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

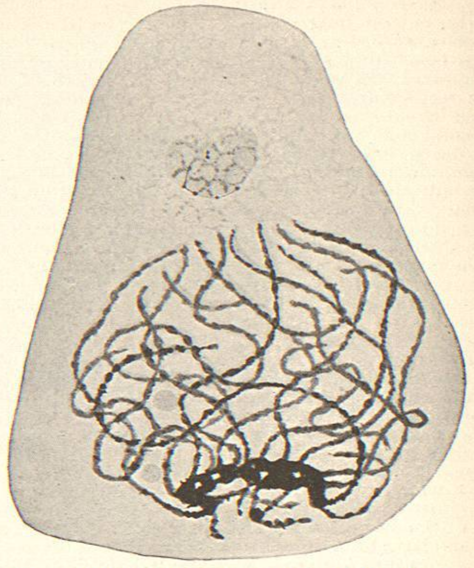

FIG. 1320.—Auxocyte (Primary Spermatocyte) of Batrachoseps. Nucleus in the spireme stage. One or two large chromoplasts are seen in the lower part of the nucleus. × about 1,500. (After Eisen.)

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 thickening 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

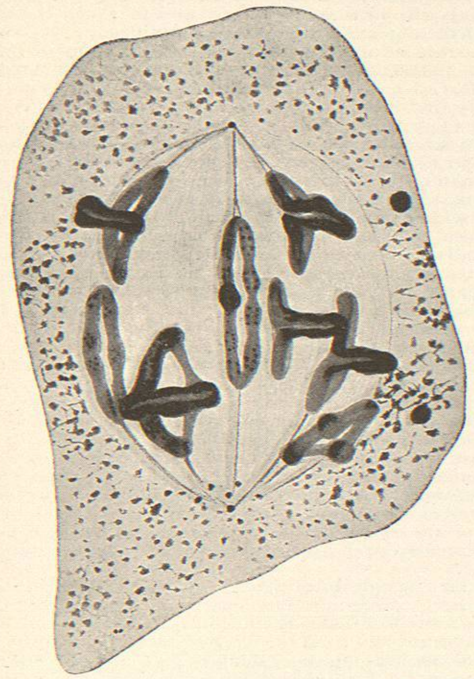

FIG. 1321.—Auxocyte of Batrachoseps in a Stage Immediately Preceding the Metaphase. Eight of the twelve chromosomes are seen approaching the equator of the spindle. × about 1,500. (After Eisen.)

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

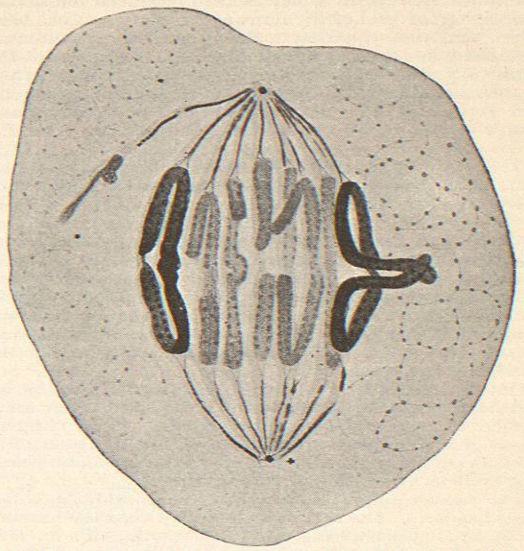

FIG. 1322.—Auxocyte of Batrachoseps in the Metaphase, Chromosomes Dividing. × about 1,500. (After Eisen.)

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

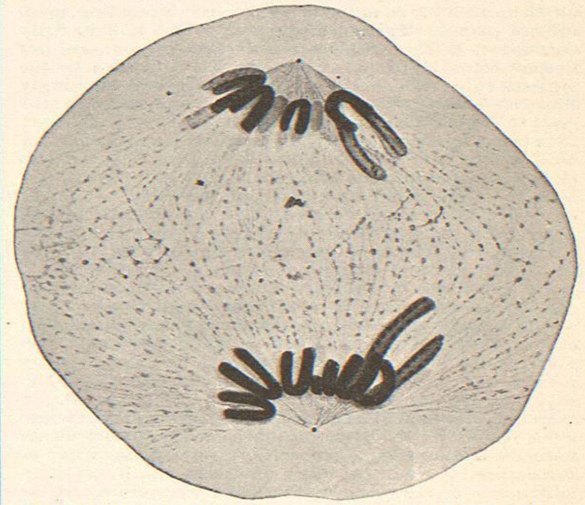

FIG. 1323.—Auxocyte of Batrachoseps in the Late Anaphase, Daughter-Chromosomes Collecting at the Poles of the Spindle. × about 1,500. (After Eisen.)

