boiled in the test tube, and having filled the graduated pipette with dilute urine (1 in 10), it is run into the copper solution till all the blue colour has gone. The amount of sugar present is read off in percentages from the pipette.

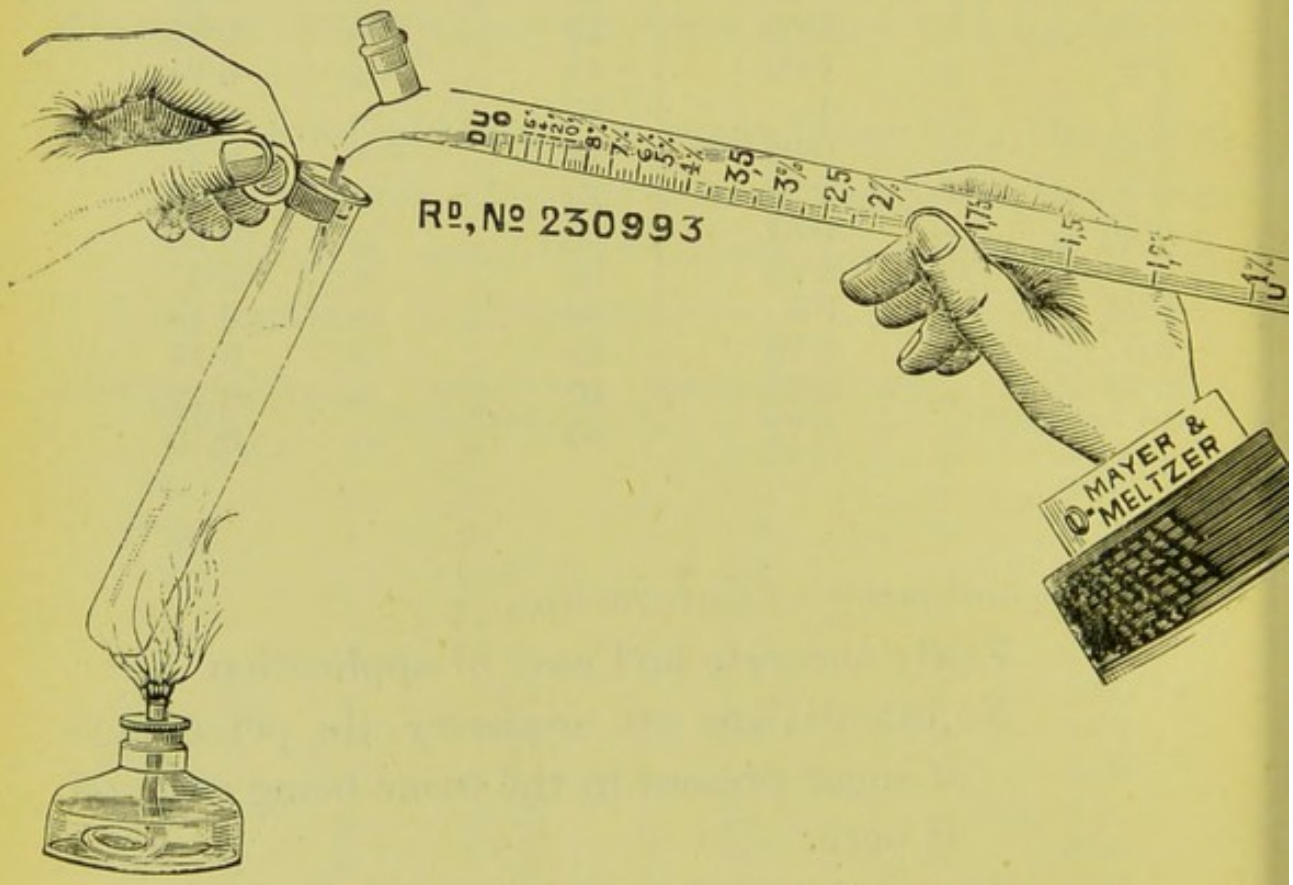


FIG. 52.—SACCHAROMETER OF CARWARDINE.

3. Pavy's Quantitative Test.

The reagent is made by dissolving (*a*) 4·158 grammes of pure sulphate of copper in 200 c.c. distilled water. Then (*b*) 20·4 grammes of the tartrate of potash and soda are dissolved in 400 c.c. of distilled water, in which have previously been dissolved 20·4 grammes of caustic potash. These two solutions (*a* and *b*) are slowly mixed. When cold, 300 c.c. of strong ammonia solution (specific gravity 0·88) are added, and distilled water to make the whole up to one litre.

This is standardised, so that the copper in 10 c.c. is completely reduced, and the colour of the solution quite gone, when 0·005 gramme glucose has been added. It is ten times weaker than Fehling's solution. The mode of procedure is the same as with Fehling's, only that precautions have to be taken to prevent the too free escape of the ammonia which keeps the oxide of copper in solution.

Method.

Place 50 c.c. of Pavy's solution in a small glass flask, which is closed by a tightly-fitting cork. This cork is perforated by two holes. Into the centre one we introduce the nozzle of the burette, and screw it tightly in, so as to attach the flask to the burette. The other perforation contains a small bent glass tube to allow

of the escape of steam. The burette is filled with the urine diluted ten times, and Pavy's solution boiled by means of a lamp below the flask, and while it is attached to the burette. While boiling run in the dilute urine, and stop when the colour has completely disappeared. Read off the number of cubic centimetres used, and calculate exactly as before.

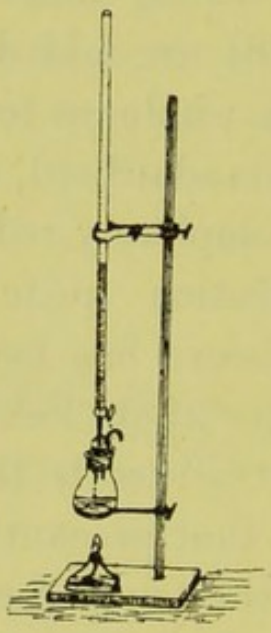


FIG. 53.—METHOD OF ARRANGING BURETTE FOR THE ESTIMATION OF SUGAR BY PAVY'S SOLUTION.

4. FERMENTATION TEST.

This test is easily applied, but cannot be relied on.

Take two 8 oz. bottles, and into each place 4 ounces of the urine to be examined. To one of them add a small piece of German yeast, and place both bottles in a warm situation for 24

hours. At the end of this time take the specific gravity of both by means of an urinometer. The one to which the yeast was added will have a lower specific gravity than the other, owing to the production of alcohol from the glucose.

It has been found that each degree of specific gravity lost in this way is equal to 0·22 gramme glucose in 100 c.c. urine, or one grain per ounce.

Thus, if after 24 hours the simple urine has a specific gravity of 1040; while the other to which the yeast was added is 1010, there must have been 30 × 0·22 gramme per 100 c.c. urine, or 6·6 grammes glucose.

If 5680 c.c. be daily excretion of urine, then 6·6 × 56·8 = 374·8 grammes glucose is the excretion per 24 hours. As grains, this is 30 per ounce, or 6000 grains glucose daily.

SACCHAROMETERS.

Nothing need be said of these here, as there are many varieties of saccharometers, and each is differently graduated.

The directions are given with each instrument, and so the percentage of glucose in the urine is easily calculated.

If the urine be highly coloured, it must be rendered less so by shaking it up with animal charcoal, or with acetate of lead, and then filtered, before examining it by the polarimeter. If we use the latter to clarify the

urine, then add one-tenth to the total amount of glucose found, as this salt tends to cause left rotation, while glucose is dextro-rotatory.

LÆVULOSURIA.

