tuberculous meningitis. Michel (*Augenheilk.*, p. 404) puts the percentage of cases of tuberculosis of the choroid accompanying tuberculous meningitis in children at thirty-five to forty per cent. This seems to the author to be very much too high.

Symptoms. The patient complains of no pain. The condition is diagnosed by use of the ophthalmoscope. The tubercles usually appear at the posterior part of the fundus, and are not visible until they occasion disturbance of the retinal pigment layer. At first, there is observed a small spot of pigment slightly more pronounced than the surrounding fundus; this is due to slight prominence of the pigment layer over the tubercle. Soon the centre of the pigment patch takes on a pale whitish color, circular or oval in shape, due to absorption of the retinal pigment, and this reaches the size of the optic disc—sometimes a little smaller, sometimes larger. If a number of miliary tubercles are grouped together, as is often the case, the size and shape of the patch are changed. Many tubercles may be scattered over the fundus, or there may be but one or two tubercles present. Retinal vessels pass over the patch, the retina is slightly raised, and in some cases a slight local detachment of the retina occurs. Vision is but little interfered with, except in the

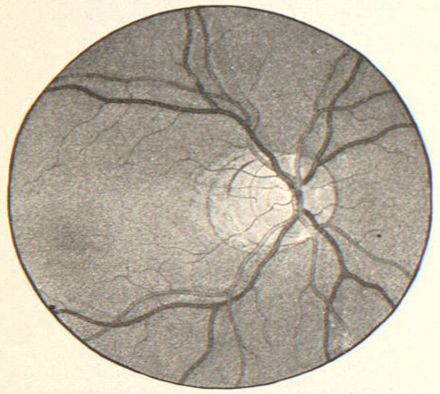

Fig. 1314.—Sclero-Choroiditis Posterior of Moderate Degree. (De Wecker and Masselon.)

portion of the field corresponding with the site of the tubercle, where there is a relative or complete scotoma.

Treatment. Since the patient usually succumbs to the effects of the disease in other parts of the system, nothing can be done to relieve the local condition. Large tuberculous tumors are sometimes met with in the choroid.

Hemorrhagic Choroiditis.—The vessels of the choroid, like those in other parts of the body, are from time to time the seat of disease, and their walls may become so weakened that the fluid and at times the corpuscular portions of the blood may escape into the tissue of the choroid and also beneath the retina. The escaped blood may break through the retina and enter the vitreous. The appearance presented is that of large, irregular patches of blood clot which often cause the retina to bulge forward. Through the action of gravity the upper border assumes a horizontal line, the lower border being curved. Above the clot the tissues are tinged a yellowish red by the partly absorbed blood pigment. The clot gradually becomes absorbed, leaving a white patch of atrophy with some pigment scattered over it. Choroidal hemorrhage may produce acute glaucoma.

Treatment. The treatment is restricted to the care of the general condition.

Detachment of the Choroid is rarely met with, but it sometimes follows an exudative inflammatory process in which the exudation, serous or fibrinous and large in amount, finds its way between the choroid and the sclera. It may be due to the presence of a tumor or to hemorrhage, and it may accompany a degeneration of the vitreous during the course of an irido-cyclo-choroiditis.

Non-Inflammatory Affection of the Choroid.—The atrophy accompanying myopia is rarely inflammmatory. The axial elongation of the globe in myopia is due to the thinning of the posterior segment of the sclera, and, as shown by the ophthalmoscope and by post-mortem sec-

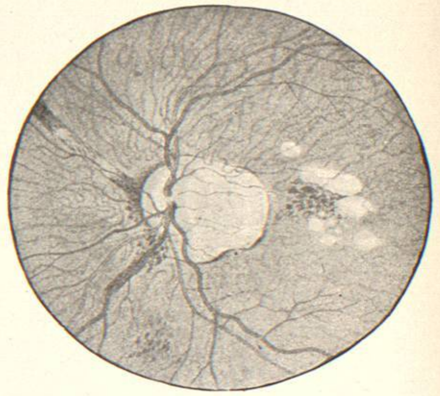

Fig. 1315.—Sclero-Choroiditis Posterior of High Degree, with Changes at the Macula. (De Wecker and Masselon.)

tion, the greatest stretching of the sclera takes place at or near the optic disc. The change in the tissue of the sclera is not accompanied by any infiltration of small cells (the characteristic accompaniment of inflammatory processes), nor do we find such infiltration of small cells in the issue of the choroid. The small myopic crescent is not a condition due to pathological changes in the choroid, but, as Michel has shown, the bulging of the sclera causes the optic disc to become more obliquely placed to the antero-posterior axis of the globe than is the case in the normal eye,