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.

In the ferns and their allies there is an alternation of generations. A prothallium derived from a non-sexual spore produces male and female germ cells. These give rise to the fern plant, which in turn produces non-sexual spores. In several of the ferns and Hepaticæ it has been found that the reduction in the number of chromosomes does not take place, as in animals, in the formation of the germ cells; but it occurs during the development of the spores, and all the cells of the prothallium, both somatic and germ cells, have half the number of chromosomes found in the somatic cells of the fern plants. (See *Reduction Division*.)

That interesting parasite, *Ascaris megalocephala*, presents a curious exception to the law of the number of chromosomes. The mature germ cells of this species have only one chromosome (var. *univalens*), or two (var. *bivalens*), and the first blastomeres in the dividing ovum have correspondingly two or four chromosomes. This is true also of the cells which in later stages are destined to form the germ cells for the next generation. But in the subsequent divisions of the purely somatic cells the chromatin becomes divided into a large number of very minute chromosomes; it is probable, however, that the number is constant.

Only in rare instances do the chromosomes persist intact from one cell-division to the next. Still there are a number of facts which seem to indicate that the chromosomes which appear preparatory to the division of a nucleus are individually the same as those which formed that nucleus after the previous division.

The evidence for this view may be considered under three heads: 1. The correspondence between the number of chromosomes entering into the formation of a nucleus and the number issuing from it. 2. The correspondence in position between the place of disappearance of the chromosomes and the place where they reappear. 3. The observed distinctness of the groups of chromosomes derived from the male and female parent respectively.

The law that "whatever be the number of chromosomes entering into the formation of a reticular nucleus, the same number afterward issues from it," has been found to hold good in all normal cell-divisions that have been observed, except in the special cases of the spermatocyte and oöcyte in animals and the corresponding spore cells of plants. These special cases, which will be fully considered in the article on *Reduction Division*, do not detract from the force of the evidence furnished by the general rule. The force of this rule is most strikingly illustrated by certain abnormalities, especially in the eggs of Ascaris.

In the commoner variety of *Ascaris megalocephala*, var. *bivalens*, the oöcyte, or immature egg, has the chromatic elements of the nucleus arranged in two groups of fours, tetrads. One tetrad goes into the first polar body; the other divides into two dyads, and one goes into the second polar body and the other dyad forms the two chromosomes of the female pronucleus. Thus we have in the first polar body four chromosomes, two in the second polar body, two in the female pronucleus, and the spermatozoon brings in two more, making a total of ten.

The variety *univalens* presents the same phenomena except that the numbers are just one-half of these. Fortunately in these wonderful eggs the polar bodies persist until the formation of the embryo is well under way, and the chromosomes in them may be counted.

Now Boveri and Herla have shown that while development ordinarily follows the normal course, various abnormalities may occur; but, with the exception of two or three possibly doubtful cases, the total number of chromosomes may always be accounted for according to the rule. For example, in var. *bivalens* it sometimes happens that two small female pronuclei are present instead of one large one, and when the chromosomes are formed it is found that only one chromosome appears in each of the small pronuclei, the total number remaining the same. In other eggs four chromosomes were found in the female pronucleus or six in the first cleavage spindle, but the second polar body was not to be found and had evidently not been extruded. Again, cases were found in which there were only three chromosomes in the first polar body, and the missing one was discovered in the second maturation spindle or in the female pronucleus.

Herla, however, found one female in which all the eggs showed the normal polar bodies of var. *bivalens*, but in the first cleavage spindle and subsequent stages there were only three chromosomes. But in the same intestine he found other worms of the var. *univalens*. There is strong reason to believe that this was a case of crossing, the female of one variety having been impregnated by the male of the other, and thus the rule would still hold good. In other worms from the same source a few cases were found of redundancy of chromosomes with normal polar bodies. Herla explains these as due to the entrance of two spermatozoa, which Van Beneden has shown to occur rarely. In short, all the abnormalities are susceptible of explanation in accordance with the rule, there being only two or three very rare cases in which the validity of the explanation might be questioned.