In rare cases lævulose is found instead of grape sugar, or along with it. It gives all the reactions of the latter, but rotates the polarised ray to the left, and, if occurring alone, this will distinguish it. If, however, it occurs along with glucose, it will lessen the right rotation of the polarised ray, and thus in such a case the polarimetric estimation would not agree with the chemical one.

LACTOSURIA.

Milk sugar is sometimes found in the urine of women who are nursing.

TESTS.

(1) Chemically, it reduces copper from its alkaline solution, but more feebly than glucose.

(2) Is dextro-rotatory.

(3) Does not undergo fermentation with yeast.

Note.—In estimating lactose, remember that

10 c.c. of Fehling's solution = 0·067 gramme lactose.

10 c.c. of Pavy's solution = 0·0067 gramme lactose.

GLYCURONIC ACID.

This has to be distinguished from sugar, as it produces a yellow or red precipitate of the sub-oxide of copper from its alkaline solution.

Occurrence.

(1) Transitorily with certain drugs, *e.g.* :—
Chloroform, morphia, chloral, curare.

(2) Constantly in certain otherwise healthy persons, and so must be distinguished from diabetes.

TESTS.

(1) Reduces alkaline copper solutions.

(2) Is dextro-rotatory.

(3) Does not undergo fermentation with yeast.

ACETONE.

Present in urine in

(1) Advanced diabetes.
Diabetic coma (not invariably).

(2) Acute fevers.

(3) Chronic renal disease.

(4) Some cancers.

(5) Gastric diseases.

(6) Acute intestinal obstruction.

TESTS.

(1) Odour is distinctive—like chloroform.

(2) Add to urine in test tube a little caustic potash solution.
Add few drops of strong watery solution of iodine in iodide of potash.

Acetone present = crystals of iodoform separate.

Microscopically = six-sided plates or stars.

(3) Nitro-prusside of sodium test.

Reagent.

Dissolve one-tenth of a gramme of nitro-prusside of sodium in 15 c.c. distilled water.

Method.

In test tube place a little urine.

Add a little of the reagent.

Add a little caustic potash or soda solution.

Acetone = ruby red tint.

Slowly fades to straw colour.

Add little acetic acid, and boil.

= rose violet colour.

Fallacies.

Aldehyde and kreatinin give similar reactions, but the red *quickly* becomes yellow, and no change follows on addition of acid.

Ethyl-Diacetic Acid.

Tests.

(1) This gives a similar reaction with nitro-prusside of sodium.

Add nitric acid = ruby red colour still remains.

Fades gradually to yellow.

(2) Add perchloride of iron solution = bright red colour.

Occurrence—Said to be always present in the urine

(1) Preceding or during diabetic coma (diacetic coma).

(2) At the height of acute fevers.

EHRLICH'S, OR THE DIAZO-REACTION IN URINE.

Reagent.

(1) Concentrated solution of sulphanilic acid.

(2) Solution of sodium nitrite (1 in 200).

Mix 100 c.c. of No. 1 with
5 c.c. pure hydrochloric acid and
3 c.c. No. 2.

Method.

Mix equal volumes of this mixture and urine.

Render strongly alkaline with ammonia.

Reaction consists in the production of a
Bright carmine red colour.
Froth is also coloured when the mixture is shaken.

This never occurs in healthy urine.

It occurs in

(1) Typhoid fever.

(2) Acute tuberculosis.

(3) Pneumonia.

ROSENBACH'S REACTION.

This consists in a dark Burgundy red colour, which appears in reddish urine when boiled, and nitric acid is dropped in.

Occurs in.

(1) Intestinal troubles.
(2) Along with Indicanuria.

FATS IN THE URINE.

Occurrence.

(1) Excess of fatty food, *e.g.*, cod liver oil.
(2) Pregnancy—Said to be a normal condition.
(3) Bright's disease.
Hydronephrosis.
(4) Waxy disease.
(5) Pancreatic disease.
(6) Fat embolism.
(7) Phosphorus poisoning.
(8) Diabetes mellitus (certain cases).
(9) Chyluria.
Urine contains in this disease serum albumin and globulin, fibrinogen, fat, cholesterin, etc., and very soon coagulates.

TESTS.

(1) Microscope shows fat globules.
(2) „ „ solution of globules by ether or chloroform.

(3) Microscope shows globules blackened by osmic acid.

MICROSCOPICAL EXAMINATION OF URINARY DEPOSITS.

Method of obtaining deposit.

Place some of the urine in a tall conical glass.
Allow to remain 24 hours.
A deposit probably has formed at the end of this period.
To remove a little of it
Pass a narrow empty pipette to the bottom of the glass, keeping the pulp of the forefinger tightly over the upper end of the pipette, so as to keep the urine from entering it.
When at the bottom slightly raise the finger.
Some of the deposit at once enters the pipette.
Close the end tightly with the finger.
Withdraw the pipette.
Allow a drop to fall on a glass slide.
Cover it carefully with a cover-glass.
Examine first with low power,
Then with high power of the microscope.

In many cases it is much better to employ the "centrifuge". We thus get the solid constituents of the urine when newly passed, and not after standing, when certain changes may have taken place.

I. UNORGANISED SEDIMENTS.

1. Uric Acid.

Found in acid urine.
Often visible to naked eye
On sides of vessel, as
Yellowish-red crystals.
Hard and gritty.

Consist of—Rosettes or Stars, } made up of conglomeration of { spikes, rods, plates.

Small crystals may be isolated, and appear as
Large lozenges.
Whetstones.
Ovals.
Squares.
Barrels.
Dumb-bells.

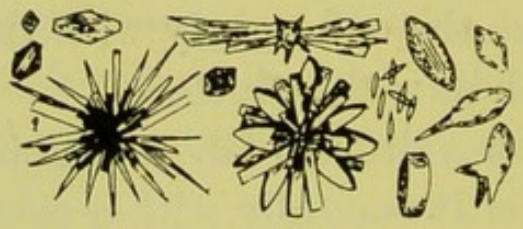


Fig. 54.—Uric Acid.
Rosette (*a*) and hedgehog (*b*) form.

Colour.

Yellow—nearly always } due to uro-
Reddish in larger masses, } erythrin.
Colourless very occasionally.

Test.

Add caustic potash = solution.

2. URATES.

Found in acid urine.

Occur in two forms.

(*a*) Amorphous—usually.

(*b*) Crystalline.

(*a*) AMORPHOUS OR MIXED URATES.

Acid urate of sodium or potassium.

Pink or brick-red precipitate.

This is usual form in which urates occur.

Mass of granules under microscope.

Yellowish in tint.

Varying size.

Disappear on heating slide.

Reappear on cooling.

(*b*) CRYSTALLINE.

Acid Urate of Sodium.

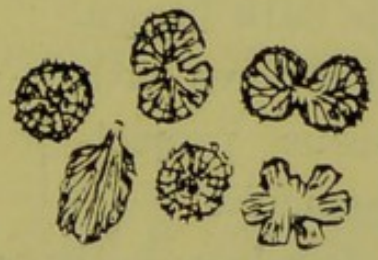


FIG. 55.—URATE OF SODIUM.

Microscopically.

Yellowish red bodies.

Outline irregularly round with

Small spines projecting.

Less frequently Star-shaped.

Fan-like.

Occurs in (1) Gout—during attack.
(2) Febrile attacks in children.

Acid Urate of Ammonium.

FIG. 56.—URATE OF AMMONIUM.

Found in alkaline urine,
Along with triple phosphate in ammoniacal fermentation of urine.
Opaque dark brown.
Round spheres with } = thorn apples.
Numerous projecting spiculæ } = hedgehog crystals.
Occur less frequently as
Elongated dumb-bells.

3. PHOSPHATES.

Amorphous.
Crystalline.

(*a*) *Amorphous.*

Calcium phosphate, $Ca_3(PO_4)_2$.
Greyish granules.
Dissolve on adding acid.