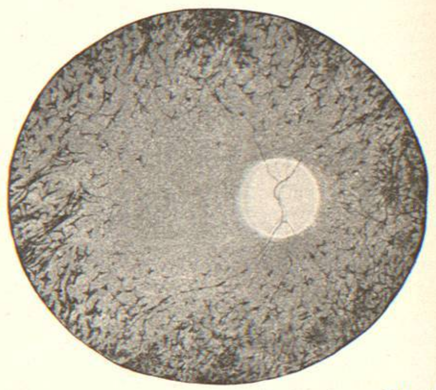

Fig. 1316.—Retinitis Pigmentosa. (De Wecker and Masselon.)

and the transparent tissue of the optic papilla permits the white, opaque tissue of the edge of the sclera and the optic nerve sheath (usually at the inner lower quadrant of the disc) to show through. The nasal side of the disc is sharply defined, but the lower temporal side is ill-defined. In high degrees of myopia the choroid at the posterior pole of the eye suffers most; at the periphery the membrane is but little changed. The condition met with is one in which the choroid is thinner than normal. The meshes between the capillaries of the choriocapillaris and between the vessels in the layer of large vessels are enlarged. The choroidal pigment is more spread out and the retinal pigment is also rendered much less dense.

In eyes thus affected the white sclera shines through to a greater extent, giving the fundus a pale appearance, often referred to as *rarefaction* of the choroid. The

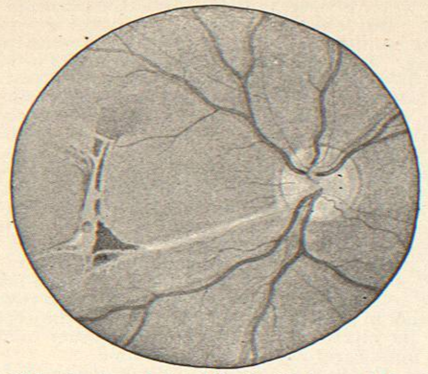

Fig. 1317.—Rupture of Choroid. (De Wecker and Masselon.)

stretching of the vascular tunic may be so great that small choroidal hemorrhages appear at or near the macula, and, because of atrophy of the choroid at this point, a condition sometimes known as central choroiditis is produced.

Superficial Senile Choroiditis.—This condition is due to atrophy of the choriocapillaris, accompanying which we have a disappearance, often, of the retinal pigment and at the same time a deep atrophy of the choroid corresponding to an obliterating arteritis of some of the larger arterial branches.

Chorioretinitis Pigmentosa is an example of a non-inflammatory process. A non-inflammatory degeneration takes place, affecting the vessels of both membranes and also affecting the structure of both membranes. This atrophy proceeds from the periphery toward the posterior pole. In some cases the vascular degeneration is accompanied by an escape of portions of the blood, which may, on becoming absorbed, leave atrophic spots in the choroid, or rather spots in the choroid from which all pigment has disappeared. Ordinarily, in cases of general atrophy of the choroid, the choroidal pigment is changed but little. A change in the retinal pigment is often noticed, sometimes amounting to an hyperplasia of the pigment, as is the case when the bone-corpuscle figures are seen. Sometimes the change is of such a character that the retinal pigment is heaped up, as in cases in which a deeply pigmented margin occurs about an atrophic choroidal patch. The ganglion cells of the retina and the axis cylinders perish as the disease advances, and secondary atrophy of the optic nerve follows as a consequence.

It sometimes happens that this passive atrophy begins at the posterior pole of the choroid, and there is then produced that variety of the condition to which the name *chorioretinitis centralis* has been given. In this type of the affection the vision fails as the disease advances. If the periphery is first attacked the field of vision is narrowed concentrically; if the process first appears at the posterior pole, a relative, negative, or positive central scotoma follows. The affection under discussion is termed chorioretinitis pigmentosa or retinitis pigmentosa, according to the degree of visible involvement of the choroid. If some atrophic choroidal patches are seen the affection is termed chorioretinitis pigmentosa; if no such patches are present, the affection is supposed to involve the retina principally and is termed retinitis pigmentosa. In reality these processes are one and the same so far as their pathology is concerned. On examination with the microscope both membranes are found to be in a condition of atrophy.

Chorioretinitis pigmentosa is often congenital in origin and is sometimes accompanied by degenerative processes in other tissues of the body. It is influenced by heredity. The intermarrying of relatives is supposed to produce it, as is also inherited syphilis.

The obscure affection known as retinitis proliferans is also a disease in which atrophy of the choroid is an accompanying condition.