The rule is further confirmed by observations of Brauer on the parthenogenetic eggs of the crustacean Artemia, and Boveri and Morgan have made the interesting discovery that it is possible to fertilize fragments of echinoderm eggs which contain no female pronucleus and to obtain larvæ whose cells contain just half the normal number of chromosomes, the number introduced by the spermatozoon. Very recently E. B. Wilson has found that the same is true of echinoderm embryos derived from eggs which have been stimulated to develop by Loeb's chemical method without the entrance of a spermatozoon.

In all these cases, wherever the number of chromosomes in the first cleavage spindle has been altered as the result of some accident of maturation or fertilization, this same number is found to reappear in subsequent stages. Thus these abnormalities contribute striking proof of the law of equality in the number of chromosomes.

While it is true that if the chromosomes maintain their individuality in the reticular nucleus, the same number must appear at the close of the resting period as were present at the beginning, the demonstration that this is the fact does not prove that the new chromosomes contain the same elements. There may be an entire rearrangement of the chromatin during the reticular stage. Therefore, if it can be shown that, besides being equal in number, the chromosomes are reformed in the same part of the reticulum where they disappeared, we shall have greatly strengthened the evidence for their individuality.

So far the only form that has supplied such evidence is Ascaris. Here in the two-cell stage when the chromosomes unite to become the nucleus, the ends of the chromosomes project from the general mass and persist during the resting stage as reticular lobes, and the first step in preparation for the second division is the concentration of the chromatin in these same lobes to form the ends of the new chromosomes. The ends of the chromosomes in this case, therefore, appear to be composed of the same chromatin before and after the resting stage. As to whether this is true of the middle part or not the evidence is inconclusive.

Finally there is a certain amount of evidence, that if not the chromosomes, at any rate the mass of chromatin derived from each parent, remains distinct. In the hybrid eggs of Ascaris, Herla found that the female pronucleus gave rise to a single thread of chromatin which divided transversely to form the two chromosomes, while the male pronucleus produced a much shorter thread that did not divide. In subsequent divisions of the series leading to the formation of the primordial germ cells of the embryo he observed that the three chromosomes arose in the same way, indicating a persistent distinction between the chromatin of maternal and that of paternal origin.

In a little copepod, *Cyclops strenuus*, Häcker and Rückert have demonstrated that the twelve chromosomes of each germ-nucleus remain distinct and give rise in the two-cell stage to a distinct half of the bilobed nucleus of each

cell. Two spiremes are formed in the next stage, producing separate groups of twelve chromosomes, and Rückert traced the maternal and paternal groups of chromosomes in this way through several successive cell-divisions and found evidence of the dual nature of the nuclei as late as the stage of the formation of germ-layers.

In conclusion it may be said that while it is not possible at present to give a rigorous proof of the individuality of the chromosomes, the three lines of evidence just reviewed give to the hypothesis a considerable degree of probability.

The physiology of the chromosomes is the most difficult question that we have to consider, because experiment is wellnigh impossible, and we can draw inferences as to their functions only from the appearances observed in the various stages of cell activity.

There are a number of observations and experiments, however, to show that the nucleus plays a very important part in the economy of the cell. Thus, if the body of a unicellular organism be divided so that one part contains no nuclear material, this part may remain alive for some time but is unable to digest food or to repair the damage, while the part containing the nucleus can do all of this and soon becomes as perfect as before.

That the chromatin is the most essential part of the nucleus seems to be evident from the phenomena of mitosis. Here we see every part of the mechanism designed apparently to effect the exactly equal distribution of the material to the two daughter-cells; and when the daughter nuclei are re-formed they are produced entirely by the transformation of the chromosomes. Rückert has found that in a shark, Pristiurus, the chromosomes persist during the growth period of the egg. At first they are small and stain darkly. During the growth of the egg they increase enormously in size and lose in staining capacity, and at the end of the period they contract to one-sixth of their original length and stain very darkly. "As Rückert points out, the great increase of surface in the chromosomes is adapted to facilitate an exchange of material between the chromatin and the surrounding substance; and he concludes that the coincidence between the growth of the chromosomes and that of the egg points to an intimate connection between the nuclear activity and the formative energy of the cytoplasm." "We may infer that the original chromosomes contain a high percentage of nucleinic acid; that their growth and loss of staining power is due to a combination with a large amount of albuminous substance to form a lower member of the nuclein series, probably a nucleo-proteid; that their final diminution in size and resumption of staining power is caused by a giving up of the albumen constituent, restoring the nuclein to its original state as a preparation for division." Ordinarily these chemical changes and interchanges between chromatin and achromatin take place in the reticular stage of the nucleus, and the chromosomes, as they are usually observed, probably have nothing to do with them. The reticular nucleus is probably not at all in a "resting stage" but is a seat of lively metabolic activity, and it is more probable that the chromatin of the chromosomes is in more nearly an inactive condition. Why the chromatin should assume this form at the time of division is not known, but the presence of the chromosomes at almost every cell-division in the whole range of forms from the protozoa to man and the higher plants indicates that their formation is an essential step in the process.