(*b*) *Crystalline.*

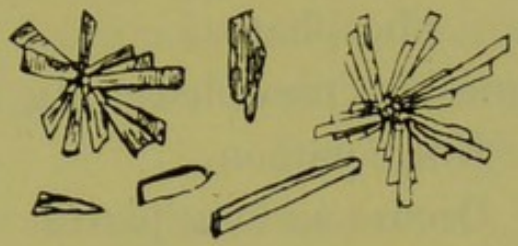


FIG. 57.—NEUTRAL PHOSPHATE OF LIME.

(*a*) Calcium phosphate, $CaHPO_4$.
Stellar crystals less frequently.
Each star consists of—
Wedge-shaped crystals.
United together by their apices.
Occasionally crystallise as
Dumb-bells.
Colourless always.
Differ from uric acid in colour.
Urine neutral or alkaline.

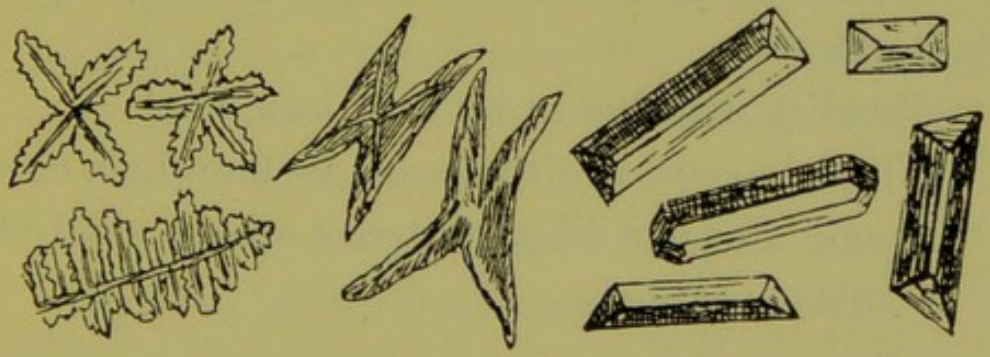


FIG. 58.—TRIPLE PHOSPHATES.

(*β*) Ammonio-magnesium or triple phosphate ($NH_4MgPO_4.6H_2O$).
Most frequently found.

Large triangular prismatic crystals.
("Knife rests," "coffin lids".)
Less often crystallises as "feathery" phosphates.

(γ) Magnesium phosphate, $Mg_3(PO_4)_2.22H_2O$.
Not common.
Occurs as long plates.

4. Calcium Carbonate ($CaCO_3$).
Occurs rarely in
Biscuit form, or as
Whitish balls.

5. Calcium Oxalate.
Present in acid or alkaline urine.
Minute octahedral crystals.
(Envelope or St. Andrew's cross.)
Small squares or diamonds with
Lines running across from opposite angles, appearing as light or dark crosses, according to the focus.
Occur as small dumb-bell crystals less frequently.
Colourless.
Readily dissolve in hydrochloric acid.
This deposit is often seen as fine lines crossing one another like scratches on the sides of the glass vessel.

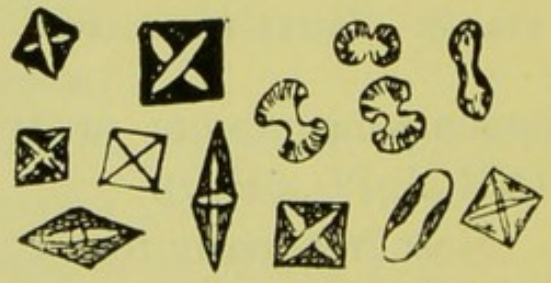


Fig. 59.—Oxalate of Lime.

II. UNORGANISED SEDIMENTS.

1. Blood Corpuscles.

In acid urine may retain their shape.
In alkaline urine usually swell up.
Become spherical.
May be shrivelled, or have
Crenated outline.
Colouring matter usually absent—having diffused out, specially so when blood comes from kidney.
"Phantom rings" then appear—pale yellow rings.
Rouleaux formation seldom seen, though they are
Often united by a cementing substance.

2. Pus Corpuscles.

Appear as irregularly shaped roundish bodies.
Larger than red blood corpuscle.
Many nuclei in each, so giving a
Granular appearance to cell.
In alkaline urine leucocytes may appear as homogeneous round globules without nuclei.
Acidify urine = nuclei reappear.
Often associated with renal epithelium.
Present in urine in cases of

Cystitis,
Urethritis, } large amount.
Ureteritis.
Pyonephrosis.
Pyelitis.

Tuberculosis of kidney, etc.
Leucorrhœal discharge in women.

3. Epithelial Cells of Various Forms.

(*a*) Most common.

Large epithelial cells from bladder, vagina.
Polygonal.
Sinuous outline.
Large oval nucleus.
Contents granular.
Occur specially in
Catarrh of Bladder or
Genito-urinary passages.

Fig. 60.—Epithelium in Urinary Sediment.
(*a-f*) Cells from the bladder; (*g-j*) Cells from the kidneys; (*k*) Squames from urethra.

(*b*) Columnar cells.

Elongated pyramidal.
Nucleus near one end.
From Urethra.
Ureter.
Pelvis of kidney.
(From prostatic sinus, often possess processes.)

(*c*) Small round epithelial cells are very characteristic.

They come from the renal tubules.

Numerous projecting corners round edge.

Distinct round or oval nucleus.

Occur singly, or in

Groups—small or larger, or as

Epithelial casts = acute nephritis.

Occur in

Acute Bright's disease = catarrh of tubules—of great diagnostic importance.

Chronic Bright's disease = fewer, and usually fatty.

(*d*) Club-shaped granular.

Nucleated cells.

Occur in large amount in

Catarrh of pelvis of kidney (*not always* present).

The epithelial cells frequently resemble colostrum corpuscles, owing to fatty degeneration.

4. Mucus Corpuscles.

Very similar to leucocytes.

Round or oval.

Add drop of acetic acid = nucleus evident.

5. Tube Casts.

Consists of inflammatory exudation into renal tubules.

These are expelled into urine.

Epithelium lining tubules may be expelled also = epithelial casts.

Many are difficult to distinguish unless stained.

Method of Staining.

Place few drops of sediment in test glass.

Add a little picrocarmine.

Allow to stain for few hours.

Mount drop of this sediment, and examine.

Other stains act more rapidly, as eosin, iodine, gentian violet, methylene blue, etc.

These can be applied in weak solutions to edge of cover-glass on slide, when they run in and stain the tube casts.

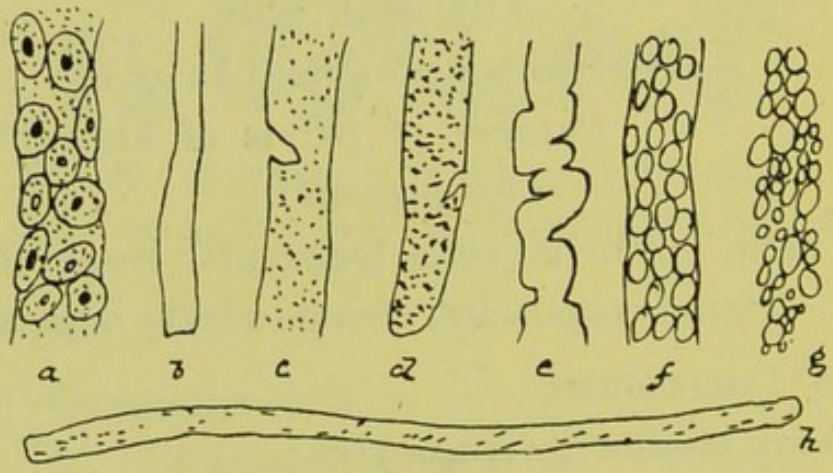


FIG. 61.—RENAL TUBE CASTS.