Traumatism of the Choroid.—It may affect the membrane in a number of ways. Hemorrhage and rupture of the choroid are frequently met with as a result of a non-perforating blow on the eye, the lesion usually appearing at a spot opposite to the point of impaction; the rupture is due to contrecoup. Hemorrhage may be from the capillaries, which is most frequently the case, or from large vessels. In rupture of the choroid the injured portion is obscured by the hemorrhage and by exudation which usually goes on for a few hours. The exudation passes into the retina and extends into the vitreous. When the exudation and blood have become absorbed, a crescentic atrophic patch is usually seen in the posterior part of the fundus, concentric to the optic disc. The retinal vessels pass over this patch, showing clearly that it affects a tissue beneath the retina. Although usually arranged in a manner concentric to the disc, ruptures of the choroid may assume almost any shape. The ruptures may be single or multiple. A scotoma is present in the visual field corresponding with the location of the rupture.

Perforating Wounds of the Choroid are of all kinds and of all degrees: perforating, lacerating, incised, clean, infected. Perforating wounds of the choroid always involve other membranes, and consideration of these must necessarily involve consideration of other parts of the eye. Clean, incised wounds, if not too extensive, will heal without destruction of the eye. If the blood clot extends into the vitreous, we may apprehend the formation of fibrous bands in the vitreous, and these may ultimately result in detachment of the retina. Infected wounds often lead to panophthalmitis.

Treatment. In rupture of the choroid from contrecoup but little can be done. It is probably best to put the patient to bed and to give remedies that will prevent the development of plastic processes or the organization of

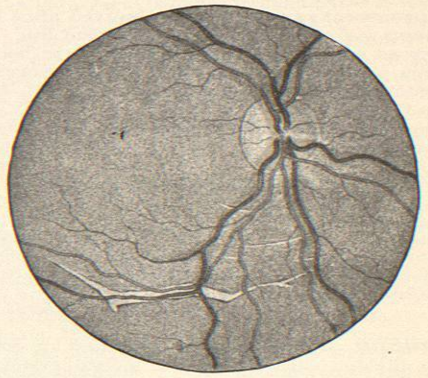

Fig. 1318.—Rupture of Choroid. (De Wecker and Masselon.)

plastic products. If left without treatment the clot and exudation will become absorbed, and almost if not quite as favorable results will be obtained.

Prognosis is favorable.

In clean, lacerating wounds the eyeball can often be saved by properly caring for it.

Infected wounds result in panophthalmitis, which should be treated as heretofore advised.

John E. Weeks.

CHROATOL.—$C_{10}H_{16},2HI$—terpin-iodo-hydrate. This occurs in greenish-yellow crystals of aromatic odor, insoluble in water, soluble in alcohol, glycerin, benzol, and acetic ether, and slightiy soluble in ether and chloroform.

In ten-per-cent. ointment or powder it has been employed for psoriasis, alopecia, and other affections of the skin.

W. A. Bastedo.

CHROMIDROSIS.—(Synonyms: Ephidrosis tincta; stearrhœa or seborrhœa nigricans; pityriasis nigricans; Fr., *Cyanopathie cutanée.*)

Definition.—A disorder of the perspiratory glands in which the sweat assumes various shades of color, as blue, red, yellow.

This is an exceedingly rare disease, so rare that many doubt its existence, but so many well-authenticated cases have been reported that further doubt is scarcely warranted. On the other hand, some of the cases observed have proved to be impostures.

The disease is most frequently observed upon the eyelids, cheeks, forehead, abdomen, and scrotum. The distribution may be unilateral or symmetrical, the disease occuring in small patches. Often the affected area changes from place to place. The color varies from a yellow to a dark brown, brick-dust-like, green, blue, or red tint. There is usually mixed with the sweat a certain amount of fat which upon drying leaves an amorphous granular deposit upon the skin, and which may be partially if not entirely removed by water or ether.

Most cases have occurred in neurotic or hysterical unmarried women, in conjunction with uterine or ovarian disorders and with chronic constipation. It was formerly thought that the absorption of indican from the intestinal canal in the latter condition was the principal factor, but this has not been confirmed, as the pigment in the sweat does not give the indican reaction.

The amount of pigment in these cases varies from day to day, and may disappear for weeks or months to recur again. The disease usually lasts for years.

Green or blue sweat occurs quite frequently in workers in copper, from internal introduction of the metal.

Blue sweat has been known to occur after taking large quantities of iron and also from potassium iodide; in the latter case the blue reaction was caused by the starch in the shirt (Taylor).

Phosphorescent sweat has been observed after taking phosphorus and after eating phosphorescent fish.

Red sweat occurring in moist regions of the body like the axilla and pubes is produced by micro-organisms (Bacterium prodigiosum), and is associated with concretions on the hairs (lepothrix).

Hæmatidrosis cruenta is produced by hemorrhage into the sweat glands or ducts, causing a reddish sweat (see *Purpura*).

The Treatment of chromidrosis depends upon the cause. In the idiopathic forms the general condition should be treated—bowels, uterine conditions, etc.