The most important function that has been ascribed to the chromosomes is that of transmitting the physical basis of heredity from one generation to the next. Statistical studies of Galton, Pearson, and others indicate that on the whole the heritages from the two parents to the offspring are equal. There must be in the fertilized egg, then, some material body derived in equal proportion from the two parents, and the chromosomes are the only bodies that so far have been found to meet this requirement. Moreover, during the first cleavage of the egg each chromosome is divided by longitudinal fission into exactly equal parts, which are distributed to the two daughter-cells so that each one has an exactly equal number of chromosomes of paternal and of maternal origin. If the individuality of the chromosomes be a fact, then this equal distribution of chromatin from the two sources is extended to all the cells of the body. If we further assume as proven that the chromatin is the seat of the formative activity of the cell, then we begin to gain some insight, apparently, into the manner in which the maternal and paternal characteristics are commingled in all parts of the offspring.

It may be asked, and with good reason, How is it possible for the complex of hereditary qualities of a gifted father to be transmitted to his distinguished son through a few ultra-microscopic threads of nucleinic acid? The theories of heredity will be discussed in another article (see *Heredity*), but it may be pointed out here that nuclein and nucleinic acid are the products of dead nuclei. We have no knowledge of the chemical substances in the living nucleus and chromosomes beyond the fact that they are so combined that when their vital activities have ceased they yield to the chemist bodies of the nuclein series. The nucleins are certainly very complex bodies, but there can be little doubt that the living chromosomes are infinitely more complex than anything we can discover with the microscope or by chemical analysis.

Robert Payne Bigelow.

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See also various articles on the cell in Merkel and Bonnet's Ergebnisse der Anatomie und Entwickelungsgeschichte, Wiesbaden, annually since 1892.

CHRYSAROBIN.—CHRYSAROBINUM, U. S. P. A neutral principle, in its commercial, more or less impure form, extracted from Goa powder, a substance found deposited in the heart wood of *Vouacapoua Araroba* (Aguaiar) Lyons (fam. *Leguminosæ*). This, sometimes misnamed chrysophanic acid, is the crystalline substance of which "Goa powder" principally consists. It has long been used in Brazil, whence its employment has spread through Portuguese commerce to India and the East. Its general European and American employment is comparatively recent. Goa, or Araroba, is a pulverulent substance, contained in long and large canals in the older wood of the trunks, and also in large irregular cavities in the same, formed by erosion or degeneration of the wood itself. It is obtained by cutting and splitting up the trees, and scooping or scraping out these canals and cavities. It is considerably irritating to the skin and mucous membranes, and severe inflammation of the face and eyes of those who collect it is not unusual. Lachrymation and sneezing are readily produced by sifting or handling the powder. Crude Goa is a coarseish powder, mixed with lumps and fine bits and fibres of wood, varying from dull yellow (when fresh) to reddish brown, or even a greenish or violet-brown color, with the other properties of its purified product as described below. Besides small amounts of sugar, gum resin, and cellular tissue, it contains, as was first shown by Professor Attfield, eighty-five per cent. of a yellow crystalline substance, which he supposed was *chrysophanic acid*, but which Lieberman afterward proved to be a mixture consisting mostly of a peculiar substance, *chrysarobin*, having many points of resemblance to the above-mentioned acid, containing a little of it, and, in fact, capable of being transformed into it by oxidation. The impure chrysarobin of the Pharmacopœia is thus described: "A pale, orange-yellow, microcrystalline powder, odorless and tasteless, turning brownish yellow on exposure to air. Very slightly soluble in cold water or alcohol; soluble, without leaving more than a small residue, in 150 parts of boiling alcohol; also soluble in 33 parts of boiling benzol, and in solutions of the alkalies."

