ing the existence of reducing division in plants appears to have been removed. Moreover, the similarity is so close at this stage that many of the figures drawn by Strasburger, Miss Sargant, and Schniewind-Thies to illustrate forms of chromosomes in plants might be substituted for some of Paulmier's or Montgomery's figures, representing corresponding stages, with very little change.

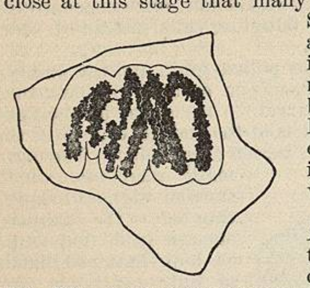

FIG. 3938.—Primary Spermatocyte of Lubber Grasshopper in Synapsis (telophase of spermatogonium). Only a few of the chromosomes are shown. (After Sutton.)

Synapsis, Reduction, and Heredity.—As stated in the introduction, the conception "reducing division" had its origin in an attempt to satisfy the requirements of a theory of heredity. The conception has very recently gained new interest and importance through an announcement made by E. B. Wilson (1902) and the publication of preliminary papers by Sutton and Cannon. It was found by Montgomery that in certain species of bugs the spermatogonia contain a pair of chromosomes that are unusually large or otherwise peculiar, and that after the synapsis in these cases there is only one large chromosome. Evidently the two peculiar ones have united. As a result of the maturation divisions each spermatid likewise contains one peculiar chromosome. The same is probably true of the egg. So one of these bodies in the spermatogonium is probably of paternal and the other of maternal origin. For this and other reasons Montgomery reaches the important conclusion that during the synapsis each bivalent chromosome formed is half of paternal and half of maternal origin, and the subsequent reducing division results in the separation of homologous paternal and maternal elements and their final isolation in separate germ cells. Now, as announced by Wilson, W. S. Sutton has found in the study of the spermatogenesis of a grasshopper, Brachystola, nearly complete proof of this inference, and W. A. Cannon has come to the same conclusion from the study of the maturation divisions of hybrid cotton plants. The chief results of Sutton's work are illustrated by Figs. 3936 to 3941. The last generation of spermatogonia have lobed nuclei, and each chromosome is formed in a separate diverticulum (Fig. 3936). In the late prophase of division the chromosomes are seen to be of different sizes, and there is one pair of each size, as *i, j, k,* Fig. 3937. In the following synapsis stage the chromosomes are seen to unite in pairs by their ends (Fig. 3938) and in the subsequent prophase there are eleven bivalent chromosomes, *a, b, c . . . k,* Figs. 3939 and 3940, corresponding to the pairs in the spermatogonium. The second maturation division is a true reducing division (Fig. 3941). If the oögenesis is the same, and the individuality of the chromosomes is maintained throughout the germinal cycle, then, of the two chromosomes that unite in synapsis, one must be of paternal and the other of maternal origin.

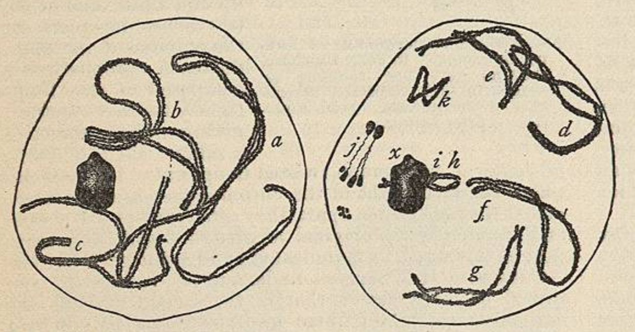

FIG. 3939.—Spiremes, or Chromosomes, from a Primary Spermatocyte in Early Prophase. Drawn in two groups to avoid confusion. From a smear preparation. (After Sutton.)