In those cases which are due to the introduction of metals or drugs into the system the treatment is obvious.

The forms produced by micro-organisms can be easily relieved by mild antiseptic applications.

William A. Hardaway.

CHROMIUM.—Compounds of chromium are constitutionally highly poisonous to the animal system, and chromic acid and its soluble salts are also intensely irritant, and even caustic. Medicinally, preparations of the mineral are used only for local purposes. The United States Pharmacopœial compounds are the following:

Acidum Chromicum, Chromic Acid (chromium trioxide, CrO_3). This compound is in "small, needle-shaped crystals, or rhombic prisms, of a dark purplish-red color and metallic lustre; odorless; destructive to animal and vegetable tissues; deliquescent in moist air. Very soluble in water, forming an orange-red solution. When brought in contact with alcohol, ether, glycerin, and other organic solvents, decomposition takes place, sometimes with dangerous violence" (U. S. P.). On heating, chromic acid first fuses to a reddish-brown liquid, and then decomposes into green chromic oxide and free oxygen. From its powerful chemical action, chromic acid should be kept in glass-stoppered bottles and never brought into contact with any kind of oxidizable organic matter. In concentrated application chromic acid is a powerful and penetrating caustic, and is available in surgery when a deep and thorough cauterization is demanded. But it should not be applied over an extensive area, lest enough be absorbed to produce constitutional poisoning. It is generally used by mixing the crystals with a drop of water to the forming of a paste. The acid is also a powerful oxidizer and antiseptic, thus proving disinfectant, both by destroying low forms of living things, and also by oxidizing foul products of zymotic processes. But its corrosive properties make the disinfectant virtues generally unavailable. Chromic acid is of use, however, for the preservation of organic tissues in the laboratory, particularly nerve structures intended for microscopical examination, since it both preserves and somewhat hardens the specimen while changing but little its histological appearance. It is used for such purpose in very weak aqueous solution. Chromic acid should not be prescribed for internal medication, and, in prescription for any purpose, the explosiveness of its mixture with glycerin and other oxidizable matters must carefully be borne in mind.

Potassii Bichromas, Potassium Bichromate ($K_2Cr_2O_7$). This well-known salt is in "large, orange-red, transparent, triclinic prisms or four-sided tables, odorless, and having a bitter, metallic taste. Permanent in the air. Soluble in ten parts of water at 15° C. (59° F.), and in 1.5 parts of boiling water, insoluble in alcohol" (U. S. P.). On heating, the salt first fuses to a dark-brown liquid, and then decomposes into neutral potassium chromate and green chromic oxide, with evolution of free oxygen. Potassium bichromate is severely irritant and poisonous, and is not used in medicine. In weak aqueous solution it is a convenient preservative for histological specimens, producing effects similar to those of chromic acid. *Mueller's fluid* is compounded of from two to two and a half parts of potassium bichromate and one part of sodium sulphate, dissolved in one hundred parts of water. Potassium bichromate is official in the Pharmacopœia for use, in solution, as a chemical test.

Edward Curtis.

CHROMIUM, POISONING BY.—All soluble compounds of chromium are poisonous. The compounds of most toxicological interest are the trioxide, commonly called chromic acid, CrO_3, the dichromates such as the sodium and the potassium dichromate, $K_2Cr_2O_7$, and the neutral chromates, potassium chromate, K_2CrO_4, and lead chromate, $PbCrO_4$. Potassium dichromate, or bichromate, is the common red salt of commerce, and has caused more fatal cases of chromium poisoning than any of the other compounds of this metal. Chrome yellow, normal lead chromate, and chrome red, a basic salt, are capable of causing chromium poisoning if ingested in sufficient quantity at one time, but when taken in small quantities through long periods of time the symptoms are those of chronic lead poisoning. The salts of chromium, such as chrome alum, $KCr(SO_4)_2$, are not known to have produced poisoning in man. The form of poisoning due to the local action of the dust of the chromates is not uncommon in factories where these chemicals are used, but cases of acute poisoning are unfrequent, though a considerable total number has been reported. The cases have been largely accidental, though there have been some suicides, and in some the dichromate has been taken as an abortifacient.

Uses of Chromium Compounds.—Chromic acid is used in medicine as an escharotic, and in the manufacture of organic chemicals as an oxidizing agent. The alkaline chromates, especially potassium dichromate, are used extensively in dyeing, calico-printing, and tanning, in certain photographic reproduction processes, and in the preparation of other chromium compounds, especially certain pigments, as chrome yellow. The lead chromates are much used in painting, and have been employed for coloring confectionery, and by bakers for giving a yellow color to cakes, etc.