Chrysarobin taken internally is an active irritant to the alimentary canal, causing violent and persistent catharsis and vomiting. It is eliminated, partly unchanged and partly converted into chrysophanic acid, by the kidneys, which glands are extremely irritated by it, and hæmaturia and interstitial nephritis may follow. It is, however, here never given internally, its use being confined to local applications as an irritant and parasiticide in chronic psoriasis, pityriasis versicolor, and tinea tonsurans. It produces an active acute inflammation, which as it subsides leaves the original malady in an improved condition. Chrysarobin stains both skin and clothing badly. The ointment (*Unguentum Chrysarobin*, U. S. P., strength five per cent.) is of a suitable strength for inunction.

W. P. Bolles.

CHRYSOIDIN. — $C_6H_5N,NC_6H_3(NH_2)_2HCl$—Diamido-azo-benzol hydrochloride. This is a red-brown crystalline powder soluble in water and used in solution as an antiseptic mouth wash. *W. A. Bastedo.*

CHRYSOPHANIC ACID.—*Rheic Acid. Rhein.* $C_{14}H_5(CH_3)(OH)_2O_2$. This is a bright yellow crystalline powder extracted from rhubarb, to which it imparts the yellow color. It is insoluble in water and only slightly soluble in alcohol, but dissolves in both ether and chloroform. It is highly irritant, and has the same properties and uses as *Chrysarobin*, which see. *H. H. Rusby.*

CHUCANDIRO.—Michoacan, Mexico. These waters enjoy a great reputation in the country because of their warmth (which is that of the normal human body), their clearness, and their curative properties. They contain a high percentage of hydrochloric acid in solution.

N. J. Ponce de Léon.

CHYLANGIOMA. See *Angioma.*

CHYLE.—The term chyle is applied to the milk-white, opaque fluid which fills the lacteals, or lymphatic ducts, of the small intestine during the digestion of food containing fat. Since the fluid from the lacteals preponderates in that of the thoracic duct and causes the latter to assume a similar appearance, the term chyle is also frequently applied to the contents of the thoracic duct during the absorption of fats. The physical and chemical properties of this fluid vary at different times and under various circumstances; the most important factor determining its properties is, however, the character of the food in the intestinal canal. In a starving animal or in one which has received only fat-free food, the liquid of the lacteals is not to be distinguished either in appearance or in chemical composition from ordinary lymph.

Much of our knowledge of the character and composition of chyle has been derived from experiments upon the lower animals, and especially from experiments upon the dog. In this animal it is not difficult to insert a cannula into the thoracic duct where it joins the left subclavian vein at the root of the neck; in this manner the chyle may be collected for any desired period and the factors affecting the composition and rate of flow studied. Unfortunately, the fluid collected in this manner is not pure chyle, but consists of a mixture of chyle and of lymph coming from the lymphatics of the liver, kidneys, pelvis, abdominal walls, lower extremities, etc. In large herbivorous animals cannulæ have been inserted into the lacteals directly and pure chyle obtained. The chyle of man has seldom been studied; in rare cases fistulæ connecting with the lacteals or with the thoracic duct have been described and the fluid escaping therefrom examined. Cases are also reported in which the thoracic duct became occluded and ruptured, allowing the chyle to escape into the pleural or peritoneal cavity, from which it was removed by puncture.

Chyle obtained by one of the above methods is, when a mixed diet has been given, a white, opaque fluid; occasionally it is colored slightly red or yellow from the accidental presence of red blood corpuscles. In herbivora it may have a greenish tinge from chlorophyl derived from the food. It has an alkaline reaction due to carbonates and phosphates of sodium. The specific gravity is 1.018 to 1.025. It has a salty taste and the odor (due to volatile fatty acids) peculiar to the animal from which it is derived. It coagulates upon standing, sometimes more, sometimes less, readily. Examined microscopically chyle is found to contain two kinds of formed elements, leucocytes and fat granules. The leucocytes have their origin chiefly in the lymphoid tissue of the intestinal tract and the lymph glands of the mesentery; chyle obtained from the lacteals before they pass through lymph glands is found to contain fewer leucocytes than that from vessels which have passed through these glands. A constant stream of leucocytes thus passes from the chyle into the blood; this forms an important source of the white corpuscles of the latter. The fat, which exists in a state of the finest division, will be discussed below.

Since chyle is but a form of lymph we should expect to find a close resemblance between the chemical composition of these two fluids; the following table from Munk, giving the results of analyses of chyle and of lymph of man, shows that this is the case.