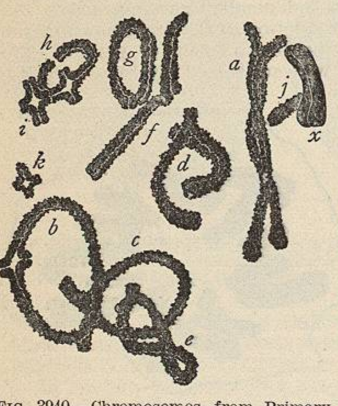

FIG. 3940.—Chromosomes from Primary Spermatocyte in Middle Prophase, showing Longitudinal Split. *a, b, c,* etc., same as in Fig. 3939. (After Sutton.)

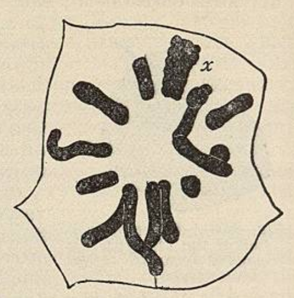

FIG. 3941.—Polar View of Equatorial Plate of Secondary Spermatocyte, showing eleven chromosomes and the accessory, *x*. (After Sutton.)

It was discovered recently by Boveri, that when the chromosomes in the segmenting ovum of a sea urchin have become disarranged as the result of double fertilization, and consequently unequally distributed to the blastomeres, abnormal larvæ result. He inferred from this that the chromosomes differ qualitatively and stand in definite relation to inheritable characters.

Taking all these results together, Wilson points out that they seem to confirm and to show a physical basis for Mendel's principle of heredity, which is being much discussed at present (see *Reversion*). Whether Mendel's theory be true or not, it is certain, as was shown in the article dealing with heredity, that it is in the nucleus of the germ cells, and especially in their chromatin constituents, that we must look to find the physical basis for heredity, and therefore the changes which these constituents undergo in the course of sexual reproduction possess the deepest interest for all students of biology.

Robert Payne Bigelow.

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REEDY CREEK SPRINGS.—Marion County, South Carolina. POST-OFFICE.—Latla. Hotel and cottages.

This resort is located about three-quarters of a mile from the Atlantic Coast Line Railroad. The surrounding country is level and covered by the long-leafed pine. The springs are three in number, and have had a local reputation for more than thirty years. The water has a constant temperature of 45° F., and its flow is very large. Mr. John L. Dew, of the springs, sends us the following list of ingredients resulting from a partial analysis by former State Chemist Chizzell: Iron carbonate, calcium, magnesium, and sulphur. The water is used more particularly for stomach, liver, and kidney disorders and debilitated states of the system. *James K. Crook.*

REFLEX ACTIONS OR REFLEXES. See *Knee-Jerk*.

REFLEXES. (CLINICAL.)—Descartes introduced the conception of reflexes into biological literature. In "Passions de l'âme" he stated that stimulation of a sensory nerve impulse may be transmitted through the brain to motor nerves and thereby give rise to contraction of muscles, and that this contraction takes place without volition, and even contrary to it. The general reflex centre he believed to be the glandula pinealis.

This definition of reflexes was correct in the early days of biology, but, with the advance of knowledge, our conception of the reflexes has been enlarged.

The term is used in medical literature to-day in a twofold sense:

1. *Specifically*, as in pupillary, knee, plantar reflexes, etc.

2. *Generically*, as in reflex neurosis, reflex spasms, reflex cough, etc.

In both the strict sense (pupillary and knee reflexes, etc.) and in the broader sense (reflex cough, reflex neurosis, etc.) reflexes are centrifugal phenomena produced by reflexion and eventual transmutation of centripetal stimulation. In other words, reflexes are physiological or pathological, motor, vaso-motor, viscero-motor, secretory or trophic phenomena, the cause of which is to be found in sensory stimulation.

There is still another group of phenomena called "reflex," to which the foregoing definition does not apply. This group is represented by a set of *centripetal* phenomena—reflex pains, reflex neuralgias, etc. Investigation shows that these phenomena are not genuine reflexes. One group of them, for instance pain in the distribution of the fifth nerve due to disease of the teeth or other structures of the head, or arm pain accompanying an anginoid attack, is, according to Head, an irradiation of a sensory stimulus to other parts or branches of the peripheral sensory apparatus of the affected locality.