Action of Chromic Acid and the Chromates.—*Local Action.*—Chromic acid is an active oxidizing agent, and when concentrated readily destroys tissues with which it comes in contact. It is hence used as an escharotic in the form of crystals and in strong aqueous solution. In strong solutions it acts on the sound epidermis slowly, but on long contact it penetrates the skin and may be absorbed in this way in sufficient amounts to give rise to constitutional effects. It acts violently on mucous membranes and wounded surfaces, from both of which it is readily absorbed. Fatal acute poisoning has followed its external use, as, for example, in a case in which the solid acid was applied to a carcinoma of the breast and death followed in a few hours with symptoms of chromium poisoning. The alkaline chromates, and especially the dichromates, have a caustic action similar to that of the acid but are much less active. Employees exposed to the dust of these compounds in factories suffer from their caustic action in two ways: through its action on the mucous membranes of the nose, mouth, and eyes, and upon the skin on various parts of the body. The effect of the dust is seen soon after exposure begins, sometimes on the first day. The first symptoms are those of a coryza, becoming more severe with the increasing irritation until there is established obstinate ulceration which ends in the perforation and destruction of the septum narium. At the same time there may develop severe inflammation of the eyelids, and in the mouth and throat ulcers closely resembling those due to syphilis. The dust attacks the site of any injury to the skin with the result that there are formed obstinate circumscribed ulcers which penetrate deeply, going to the bone and even into it. These ulcers may be developed on any part of the body, even those parts covered by the clothing, and have been especially observed about the genitals. As the result of long exposure and irritation the external skin may show chronic skin disorders of the nature of eczema, psoriasis, etc.

Acute Poisoning.—The alkaline chromates are readily absorbed after ingestion, and produce symptoms which, together with those due to the local action in the stomach and intestines, give a marked type of acute poisoning. The salts have a metallic, bitter taste. The symptoms produced by them are, first, those of a severe gastro-enteritis; nausea, vomiting of yellow colored material which may be bloody; diarrhœa, and even bloody movements; thirst; abdominal pain; colic; tenesmus; cramps in the legs; great anxiety and prostration; cold and clammy skin; rapid and feeble pulse. These symptoms are followed by pain in the region of the kidneys accompanied by the passage of albuminous bloody urine containing renal tube casts, and even by suppression of the urine. The respiration becomes feeble and irregular, the patient loses consciousness and dies in coma or convulsions. If the fatal result is delayed beyond the first day, jaundice appears as a result of fatty degeneration of the liver. In some cases the gastro-intestinal symptoms are not as prominent as in the typical case, and they may be wanting. If the case be prolonged the symptoms referable to the kidneys and bladder, and to the liver, become more prominent. Death has commonly resulted in from four to fourteen hours (Falk), but has been delayed to fifty-four hours.

Post-Mortem Appearances.—The signs of inflammatory action are usually found in the alimentary tract, though they may be absent. These signs have been observed in all portions of the tract and have indicated all grades of intensity of action: hyperæmia, swelling, ecchymoses, brownish injection of the mucous membrane; corrosion and ulceration. Signs of inflammatory action have also been found in the bladder, the lungs, the endocardium, and the pericardium. The kidneys have been reported as hyperæmic and as showing structural changes in the epithelium of the tubules with abundant cast formation. Fatty degeneration has been observed in the liver and heart muscle, and the blood has been found viscid and very dark. The dark appearance is said to be due to the presence of methæmoglobin (Priestley). The gums may show a bluish-gray line about the teeth which is ascribed to the reduction of chromic acid to chromic oxide, Cr_2O_3.

Fatal Dose.—The amount of alkaline chromates required to produce death is not accurately known, but small doses of potassium dichromate (.03–.20 gm.) may produce distressing symptoms, and under favorable conditions a few centigrams (0.2—0.5 gm.) may produce threatening symptoms. Falk mentions four cases of recovery after doses varying from 0.25 to 4 gm., and recovery has followed doses up to two ounces in cases properly treated. The smallest dose known to have been fatal to an adult appears to have been that in Mr. Wood's case, in which 7.7 gm. (ʒ ij.) caused the death of a woman in four hours (Taylor). Rabbits and dogs are killed by doses of 0.06–0.36 gm. of dichromate, and rabbits from subcutaneous doses of 0.26 gm. of the neutral chromate (Gergens). Considering these data and the effects seen after doses of a few centigrams in man, it is probable that the minimum fatal dose for man is considerably smaller than the one thus far observed, 7.7 gm.

Treatment.—The first indication in acute poisoning is the neutralization and removal of the poison. The acid salt may be converted into the less irritating neutral chromate by the administration of magnesia or sodium bicarbonate. Lead acetate has been recommended with the view of forming the difficultly soluble lead chromate, but it should obviously be used with caution. More important than these chemical antidotes is prompt removal of the contents of the stomach by the use of emetics if there be little vomiting, but better by very thorough washing with the stomach pump. The subsequent treatment of the gastro-enteritis is that of metallic poisons in general, though subnitrate of bismuth would seem to be specially indicated because of the nearly insoluble bismuth chromate that would be formed with the traces of poison remaining.