One hundred parts.	Chyle.	Lymph.
Water	92.2	95.2
Solids	7.8	4.8
Fibrin	.1	.1
Proteids	3.2	3.5
Fats (lecithin and cholesterin)	3.3	Traces.
Extractives	.4	.4
Salts	.8	.8

This table shows very clearly that chyle differs from ordinary lymph in but one important point, viz., in containing a larger percentage of fat. In exceptional cases chyle contains a larger percentage of sugar than does lymph; this point will be discussed below. Since chyle, like lymph, is derived from the blood, it is of interest to compare the composition of the blood serum and the chyle of the same animal. The following table is from analyses made by Hoppe-Seyler; the fluids were obtained from a dog.

	Chyle.	Serum.
Water	90.67	93.60
Fibrin	.11	....
Albumin and globulin	2.10	4.52
Fat (lechithin and cholesterin)	6.48	.68
Other organic substances	.23	.29
Salts	.79	.87

These analyses show that chyle differs from serum in two important particulars: it contains a larger percentage of fats and a smaller percentage of proteids. Lymph similarly contains a smaller percentage of proteids than does blood serum. The amount of urea in the chyle is, according to Grehant and Quinquaud, greater than that in the blood; they found from 46 to 95.5 mgm. of urea in 100 gm. of chyle, and only about one-half as much in blood.

The salt occurring in the greatest abundance in chyle is sodium chloride (.58 per cent.); then come sodium carbonate (.15–.22 per cent.) and the phosphates of the alkalies and alkaline earths (.04 per cent.). Other salts, as potassium iodide and potassium ferrocyanide, are occasionally found in the chyle as abnormal constituents. At times a small amount of lactic acid is present.

The proteids of the chyle are serum albumin and serum globulin: the former is two and a half to four times as abundant as the latter. Cholesterin and lecithin are constant constituents of the chyle: in analyses they are frequently reckoned with the fats in the "ethereal extract."

Some analyses showed from 18 to 102 mgm. of cholesterin per 100 gm. of chyle; lecithin was found in much smaller quantity—only about half as much of this being present, as a rule, as of cholesterin.

It has already been shown that the only important difference between chyle and lymph is the presence in the former of a large amount of fat. If the contents of the lacteals be examined in an animal which has received no food for many hours or only fat-free food, this difference does not obtain, and the contents of the lacteals cannot be distinguished from ordinary lymph. These considerations suggest that fats are absorbed by the lacteals, and that this is the case has long been known. The question is often raised, Are the lacteals the only path for the absorption of fats? While this question is usually answered in the affirmative, the proofs are by no means complete. The amount of fat absorbed from the intestines is easily determined by weighing the amount of fat fed, and that remaining in the digestive tract after a given period; the difference gives the total amount absorbed. The fat absorbed by the lacteals is determined by collecting the chyle as it flows from the thoracic duct and weighing the fat it contains. When the amount of fat obtained from the thoracic duct is compared with that absorbed from the intestines, a marked deficit is always found; the most careful work has failed to recover more than sixty per cent. in this way. The fate of the rest of the fat is not known; there is, however, no evidence that any of it passes into the portal system.

Fat does not seem to be absorbed by the lymphatics of either the large intestine or the stomach, for the contents of these are always clear; the epithelial cells lining these organs are, however, sometimes found filled with fat droplets, but it is not known what finally becomes of these.