(*a*) Epithelial; (*b*) Hyaline; (*c*) Finely granular; (*d*) Coarsely granular; (*e*) Waxy; (*f*) Blood; (*g*) Fatty; (*h*) False Cast "mucous cylinder".

VARIETIES.

(*a*) *Hyaline.*

Colourless, structureless.

Outline very faint, so are often overlooked.

(Oblique illumination or staining renders them more evident.)

May occur without renal inflammation.

(*b*) *Waxy.*

Not so common.

Resemble the preceding.

Long.

Often coated with granular matter, or Fatty globules.

Give the amyloid reaction, *e.g.* :—

Iodine and sulphuric acid = blue.

Methyl violet = red.

Occur in all forms of nephritis—acute or chronic.

Waxy disease of kidney (not specially).

(*c*) *Blood.*

Densely packed red corpuscles.

May be only few embedded in hyaline or waxy casts.

Occur in (1) Acute nephritis.

(2) Hæmorrhagic infarction into kidney.

(3) Hæmaturia.

(*d*) *Epithelium.*

Are usually small round cells.

Nucleus distinct.

Often fatty.

May be as epithelial tubes alone.
May only cover hyaline, waxy, or blood casts.

Occur in

Acute or chronic nephritis.

(*e*) *Leucocytes.*

May be as casts alone, or
Covered by epithelium.

(*f*) *Granular.*

Elongated tubes—made up of
Fine or coarse granules.
Colour—pale yellow.
reddish brown.
Often broken abruptly across.
Occur—Chronic renal diseases.

(*g*) *Fatty.*

Aggregations of highly refracting small fat globules.
Often bristling with acicular crystals of fatty acids.
Occur in
Fatty degeneration of kidney, specially
Large white kidney.

(*h*) *Uratic.*

Acid urate of sodium crystals adhering to an organised cast.

(*i*) *Pus Casts*—Very rare.
Occur in multiple abscess of kidney.

(*j*) *Bacterial Casts*—Made up of micrococci.
Granular in appearance.

Occur in septic diseases, *e.g.*, septic phrosis.

Significance of Presence of Casts.

Blood, Leucocyte, Epithelium, Granular, } casts of greatest clinical significance. They indicate the presence of acute nephritis.

Large hyaline, Waxy, Fatty, } casts = chronic renal disease.

Granular, Fatty, } casts = degenerations of epithelial casts.

6. Cylindroids (Thomas').

Very long ribbon-like bodies.
Extremities twisted.
Occur in (1) Scarlatina in children.
(2) Acute and chronic nephritis.

7. Leucin.

Yellowish brown.
Oily-looking round masses.
Radiating striæ with
Concentric markings.
They are often arranged in rosettes.

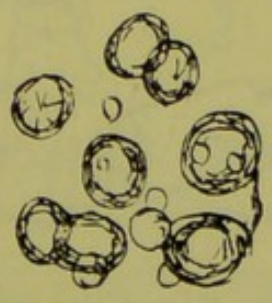


Fig. 62.—Leucin.

8. Tyrosin.

Long silky
Needle-shaped crystals.
Arranged in sheaves or broom-like bundles.

Leucin and Tyrosin usually occur together, but are rare.

Occur in Acute yellow atrophy of liver.
Cirrhosis of liver.
Phosphorus poisoning.
Typhus.
Variola.

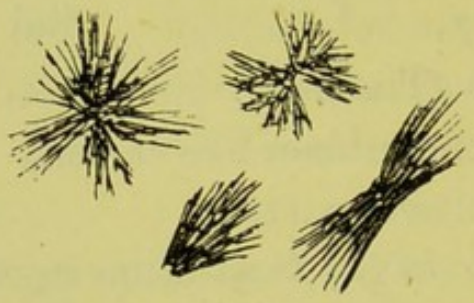


Fig. 63.—Tyrosin.

9. Cholesterin.

Rhombic plates with
One corner awanting.
It is rare.

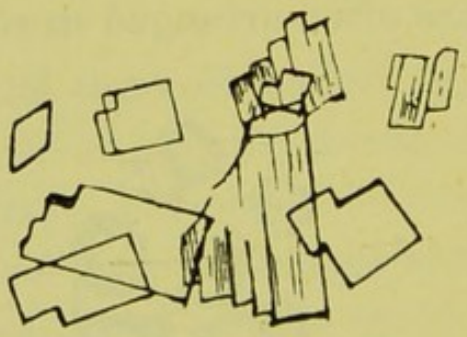


Fig. 64.—Cholesterin.

TESTS.

(1) Play of colours with iodine and sulphuric acid—blue—red—green.

(2) Heated with solution of sulphuric acid (5 to 1 of water), edges of crystals become red.

10. CYSTIN.

Occurs only in acid urine.

Small hexagonal plates.

Yellow in colour (faint).

Mother-of-pearl opalescence.

Often superimposed on one another.

TESTS.

(1) Heated on silver leaves a black stain from sulphur contained.

(2) Add oxalic acid solution = crystals dissolve (while uric acid remains).

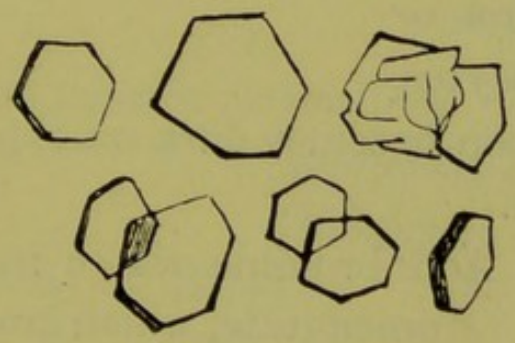


FIG. 65.—CYSTIN.

11. HIPPURIC ACID.

Occasionally found.

Elongated rhombic prisms.

Singly or in groups.

Occurs after taking benzoic acid internally.

12. Fat Globules.

Occur in

(1) Advanced cirrhosis of kidney sometimes.
(2) Fatty degeneration of kidney.
(3) Diabetes mellitus.
(4) Phosphorus poisoning.
(5) Chyluria.
(6) During pregnancy.

13. Indigo Blue Crystals.

Sometimes present in decomposing urine rich in sulphate of indoxyl (Indican).
Fine needles arranged in feathers or
Masses sometimes.

14. Melanin.

Dark brown or black particles.
Either free or
In leucocytes.
Urine soon becomes dark on exposure to light.

Tests.

(1) Add bromine water to urine = yellow precipitate, which gradually blackens.
(2) Add solution of ferric chloride = dark brown cloudiness or black precipitate soluble in excess.

Occurs in

(1) Melanotic sarcoma.
(2) Intermittent fever.
(3) Wasting diseases.

15. New Formations.

Fragments of villous tumour from the bladder.
Epithelial cell nests in carcinoma cervicis uteri.

16. Spermatozoa.

Pear-shaped bodies.
Very long tail springing from blunt end of pear.
Usually dead and quiescent.

(See page 119.)

17. Distoma Hæmatobium—Ova of.

Small oval bodies.
Extremities somewhat pointed.
Usually along with Blood.
Pus.
Fat.

18. Echinococci.

Sometimes present as Scolices.
Membranes.
Hooklets.
Accompanied by Blood.
Pus.
Cellular debris.

19. Micrococci and Bacteria.

Urine usually clouded when voided.
Micrococcus Ureæ.
Largely present in decomposing urine.
Found on surface and in sediment of urine.

Cocci are large.

Form chains.

Pathogenic Organisms present in freshly passed urine, as in septic infection from catheter, or along with infectious diseases, *e.g.* :—

Pneumonia.

Enteric fever.

Ulcerative endocarditis.