Experiments on Animals.—The highly poisonous character of chromic acid and its soluble salts has been abundantly shown by experiments. The symptoms and post-mortem appearances seen in the lower animals have been similar to those described as occurring in man, and are referable especially to the irritant action of the poison on the alimentary tract and on the kidney. The structural changes in the kidney have been uniformly found on microscopic examination, even when not obvious from their macroscopic appearances. In long-continued cases typical appearances of contracted kidney have been observed, and several authors indicate this condition as one of the most likely sequelæ to poisoning by chromates. According to Priestley the vaso-motor centres are first stimulated and then paralyzed, and general paralysis precedes the convulsions. The elimination of chromic acid takes place chiefly by way of the urine, but in part also in the fæces. It is found in the mucous membrane of the intestines, and in fæces, even after subcutaneous injection (August Mayer). The elimination is rapid, so that within eight hours sixty per cent. has been removed, and at the end of four days only traces of chromium are to be found in the urine and fæces (Viron).

Chronic Poisoning.—The form of poisoning seen in workers in factories, and due to local action of the dust or strong solutions of the chromate, may properly be considered as a chronic poisoning, but the marked structural changes seen in acute poisoning suggest the inquiry whether there is also a chronic general poisoning due to the absorption of small amounts of chromate. There has been abundant opportunity for the occurrence of cases of such poisoning among employees in factories where chromates are largely used, and also as the result of the therapeutic use of potassium dichromate, in the form of Güntz' solution, in syphilis. It appears, however, that no chronic condition ascribable to this cause has as yet been observed in man. It is possible that the rapid elimination of the chromate is a sufficient protection in the case of man against the effects of small doses, but as a chronic intoxication has been produced in dogs by very long-continued action of chromates (Viron), the possibility of its occurrence in man should be recognized.

COMPOUNDS OF CHROMIUM.—There appear to be no recorded cases of poisoning in man by salts of the metal chromium, but experiments on animals indicate that they are capable of producing the same lesions as the chromates, but that the dose required is very much greater, and that even with moderately large doses the action is much slower. Pander found that using chromium sodium lactate hypodermically, the lethal dose for warm-blooded animals is about one hundred times that of the dichromate. The elimination is also very rapid. These observations indicate that very large doses indeed would be required to produce serious effects on man.

Herbert E. Smith.

CHROMOSOME.—(*χρῶμα, χρώματος*, color, and *σῶμα*, a body.) The substances forming the nucleus of a cell may be roughly divided into two groups. One of these is distinguished by the ease with which the material may be colored with the basic aniline dyes, while the other, like most cytoplasmic structures, is not readily stained with these dyes. The former is called *chromatin*, the latter *achromatin*. During the stages preparatory to the mitotic division of the nucleus the chromatin becomes segregated into a definite number of equal portions. The bodies thus formed are the *chromosomes*.

The difference in staining reactions that the chromosomes exhibit when compared with most of the other structures in the cell indicates a difference in chemical or physical condition. If a quantity of yeast, pus cells, nucleated red blood corpuscles, or other ordinary cells be subjected to artificial digestion with pepsin and hydrochloric acid, the albumens are dissolved and may be removed, leaving a residue which is more or less soluble in weak alkalies and may be precipitated by hydrochloric acid. After being purified this residue is found to be a colorless, amorphous substance insoluble in alcohol and ether, and insoluble or very slightly soluble in water, pepsin and hydrochloric acid, or in weak mineral acids. Microscopical examination of the undissolved residue shows that it consists chiefly of nuclear material, and the chemical substance which is isolated after purification has accordingly been named by Miescher *nuclein*. True nuclein is further characterized by its property of giving off xanthin bodies when boiled with dilute acids; and when treated with an alkali it is split into two substances, an albumin and *nucleinic acid*, as was shown by Altmann. Nucleinic acid, like nuclein, is rich in phosphorus, and Miescher gives as the formula for nuclein obtained from salmon sperm $C_{40}H_{54}N_{14}P_4O_{27}$. But there are undoubtedly several varieties of nucleinic acid, so it is impossible to give a general formula for the series. Both nuclein and nucleinic acid are stained readily with the basic aniline dyes. While similarity of staining reaction does not necessarily indicate similarity of chemical composition, and the reaction of parts of a cell depends largely upon its previous treatment, the evidence as a whole goes to show that the chief chemical substance by which the chromosomes are distinguished from other structures in the cell is nucleinic acid.

FIG. 1319.—Spermatogonium of the Earthworm (Lumbricus), Showing the Mitotic Figure in the Late Prophase. Twenty-four of the thirty-two small chromosomes may be seen gathered at the equator of the spindle. × about 1,600. (After Calkins.)