The amount of fat in the chyle varies within wide limits, being determined by the amount and character of the fat of the food. It is said that the chyle of the dog may contain as much as fifteen per cent. of fat; the maximum amount found by Munk in man was about five per cent. The time after a meal at which fat appears in the chyle is very variable, being determined largely by the character of the fat fed. Zawilski (Ludwig's "Arbeiten," ii., 1876, p. 147) introduced into the stomach of a dog 150 gm. of fat (the variety is not stated). Two hours afterward fat was detected in the chyle; the maximum amount was found in the tenth hour, and fat was still present after nearly thirty hours. Munk and Rosenstein (to whom we are indebted for nearly all of our knowledge of the absorption of fat in man) carried out a similar series of experiments on a human being (Virchow's *Archiv*, 123, p. 230). These investigators had the opportunity of observing and experimenting upon a girl who, as a result of elephantiasis of one leg, had a fistula in the thigh which communicated through the left lumbar lymphatic duct with some of the lacteals. It was found that when fat was given to this patient, two-thirds of it could be recovered in the fluid escaping from the fistula in the following twelve hours; further, examination of the blood at the height of digestion showed no more fat to be present than when the patient was fasting. Munk and Rosenstein concluded from these observations that nearly all the chyle escaped through the fistula. A unique opportunity was thus offered to extend to man the experiments which had been made upon animals as to the absorption of fats. Some of the more important results will be given below. In one experiment the patient was given 41 gm. of olive oil; the fluid escaping from the fistula, and which had hitherto been clear, became milky in appearance during the second hour and chemical examination showed the presence of much fat. The maximum amount of fat was found in the fluid escaping during the fifth to the sixth hour; the fluid now contained 4.3 per cent. of fat, and 5.6 gm. passed out during the hour. The percentage of fat in the chyle rapidly decreased from this time on, and from the eleventh to the thirteenth hour only 0.8 gm. was obtained. In all, 60 per cent. of the fat fed escaped from the fistula. When a fat with a high melting point (like mutton fat which is solid at ordinary temperatures) was given, the course of absorption was similar, except that the maximum percentage of fat in the chyle (3.8 per cent.) appeared somewhat later—between the seventh and the eighth hour; that is, the mutton fat was absorbed with more difficulty than was the olive oil. The greatest amount recovered in one hour was 4.7 gm., and of the entire amount 55 per cent. was obtained from the chyle. When cream was given to the patient, as much as 11.2 gm. of fat was obtained in one hour.

From earlier experiments on lower animals Munk had found that when fatty acids are fed they appear in the chyle as neutral fats; he was able to confirm this result on the patient in question. For example, when 17 gm. of erucic acid was given, 8 gm. of the corresponding neutral fat (erucin) was obtained from the chyle escaping during the following ten hours; in other words, a union of erucic acid and glycerin (derived from the tissues) had occurred during the course of absorption. Very little free acid was found in the chyle. Munk also tried experiments with spermaceti, a fat which melts at a temperature (127° F.) much above that of the body, and in which the palmitic acid is combined with cetyl alcohol instead of with glycerin as in ordinary fats. In these experiments the fatty acid appeared in the chyle in combination with glycerin: that is, the spermaceti had been decomposed and the palmitic acid had combined with glycerin during the course of absorption. These experiments also show that fats which are solid at the temperature of the body can be absorbed; the earlier view was that such fats escaped absorption altogether. When a fat containing amyl alcohol instead of glycerin was given, the fat of the chyle was a triglyceride, showing again that a decomposition and synthesis had occurred during absorption. In other experiments oil in the form of an emulsion was given by the rectum; four to six per cent of the fat was absorbed and appeared in the chyle in the course of eight or nine hours.

It is held by some that fats are absorbed from the intestines chiefly in the form of soaps; if this is the case they are transformed into neutral fats very soon after absorption, for soaps are present in but very small quantities in the chyle—only to the extent of about 0.2 per cent. In fact the soaps of the alkalies have been shown by Munk to produce poisonous effects similar to those caused by the albumoses when they are injected intravenously. Very little free fatty acid has been found in the chyle, and the amount is not increased by the ingestion of fatty acids.

Thus the fat of the chyle is almost entirely in the form of neutral fats; it is suspended in the liquid as an extremely fine emulsion. The fat granules are less than 1 μ in diameter and show Brownian movements. This emulsion is much finer and more uniform than that which is formed in the intestine; the fat granules in the latter vary in size from 1 to 20 μ or even more. The emulsion of the chyle also differs from ordinary fat emulsions in that it is not destroyed by acids. There is, however, no protecting membrane, as was once thought to be the case; the fat is easily removed by shaking with ether which causes the liquid to become transparent.

Many experiments have been made to determine whether substances other than fats, such as proteids and carbohydrates, pass from the intestinal tract into the chyle. The numerous experiments upon the lower animals and those of Munk and Rosenstein upon man agree in showing that normally fat is the only food-stuff which takes this path. Water and substances easily soluble in water, such as salts, proteids, and sugars, are absorbed by the blood-vessels. When, however, very large amounts of sugar, etc., are fed, some may be absorbed by the lacteals and so appear in the chyle. Munk and Rosenstein, for example, found that after giving 100 gm. of sugar the percentage of sugar in the chyle rose from 0.1 to 0.33 per cent.; only 0.5 per cent. of the total amount absorbed from the intestine was found, however, in the chyle. These authors found no appreciable increase in