Tubercle Bacilli most important.

Cover-glass films made and stained as described for the sputum (p. 17).

Their presence shows that there is a tubercular ulceration in some part of the genito-urinary apparatus.

Sarcinæ—Sometimes present.

Have same characters as those found in stomach (p. 59).

PTOMAINES IN URINE.

In healthy urine there are toxic substances of an alkaloidal nature.

In diseased conditions these are found in large amount.

E.g.—Measles.

Pneumonia.

Diphtheria.

Cholera.

Method of Separation.

Acidify urine with acetic acid.

Add solution of the iodides of mercury and potassium.

Precipitate falls = alkaloids if present.

Soluble in warm alcohol (so distinguishing it from albumin, mucus, uric acid, which are also precipitated by this reagent).

The alkaloids may also be separated by the Stas-Otto process (p. 70).

FERMENTS IN URINE.

A Pepsin-like body is present in Normal Urine.

Test—Place a small piece of pure fibrin in the urine for some hours (during which time it absorbs the pepsin if present).

Then remove and place in 0·2 per cent. hydrochloric acid solution.

Keep at temperature of 38° C.

Fibrin gradually dissolved = pepsin present.

It is *absent* from urine in

Enteric fever.

Nephritis.

Cancer of stomach.

Other ferments said to be normally present, e.g. :—
Diastatic or amylolytic
Milk curdling.

CHANGES IN THE URINE IN LOCAL OR GENERAL DISEASES.

I. Diseases of the Kidney.

1. Acute Nephritis.

Quantity —greatly diminished.
Colour —smoky, turbid, or dark brown.
Specific gravity—high.
Reaction —acid.
Total solids —reduced.
Albumin —present in large amount.
Urea —greatly reduced.
Blood pigment —present in large amount.
Uric acid, Chlorides, } diminished.
Microscopically.
Blood corpuscles—many.
In various conditions.
Single—or in groups.
Phantom rings.
Epithelial cells—small polyhedral, from renal tubules.
Pus corpuscles.
Tube casts—(hyaline, epithelial, blood, pus).

2. Chronic Venous Congestion.

Quantity—diminished.
Colour —dark red.
Sp. gr. —high, 1025·30.
Reaction —strongly acid.
Albumin —present.
Urea —normal.
Uric acid, Urates, } increased.
Microscopically.
Red blood corpuscles—few.
Tube casts—hyaline.

3. Chronic Nephritis.

Quantity —only slightly lessened.
Colour —normal or pale.
Sp. gr. —normal or slightly below.
Total solids—diminished.
Albumin —present in large amount.
Urea, Chlorides, } diminished.
Microscopically.
Epithelium —cylindrical.
Often fatty.
Pus corpuscles—numerous.
Tube casts—(granular, fatty).
Free fat globules.

4. Granular Contracted Kidney.

Quantity—greatly increased.
Colour —pale.
Sp. gr. —low.

Reaction—acid.
Albumin—none, or mere trace.
Urea, Phosphates, } reduced.
Microscopically—Nothing, or
Casts—few granular or hyaline.
Crystals—Uric acid. Oxalate of lime.

5. Uræmia.

Quantity —greatly diminished or totally suppressed.
Sp. gr. —diminished.
Total solids—lessened.
Albumin —present.
Urea —markedly diminished—50-100 grains *per diem.*
Microscopically.
Pus corpuscles, Epithelium, Tube casts, } frequently.

6. Waxy Kidney.

Quantity —increased.
Colour —pale.
Sp. gr. —low.
Total solids—slightly diminished.
Albumin —present in small amount. Occasionally in large amount.

Serum albumin usually.
Serum globulin often in greater amount.

Urea —diminished.
Microscopically—Nothing, or
Casts—few hyaline or waxy.

7. Cystic Disease of Kidney.

Quantity —increased.
Colour —pale.
Specific gravity—low.
Albumin —present.
Urea —diminished.
Phosphates —increased.
Microscopically.
Blood corpuscles.
Pus corpuscles.
Tube casts—large granular.
Crystals —triple phosphates.

8. Strumous Disease of Kidney.

(*a*) Early stage.

Quantity—increased, 2-3 litres.
Colour —clear yellow.
Spec. gr.—low, 1005.
Reaction—acid.
Albumin—a little.
Microscopically.
Blood corpuscles, Leucocytes, Casts—hyaline, } few.

Epithelium from tubules rarely.

(*b*) Later—when ulcerating.

Urine milky.

Reaction—alkaline.

ammoniacal later.

Albumin—present.

Microscopically.

Blood corpuscles.

Pus (remains suspended in urine).

Caseous debris.

Crystals — triple phosphate.

Stain for tubercle bacilli.

9. Acute Pyelitis.

Quantity—increased.

Colour —yellow, with fine flecks of pus.

Sp. gr. —low.

Reaction—feebly acid or alkaline.

Albumin—frequently present.

Microscopically.

Tube casts ; pus, hyaline, granular.

10. Chronic Pyelitis.

Quantity—increased.

Colour —pale yellow.

Sp. gr. —low.

Reaction—faintly acid.

Albumin—present.

Odour —very fœtid.

Pus often in plugs.

11. Renal Calculus.

(*a*) During passage of stone.

Quantity—diminished.
Colour —smoky or porter.
Reaction—acid.
Blood, Pus in plugs, } present.
Uric acid, Urates, } in large amount.
Microscopically.
Red, White } blood corpuscles.
Tube casts; hyaline, granular.
Crystals—oxalate of lime.

(*b*) After paroxysm.

Quantity—greatly increased.
Sp. gr. —low.
Pus present in large amount.

12. Renal Infarction.

Quantity—diminished.
Colour —dark.
Sp. gr. —increased.
Reaction—acid.
Albumin —present in large amount.
Microscopically.
Blood, Pus } corpuscles.
Tube casts; hyaline, epithelial, pus.

13. Cancer of Kidney.

Quantity—increased.
Blood —much, often in clots.
Occurs intermittently.
Albumin, Pus, } in small amount.
Acetone often present.

14. Hydronephrosis.

Quantity —increased, diminished, } intermittently.
Sp. gr. —low.
Total solids —diminished.
Albumin —present.
Urea, Phosphates, } reduced.
Blood —often in clots.
Pus corpuscles.

15. Pyonephrosis.

Quantity —greatly diminished during obstruction.
Sp. gr. —low.
Reaction —acid early.
ammoniacal later.
Albumin —present.
Microscopically, { blood. pus, epithelium.

16. Surgical Kidney.

Colour —pale cloudy yellow.
Sp. gr. —reduced.
Reaction —neutral or alkaline.

Smell —foul.
Albumin —present.
Urea —reduced.
Microscopically.
Pus.
Blood.
Debris.
Bacteria.
Epithelial casts.

17. Hæmatinuria—Hæmoglobinuria.

Quantity —increased.
Colour —clear port wine or porter.
Sp. gr. —rather higher than normal.
Reaction —faintly acid.
Albumin —serum albumin, serum globulin, } present.
Urea —increased.
Chlorides—deficient.
Indican —increased.
Spectrum of methæmoglobin (p. 160).
Sediment—granular chocolate colour.
Microscopically.
Epithelium.
Tube casts ; granular, hyaline.
Crystals—hæmatin.
Oxalate of lime.

II. Diseases of the Bladder.

1. Acute and Subacute Cystitis.

Colour —turbid.

Sp. gr. —low.
Reaction—alkaline.
Odour —ammoniacal.
Albumin —present or not.
Microscopically.
Epithelial cells (many with processes) from bladder.
Leucocytes.
Red blood corpuscles (always in acute).
Bacteria always.

2. Tubercular Ulceration of Bladder.

Characters of urine similar to those in pyelitis (*q.v.*).
Blood is frequently present, however.
Tubercle bacilli present in large numbers (make cover-glass preparations, p. 16).