In form and structure the chromosomes differ greatly in different organisms, in different cells, and in different stages of development of the same organism. They vary in form from minute globular or elliptical bodies (Fig. 1319) to elongated rods, often bent or twisted, and frequently in a V- or U-shape (Figs. 1322 and 1323). In the process of maturation of the germ cells of both animals and plants the chromosomes appear in the form of tetrads, practically four chromosomes more or less joined together. During the formation of the tetrads the chromosomes often assume the form of rings or crosses, and both of these forms may appear with others in the same cell, as Calkins found to be the case in certain ferns. (See article *Reduction Division*, also articles *Ovum* and *Spermatozoa*.)

Many observers have noticed that, when highly magnified, in numerous cases the chromosomes may be seen not

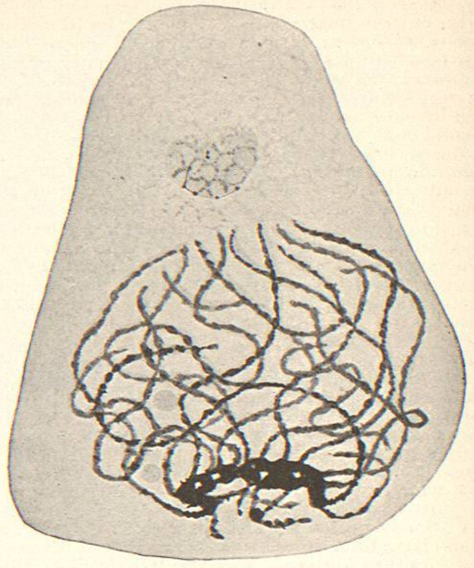

FIG. 1320.—Auxocyte (Primary Spermatocyte) of Batrachoseps. Nucleus in the spireme stage. One or two large chromoplasts are seen in the lower part of the nucleus. × about 1,500. (After Eisen.)

to be homogeneous, but to be composed of smaller units, minute granules of chromatin. In a recent paper on the spermatogenesis of a Pacific coast salamander, Batrachoseps, Gustav Eisen (1900) describes the chromosomes as being composed of a homogeneous chromoplasm containing a definite number of minute bodies, which he calls *chromioles* (Fig. 1322) and believes to be fundamental elements of the nucleus. These are arranged in two rows, one on each side of the chromosome. The latter is constricted slightly at regular intervals, and is thus divided into segments, or chromomeres (Fig. 1321). In the fully developed chromosome of this species there are six chromomeres, each containing six chromioles.

Chromosomes, as a rule, appear only during cell division and their origin and fate are intimately associated with that process, for a description of which the reader should consult the article on *Cell*. Here we are concerned only with the important part played by the chromosomes. In the so-called resting, or vegetative, stage, the chromatic material is generally scattered throughout the nucleus in the form of fine granules, although more or less of it may be gathered together forming "net-knots," or "chromatin-nucleoli." According to Eisen the granules are chromioles. To the chromatin-nucleoli he gives the name of *chromoplasts*, and believes them to be of equally fundamental importance with the chromioles. Preparatory to division, the chromatin becomes united into one or more slender threads coiled within the nuclear membrane and forming the *spireme* (Fig. 1320). Next the spireme thread shortens and thickens, and finally it is divided by transverse fission into a number of separate segments: these are the chromosomes. According to Eisen, in the cells of the testes of Batrachoseps the chromoplasts are the centres of activity in the formation of the spireme. The chromioles become arranged in rows and connected by an enveloping chromoplasm, forming slender threads, or "leaders," and this takes place in connection with the chromoplasts, each one having several leaders radiating from it (Fig. 1320). The usual shortening and thicken-

ing of the leaders takes place, and they become reduced in number until, in somatic mitoses, there are twenty-four. Finally, the chromoplasts divide so that there are formed twenty-four separate chromosomes, each one provided with a chromoplast at one end.

In the mean time the achromatin spindle has been formed, and the nuclear wall has faded away leaving the chromosomes lying free in the cytoplasm. The chromosomes now migrate toward the equator of the spindle until they become arranged in a circle around it (Fig. 1321). Then follows the most important and essential operation in the division of the nucleus, the separation of each chromosome into two exactly equal halves (Fig. 1322). This is preceded by a *longitudinal* fission, which takes place in some species at this stage, in others at various earlier stages as far back as the spireme. The separation having been accomplished, one-half of each