Another group, for instance headache due to disease of the abdominal viscera, is, according to the same author, due to irradiations of the sensory stimulation to a central sensory station, and from here to allied sensory structures. Thus the difference between the two types becomes quite apparent.

The genuine reflex phenomena consist of neural stimulation that is reflected from one set of neurones (centripetal neurones) to a physiologically different set of neurones (centrifugal neurones).

The other type consists of neural stimulation that is irradiated and propagated from one set of neurones (centripetal) to another physiologically homologous set (centripetal neurones).

Finally, the term reflex is used promiscuously in medical literature to denote a phenomenon, the cause of which operates at some distance from where its effects are manifest.

According to the conception of genuine reflexes outlined above, all organic functions, save perhaps the distinctly voluntary functions, and some automatic visceral functions, may be looked upon as reflexes. Whether this be fully so or not, we will not attempt to decide. The considerable interest bestowed upon these phenomena, since the times of Descartes, testifies to the great importance of reflexes. (For further details in regard to these, consult the article on *Knee-Jerk* in Vol. V.)

In 1875 Erb and Westphal, working independently, demonstrated the clinical value of reflex phenomena, and since then their importance is daily more appreciated.

Prior to the publications of Erb and Westphal reflexes were observed and registered at the bedside in Charcot's Clinic. Charcot apparently divined their importance, but he had not yet appreciated their clinical significance.

Abundant clinical, experimental, and histological facts have been collected for the proper theoretical interpretation of reflex phenomena. However, a unanimity of opinion has not yet been reached. Some accept the original teachings of Erb, who interpreted reflexes, particularly tendon reflexes, as true reflexes; others adhere to Westphal's teaching, who believed that they were not true reflexes, but phenomena dependent upon the muscle tonus. Gowers calls the tendon reflexes myotatic phenomena, and his conception is akin to that of Westphal.

We shall not consider here the evidence which tends to substantiate either of these theoretical views. Here the theoretical basis of the reflex phenomena will be discussed only in so far as is necessary for a proper and intelligent interpretation of these phenomena at the bedside. The best-known and most studied of all reflexes are the tendon reflexes, and their classical representative is the knee-jerk.

The subsequent remarks apply to tendon reflexes in general, and to the knee-jerk in particular.

A reflex is a neural phenomenon which originates in a sensory end organ, travels along a centripetal pathway, passes a ganglionic station, and leaves it changed or unchanged in quality or quantity, and pursues its way outward on a centrifugal pathway to a centrifugal end organ. The anatomical structure subserving this consists of: A sensory end organ, a peripheral sensory fibre, a ganglion cell, a peripheral motor fibre, a motor end-organ—in other words, a sensory and a motor neurone of the peripheral kind.

This anatomical structure is called a reflex arc. The primary reflex arc is under the influence of one or more secondary arcs, which are represented by an analogous arrangement of secondary neurones.

The centrifugal branch of one of the supposed secondary arcs is represented by the fibres of the pyramidal tracts. The centripetal partner and the central connection of the two are not fully known. The former is probably found in the ascending cerebral and cerebellar tracts, and the central station is probably situated in the gray matter of the cerebrum and cerebellum, and in the nuclei and gray matter of the mesencephalon. The tendon phenomena are accompanied by conscious sensation. Whether this sensation is carried up along the centripetal pathways above mentioned or not is not known. Usually, when a reflex arc is spoken of, only the strict neural elements are understood to represent it, while the sensory and motor end-organs are not included. The ganglionic stations are spoken of as reflex centres. In addition a reflex arc is under the modifying influence of individual segments of the spinal cord above it.

In the lowest forms of life the anatomical substratum of most reflexes is represented by one reflex arc only. This is the case also in some of the simpler forms of reflexes.

All that has been said thus far applies particularly to the tendon phenomena. For other reflexes, skin reflexes, visceral reflexes, etc., analogous anatomical structures are supposed to exist. Their exact location and connections are fully known in some instances, not entirely in others, while in still others they are altogether hypothetical.