3. Vesical Calculus.

Often much blood present—
Bright in colour.
Separates in a layer.
Microscopically.
Epithelium.
Pus cells.
Crystals—Uric acid, } occur
Oxalate of lime, } early.
Phosphates.

4. Tumours of the Bladder.

Colour—bright red.

Hæmaturia usually large in amount.

Microscopically.

Shreds of villous tumour (simple or malignant).

Appear as pale fragments.

Processes covered by epithelium.

No distinction can be made between those from simple or malignant growths.

5. Prostatorrhœa.

Microscopically.

Cylindrical epithelium.

Leucocytes.

Fat globules.

Corpora amylacea.

Bottcher's crystals.

III. Diseases of the Urethra.

1. Simple Urethritis.

Microscopically.

Large flat epithelial scales in great amount.

Much pus.

2. Specific Urethritis—Gonorrhœa.

Microscopically.

Many flat epithelial cells.

Pus corpuscles—many.
Examine for micro-organism.

Gonococci.

Stain (1) In fuchsin—as for tubercle bacilli.

(2) Schutz's method.

Place prepared cover-glass films in solution of methylene blue (half-saturated) containing 5 per cent. carbolic acid for ten minutes.

Wash in acidified distilled water (5 minims dilute acetic acid to 20 c.c. water).

Contrast stain—weak safranin solution.

Cocci are small.

Closely aggregated in large groups.

Cover over or / Invade } epithelial cells.

They do not stain by Gram's method.

(See page 119.)

IV. Diseases of the Liver.

1. Cirrhosis of Liver.

Quantity —*always* diminished.

Colour —dark reddish brown or blackish.

Acidity —increased.
Deposit —Urates.
Oxalates.
Uric acid —above normal.
Chlorides —diminished.
Bile pigment—always present.

2. Acute Yellow Atrophy.

Quantity—much lessened.
Colour —dark brown.
Reaction —strongly acid.
Albumin —occasionally present.
Bile pigments, Bile acids, } present.
Microscopically.
Leucin, Tyrosin, } in large amount.
Tube casts—occasionally.

3. Jaundice.

Quantity —usually lessened.
Colour —deep yellow to porter colour.
Reaction —strongly acid.
Urea —diminished.
Uric acid —increased.
Hippuric acid—absent.
Bile pigments, Bile Acids, } present.
Sugar —present in grave cases.

V. Other Diseases.

1. Chyluria.

Colour —milky—Remains so without clearing.
pink from presence of blood.
Sp. gr. —low.
Reaction —faintly acid.
Total solids — diminished.
Albumin —present.
Coagulation — frequently spontaneous from presence of fibrin.
Fat —in cream-like flakes on surface.

Microscopically.

Epithelial cells.
Leucocytes—many.
No casts.
Uric acid crystals—often.
Filaria sanguius hominis — often present in night urine.

2. Diabetes Mellitus.

Quantity —enormously increased.
Colour —pale greenish.
Sp. gr. —high, 1030-50.
Reaction —highly acid.
Froths much on shaking.
Odour —sweet.
Albumin —usually absent.
May be present towards end.

Urea —increased largely.
Grape sugar —always present, 1-15 per cent.
Acetone —frequently present in large amount.
Indican —much present.
Uric acid —diminished.
Phosphates —increased.
Fermentation—rapid.

3. Diabetes Insipidus.

Quantity —marked polyuria, 8-16 quarts.
Colour —colourless and clear.
Sp. gr. —very low, 1000-4.
Reaction —neutral or feebly acid.
Albumin, Sugar, } absent.
Urea, Phosphates, } increased somewhat.
Decomposes—soon.
Inosite —sometimes present.

VI. Urine in Specific Fevers.

1. Urine in Fevers Generally.

Quantity —diminished.
Colour —high.
Sp. gr. —high.
Reaction —strongly acid.
Deposit —large one of urates.
Albumin —in small amount.

Urea,
Uric acid,
Sulphates, } increased.
Chlorides,
Phosphates, } diminished.
Hippuric acid—present in large amount.
Microscopically.
Uric acid.
Urates.
Pus.
Casts—hyaline.

2. Rheumatic Fever.
As above.
Urea greatly increased—200-300 grains above normal daily excretion.
Sulphates much increased.
Albuminuria transient.

3. Typhoid Fever.
Ut supra.
Diazo reaction present after 4th day (see page 295).

4. Scarlatina—Ordinary characters of febrile urine.
Examine as under acute nephritis.

5. Typhus Fever—As in febrile urine.
Chlorides greatly reduced or absent.
Albumin may be present in large amount.

6. Variola—As in Pyrexia.
Bile pigment often present.
Hæmoglobin found in malignant type.

7. Diphtheria—As above.

Copious deposit of uric acid, urates, oxalates, and phosphates.

Albuminuria usual and copious.

8. Yellow Fever.

Greatly diminished volume.

Colour—bright yellow—orange—olive brown—red.

Albuminuria constant.

Hæmaturia.

Uræmia frequent.

9. Cholera.

Almost total suppression in algide stage.

During recovery—low specific gravity.

Urea almost absent at first.

Uric acid, colourless crystals.

Chlorides absent at first.

Normal pigments—Colour almost none at first.

Indican in excessive quantity, Albuminuria constant, } diagnostic.

VII. General Diseases.

1. Gout.

(*a*) *Between attacks.*

Total solids—diminished.

Urea,
Uric acid,
Phosphates, } diminished.

Uric acid may be absent immediately before attack.

(*b*) *During attack.*

Quantity —diminished.
Pigment — „
Phosphates — „
Albumin —present usually.
Crystals of oxalate of lime.

2. Anæmia.

Quantity—slightly increased.
Colour —pale.
Sp. gr. —low.
Reaction —neutral or alkaline.

3. Pernicious Anæmia.

Colour—sometimes very dark from increased amount of urobilin present.

VIII. Nervous Diseases.

1. Hysteria.

1. Quantity —greatly increased.
Colour —pale.
Sp. gr. —low.
Acidity —diminished.
Total solids—reduced.
} watery urine.

2. May be totally suppressed.

2. Epilepsy.

After Fit.

Increased excretion.
Colour—pale.
Sp. gr.—low.
Feebly acid.
Albumin, Sugar, } occasionally.
Urea and phosphates increased.
Deposit of urates and uric acid.

3. Meningitis.

Quantity —low.
Sp. gr. —high.
Reaction —feebly acid or alkaline.
Phosphates—great excess.
Chlorides —slightly increased.
Urea —increased.
Albumin —slight.

IX. Urine in Pulmonary Diseases.

1. Phthisis Pulmonalis — subject to marked variations—usually.

Quantity increased (except when diarrhœa).
Urea normal or increased during rise of temperature.
Deposit of pink urates.
Diazo reaction often present towards termination.
Albuminuria often present.
Casts often of waxy variety.

2. Pneumonia—Has characters of febrile urine.
   - Quantity —diminished.
   - Colour —deep.
   - Sp. gr. —greatly increased.
   - Large deposit of urates—red, brown.
   - Urea, uric acid—increased.
   - Chlorides —always greatly diminished or absent.
   - ,, —in excess during late convalescence.
   - Sulphates —increased always.
   - Phosphates —reduced.
   - Albuminuria—frequent in bad cases.
   - Blood, Casts, } from nephritis.

3. Bronchitis, Acute—as in febrile urine.
   - Quantity —reduced.
   - Total solids—markedly lessened.

4. Pleurisy—as in febrile conditions.
   - Peptone often present in large amount during absorption of exudation.

X. Urine in Diseases of the Alimentary Tract.

1. Acute Gastric Catarrh.
   - As in febrile urine.

2. Chronic Gastric Catarrh.
   - Quantity—increased.
   - Colour —pale.
   - Sp. gr. —low.
   - Reaction—alkaline.

Large deposit of earthy phosphates and oxalate of lime.
Urea usually much lessened.
Albuminuria, } sometimes transiently
Sugar, } present.