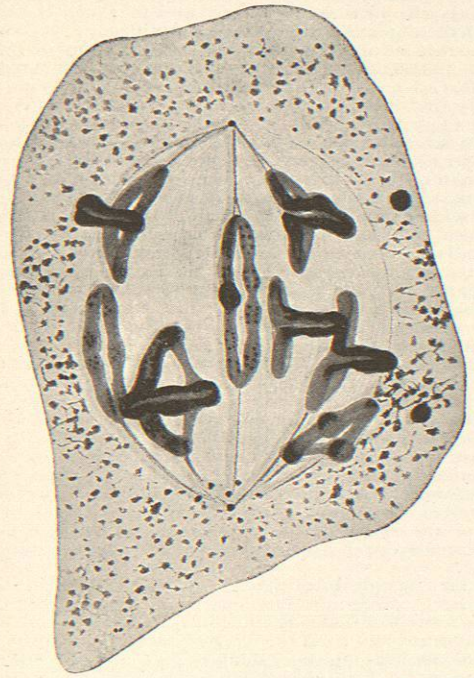

FIG. 1321.—Auxocyte of Batrachoseps in a Stage Immediately Preceding the Metaphase. Eight of the twelve chromosomes are seen approaching the equator of the spindle. × about 1,500. (After Eisen.)

chromosome moves to one pole of the spindle, the other to the other pole; so that in the anaphase there are collected at each pole of the spindle the same number of chromosomes that were formed in the mother-nucleus (Fig. 1323). Each of these groups of chromosomes then forms a new daughter-nucleus. This may take place in one of two ways: either the chromosomes may unite to form a spireme thread, after which the chromatin becomes more diffused and a nucleus membrane is formed around the whole; or else each chromosome may swell and form a vesicle, and the vesicles then fuse to form the new nucleus. When, after a resting stage, the nucleus again prepares for division, the chromosomes which reappear within it are of the same number as those of which it was originally formed.

It is now established as highly probable, that every species of animal and plants has a constant and characteristic number of chromosomes, which appears at each successive division of the somatic cells. Wilson gives a list of seventy-two species in which the number has been determined. Thus, in the worm Ophryotrocha, there are four; in Nais, Spirogyra, Limax, Pinus, and Allium there are sixteen, and man has been supposed to have

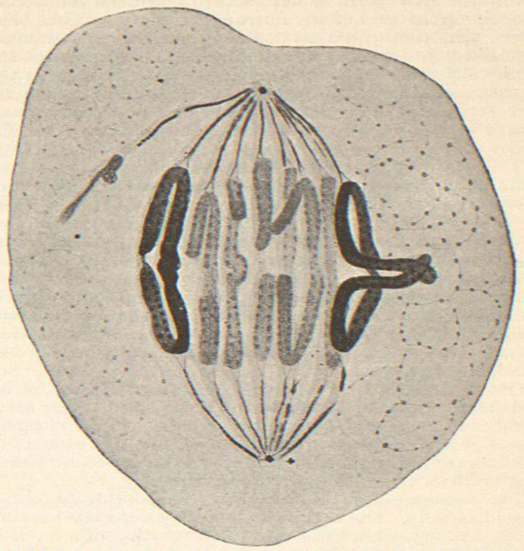

FIG. 1322.—Auxocyte of Batrachoseps in the Metaphase, Chromosomes Dividing. × about 1,500. (After Eisen.)

this same number; eighteen are found in the sea urchin, Echinus, and in Ascidia; the salmon, frog, mouse, and lily have twenty-four; thirty-six have been found in Torpedo and certain sharks; and the crustacean, Artemia, is said to have one hundred and sixty-eight. It will be noticed that in each of these cases the number is an even

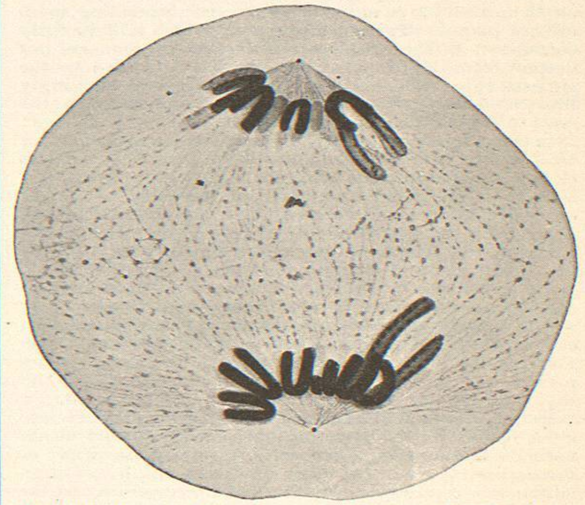

FIG. 1323.—Auxocyte of Batrachoseps in the Late Anaphase, Daughter-Chromosomes Collecting at the Poles of the Spindle. × about 1,500. (After Eisen.)

one; and in each of these cases and the others mentioned in Wilson's table the nuclei of the mature male and female germ cells have been found to contain exactly half as many chromosomes as the somatic cells.