3. Chronic Constipation.
Indican present in large amount.

4. Ulceration or Cancer of Stomach or Bowels.
Peptone often present in large amount.

DETECTION OF POISONS IN URINE.

1. Mercury.
Acute poisoning—Urine scanty in amount.
Much albumin.
Blood often.

Detection.
Acidify urine with hydrochloric acid.
Drop in strip of copper foil or brass wire.
Heat for one hour.
Remove foil or wire, and wash.
Place small piece in sublimation tube and heat.
Mercury is volatilised and deposited on sides of tube higher up.
Microscope shows round globules of mercury.
Place fragment of iodine in bottom of tube and heat.
Brilliant red produced = iodide of mercury.

2. Lead.

Urine albuminous.

Detection.

Place strip of magnesium ribbon (free from lead) in urine.

Allow to remain several hours = lead deposited on ribbon.

Remove strip, wash.

Dissolve off lead by nitric acid.

Apply tests for lead, *e.g.* :—

Sulphuretted hydrogen	= black precipitate.
Sulphuric acid	= white.
Iodide of potassium	= bright yellow silky precipitate.
	Soluble on heating.
	Returns on cooling.

3. Copper.

Urine albuminous, Bloody, } from acute nephritis produced.

Detection.

Add equal volume dilute hydrochloric acid to urine.

And chlorate of potassium.

Allow to stand some hours; then heat to 60° C.

Add chlorate of potassium till fluid is no longer brown.

Evaporate on water bath till chlorine is no longer given off.
Dilute with water and filter.
Pass sulphuretted hydrogen through filtrate = Dark precipitate of sulphide of copper.
Dissolve this in nitric acid = blue solution.
Add ammonia = blue intensified.
Add ferrocyanide of potassium = mahogany brown precipitate.
Steel blade introduced = copper deposited on it.

4. Arsenic.

Acute poisoning produces acute nephritis.

Detection (Reinsch's Process).

Destroy organic matter by boiling with hydrochloric acid and chlorate of potassium.
Evaporate almost to dryness.
Add water, filter.
Evaporate filtrate again.
Redissolve and add one-sixth of the bulk of pure (arsenic free) hydrochloric acid.
Drop in strip of pure copper foil.
Boil for some minutes.
Dark iron grey coating on foil = arsenic.
Remove foil, wash gently and dry.
Cut up and place fragments in sublimation tube.
Heat = arsenious acid sublimed and deposited further up tube.
Microscope = octahedral crystals.

(Often better to evaporate urine to small bulk before commencing.)

5. PHOSPHORUS.

Albumin, Peptone, Fat, } all present in the urine frequently.

Test.

Distil urine (acidified with sulphuric acid).

Luminous rings seen.

6. CHLOROFORM.

Urine—Sp. gr., high.

Albumin present in traces.

Glycuronic acid present (test, p. 293).

7. ALKALOIDS.

Detection (see p. 70).

DETECTION OF DRUGS IN URINE.

1. CARBOLIC ACID.

Colour—dark green.

Odour—of carbolic acid.

Albumin, Blood, } present.

Acid itself not found.

2. QUININE.

Colour—may be dark.

Test.

Take large quantity of urine.

Add ammonia and ether and shake.

Decant off ethereal extract.

Evaporate = quinine left.

Redissolve in acidulated water.

Add chlorine water and ammonia = emerald green colour.

3. ANTIPYRIN.

Urine dark in colour.

Remove albumin by heat if present, and

Test.

Add perchloride of iron solution = purple red colour.

4. ANTIFEBRIN.

Test.

(1) Boil urine with one quarter its volume strong hydrochloric acid.

Allow to cool.

Add a little 3 per cent. solution of carbolic acid and

Few drops solution of chromic acid =

Red colour = antifebrin.

Add ammonia = red becomes blue.

(2) Add chloroform to urine and shake.

Decant off urine.

Evaporate off chloroform.

Add mercurous nitrate = deep green colour.

5. SALICYLATES.

Excreted as salicylic and salicyluric acids.

Test.

Add perchloride of iron = violet colour.

6. SALOL.

Urine dark green in colour, similar to carbolic acid urine.

7. Phenacetin.

Test.

Acidify urine with hydrochloric acid and heat.
Add perchloride of iron = chocolate colour.

8. Chrysophanic Acid.

(Contained in rhubarb, senna, etc.)
Urine reddish brown in colour.

Tests.

(1) Add alkali = red colour.
To this add reducing agent as sulphide of ammonia = colour gone.
(2) Add baryta water = acid precipitated.

9. Santonin.

Urine yellow in colour. Dissolve out by chloroform.

Test.

(*a*) Add alkali = red.
(*b*) Add sulphide of ammonia = no change.
(*c*) Dissolve in sulphuric acid. Warm and add ferric chloride in drops = red rings becoming purple round each drop.

10. Turpentine.

Urine—characteristic odour of sweet violets.

11. Iodides, Iodoform, etc.

Test for Iodine.

Add little strong nitric acid.
Shake up with chloroform = reddish yellow extract.
Decant off urine.
Add little starch solution = deep blue.

12. Iron.

Test.

Add nitric acid to urine and boil.

Add ferrocyanide of potassium = Prussian blue colour.

URINARY CALCULI.

Mode of Examination.

(1) When the calculus is homogeneous throughout.
Powder any part and apply appropriate tests.

(2) When composed of different salts in different layers.

(*a*) Each layer may be separated by careful hammering.

(*b*) Powder the calculus, then

Boil in water. Filter. Test filtrate for soluble urates.

Add hydrochloric acid to residue on filter.

(Note if effervescence = carbonates.)

Apply tests to acid solution.

Varieties of Calculi.

1. Uric Acid or Urates.

With or without phosphates.

Calculus—Smooth or nodulated.

Colour reddish.

Easily broken down.

Concentric lamellæ.

Test.

Heat with dilute hydrochloric acid.

Filter. Wash residue and test by

Murexide test = uric acid and ammonium urate.

Ammonium Urate.

Powder piece of calculus.

Heat with solution of carbonate of soda.

Ammonia is given off.

Hold rod dipped in hydrochloric acid near = white fumes of ammonium chloride.

If this test fails = uric acid calculus.

2. Mixed Calculi.

Contain much larger amount of phosphates than uric acid.

Usually deposited in concentric rings on outer surface of other calculi.

Calculi are white.

Chalky.

Very friable.

Test.

Add hydrochloric acid to powder and warm.

If dissolves entirely = phosphates entirely.

Test for these (p. 236).

Pure phosphatic calculi are very rare.

If residue left—filter.

Test residue for uric acid and urates (as above).

(These calculi fuse under blowpipe—hence are called fusible calculus.)

3. Oxalate of Lime (Mulberry Calculus).

Often along with urates.

Calculus—Dark brown or grey.
Irregularly nodulated.
Very hard and brittle.

Tests.

(1) Add hydrochloric acid = solution without effervescence.

(2) Heat on platinum foil = decomposed into carbonate of lime.

This effervesces on adding an acid.

4. Carbonate of Lime (rare).

Calculus—Grey or bronze colour.
Smooth.
Hard.
Translucent.

Tests.

Add hydrochloric acid = complete solution *with* evolution of carbonic acid.

5. Phosphate of Lime (rare).

Calculus—Chalk-like.
Dense or spongy.
Round or irregular.

6. Cystin (rare).

Calculus—Small oval.
Smooth.

Soft and compressible.
Yellowish green in colour.
Crystals adherent.
Section is wax-like.

Tests.

Dissolve in ammonia.
Add acetic acid.
Examine precipitate by microscope =
Hexagonal plates of cystin.

7. Xanthin (very rare).

Calculus—Smooth.
Cinnamon-red colour.

Tests.

(1) Dissolve on porcelain dish in nitric acid.
Evaporate to dryness and allow to cool.
Add drop of caustic potash = red colour.
Heat = red violet.

(2) Crystals of xanthin may be got by dissolving a fragment in hydrochloric acid on a slide.
Allow to evaporate.
Microscope shows
Characteristic crystals—lemon-shaped.

8. Fibrinous Calculi.

Glassy appearance on fracture.
Burn entirely away.

TABULAR ARRANGEMENT OF THE USUAL METHOD OF ANALYSING URINARY CALCULI.

On heating the powder on Platinum Foil, it				
Does not burn.	Does burn.			
The powder when treated with HCl.	With flame.	Without flame.		
Does not effervesce.	Effervesces.	The powder gives the murexide test.		Does not give murexide test. The powder dissolves in HNO_3 without effervescence. The dried yellow residue becomes orange with alkali, beautiful red on warming.	Uric acid.
The powder gently heated with HCl.		The powder when treated with KHO gives	No noticeable ammonium reaction.	Flame pale blue; burns a short time. Peculiar sharp odour. The powder dissolves in ammonia, and hexagonal plates are deposited on its evaporation.	Ammonium urate.
			Strong ammonium reaction.	Flame pale yellow, continuous. Odour of resin or shellac on burning. Powder soluble in alcohol or ether.	Xanthin.
The powder when moistened with a little KHO.				Flame yellow, continuous. Odour of burnt feathers. Insoluble in alcohol or ether, soluble in KHO with heat; but precipitated from it by acetic acid with evolution of H_2S.	Cystin.
	Effervesces.				Urostealith.
					Fibrin.
					Calcium carbonate.
NH_3 or only traces of ammonia. Powder dissolves in acetic or hydrochloric acids. This solution is precipitated by ammonia (amorphous).					Calcium oxalate.
Abundant ammonia. Powder dissolves in acetic or hydrochloric acids. This solution gives a crystalline precipitate with ammonia.					Magnesium and calcium phosphate.
					Triple phosphate.

SWEAT.

Reaction, normally *acid*, due to acid sodium phosphate.

Alkaline or neutral when very profuse.

Very acid—acute rheumatism.

Increased. (1) After drinking much water.

(2) Certain drugs, strychnine, pilocarpine, morphine, camphor, ammonia.

(3) Warm weather.

(4) Rheumatic fever.

Diminished. (1) Cold weather.

(2) Acute febrile conditions, *e.g.*, pneumonia.

(3) Certain drugs, atropine, large doses of morphine.

(4) Bright's disease, chronic.

Abnormal Constituents.

1. Sugar in cases of diabetes.
2. Bile pigment in jaundice.
3. Blood pigments.
4. Albumin in acute rheumatism.
5. Indigo in chromidrosis.
6. Urates and oxalates in gout.
7. Lactic acid in rickets and bone diseases.
8. Cystin.

TABLES FOR REFERENCE.

1. *Weights.*

One milligramme	= 0·001 gramme.		
One centigramme	= 0·01 ,,	= 10 milligrammes.	
One decigramme	= 0·1 ,,	= 100	,,
One gramme	= 1 ,,	= 1000	,,
One dekagramme	= 10 ,,		
One hectogramme	= 100 ,,		
One kilogramme	= 1000 ,,		

2. *Measures of Capacity.*

1 cubic centimetre (c.c.)	=	1 millilitre	=	1 gramme water.		
10 ,, ,,	=	1 centilitre	=	10	,,	,,
100 ,, ,,	=	1 decilitre	=	100	,,	,,
1000 ,, ,,	=	1 litre	=	1000	,,	,,

3. *Relation of Weights.*

1	pound	= 453·592	grammes.
1	ounce	= 28·349	,,
1	grain	= 0·0648	,,
15½	grains	= 1	,,

4. *Conversion of Grammes into Grains.*

1	gramme	=	15·432 grains.
2	,,	=	30·864 ,,
3	,,	=	46·297 ,,
4	,,	=	61·729 ,,
5	,,	=	77·161 ,,
6	,,	=	92·594 ,,
7	,,	=	108·026 ,,
8	,,	=	123·458 ,,
9	,,	=	138·891 ,,

5. *Conversion of Grains into Grammes.*

1	grain	=	0·0648 grammes.
2	,,	=	0·1295 ,,
3	,,	=	0·1943 ,,
4	,,	=	0·2590 ,,
5	,,	=	0·3239 ,,
6	,,	=	0·3887 ,,
7	,,	=	0·4535 ,,
8	,,	=	0·5183 ,,
9	,,	=	0·5830 ,,

6. *To Convert Grammes per Litre into Grains per Gallon.*

Multiply by 70.

7. *To Convert Grammes per* 100 *c.c. into Grains per Gallon.*

Multiply by 700.

8. *To Convert Grammes per* 100 *c.c. into Grains per Fluid Ounce.*

Multiply by 4·375.

9. *To Convert Grains per Gallon into Grammes per Litre.*

Multiply by 0·01428,
or
Divide by 70.

10. *Table of Equivalents.*

To reduce			
Grains	to grammes,	multiply by	0·0648.
Grammes	,, grains,	,, ,,	15·432.
Ounces	,, grammes,	,, ,,	28·349.
Fluid ounces	,, cubic centimetres,	,, ,,	28·396.
Litres	,, gallons,	,, ,,	0·22.
Gallons	,, litres,	,, ,,	4·548.
Pints	,, cubic centimetres,	,, ,,	567·936.
Kilogrammes	,, pounds,	,, ,,	2·2046.
Inches	,, metres,	,, ,,	0·0254.
Inches	,, centimetres,	,, ,,	2·54.
Centimetres	,, inches,	,, ,,	0·3937.
Inches	,, millimetres,	,, ,,	25·4.

Thermometers.

11. *Equivalence of Centigrade and Fahrenheit.*

Centigrade.		Fahrenheit.
0°	=	32°
5°	=	41°
10°	=	50°
15°	=	59°
20°	=	68°
25°	=	77°
30°	=	86°
35°	=	95°
40°	=	104°
45°	=	113°
50°	=	122°
55°	=	131°
60°	=	140°
65°	=	149°
70°	=	158°
75°	=	167°
80°	=	176°
85°	=	185°
90°	=	194°
95°	=	203°
100°	=	212°

12. *To Convert Fahrenheit Scale into Centigrade.*

Subtract 32.
Multiply by 5.
Divide by 9.

13. *To Convert Centigrade into Fahrenheit Scale.*

Multiply by	9.
Divide by	5.
Add	32.

14. *Normal, Decinormal, and Centinormal Solutions.*

Each is made by dissolving the undernoted amount of the substance in one litre of distilled water.

	Normal $\frac{N}{1}$.	Deci-normal $\frac{N}{10}$.	Centi-normal $\frac{N}{100}$.
Oxalic acid ($H_2C_2O_4.2H_2O$ = 126. It is dibasic, so only one-half is taken),	63	6·3	0·63 gms.
Hydrochloric acid (HCl = 36·5), . . .	36·5	3·65	0·365 „
Sulphuric acid (H_2SO_4 = 98, also dibasic), . .	49	4·9	0·49 „
Caustic soda (NaHO = 40),	40	4·0	0·4 „
Caustic potash (HKO = 56·1), . . .	56·1	5·61	0·561 „
Sodium carbonate (Na_2CO_3 = 106, dibasic), . .	53	5·3	0·53 „
Silver Nitrate ($AgNO_3$ = 170), . . .	170	17	1·7 „

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