which contact of two points gave rise to a sense of a third point of contact. Certain conditions of the nerve centres affect the senses both of touch and temperature. Under the influence of morphia the person may feel abnormally enlarged or diminished in size. As a rule the senses are affected simultaneously, but cases occur where one may be affected more than the other.

Sensations of heat and cold are chiefly referred to the skin, and only partially to some mucous membranes’, such as those of the alimentary canal. Direct irritation of a nerve does not give rise to these sensations. The exposed pulp of a diseased tooth, when irritated by hot or cold fluids, gives rise to pain, not to sensations of temperature. It has now been ascertained that there are minute areas on the skin in which sensations of *heat* and *cold* may be more acutely felt than in adjoining areas; and, further, that there are points stimulated by addition of heat, hot spots, while others are stimulated by withdrawal of heat, cold spots.

A simple method of demonstrating this phenomenon is to use a solid cylinder of copper, 8 in. in length by ½ in. in thick- ness, and sharpened at one end to a fine pencil-like point. Dip the pointed end into very hot water, close the eyes, and touch parts of the skin. When a hot spot is touched, there is an acute sensation of burning. Such a spot is often near a hair. Again, in another set of experiments, dip the copper pencil into ice-cold water and search for cold spots. When one of these is touched, a sensation of cold, as if concentrated on a point, is experienced. Thus it may be demonstrated that in a given area of skin there may be hot spots, cold spots and touch spots.

Cold spots are more abundant than hot spots. The spots arc arranged in curved lines, but the curve uniting a number of cold spots does not coincide with the curve forming a chain of hot spots. By Weber’s method it will be found that we can discriminate cold spots at a shorter distance from each other than hot spots. Thus on the forehead cold spots have a minimum distance of 8 mm., and hot spots 4 mm.; on the skin of the breast, cold spots 2 mm., and hot spots 5 mm.; on the back, cold spots 1∙5 mm., and hot spots 4 to 6 mm.; on the back of the hand, cold spots 3 mm., and hot spots 4 mm.; on the paIm, cold spots 8 mm.t and hot spots 2 mm.; and on the thigh and leg, cold spots 3 mm., and hot spots 3∙5 mm. Electrical and mechanical stimulation of the hot or cold spots call forth the corresponding sensation. No terminal organ for discrimination of temperature has yet been found. It will be observed that the sensation of heat or cold is excited by change of temperature, and that it is more acute and definite the more sudden the change. Thus discrimination of temperature is similar to discrimination of touch, which depends on more or less sudden change of pressure. The term cold means, physiologically, the sensation we experience when heat is abstracted, and the term heat, the sensation felt when heat is added to the part. Thus we are led to consider that the skin contains at least two kinds of specific terminal organs for sensations of touch and temperature, and two sets of nerve fibres which carry the nervous impulses to the brain. In all probability, also, these fibres have different central endings, and in their course to the brain run in different tracts in the spinal cord. This will explain cases of disease of the central nervous system in which, over certain areas of skin, sensations of touch have been lost while sensations of temperature and pain remain, or vice versa. Tactile and thermal impressions may influence each other. Thus a leg sent to “sleep” by pressure on the sciatic nerve will be found to be less sensitive to heat, but distinctly sensitive .to cold. In some cases of disease it has been noticed that the skin is sensitive to a temperature above that of the limb, but insensitive to cold. It is highly probable that just as we found in the case of touch (pressure), the terminal organs connected with the sense of temperature arc the fine nerve filaments that have been detected in the deeper strata of the Malpighian region of the epidermis, immediately above the true skin, and it is also probable that certain epidermic (epithelial) cells in that region play their part in the mechanism. Sensations of a painful character may also, in certain circumstances, be referred to the viscera, and to mucous and serous surfaces. Pain is not a sensation excited by irritating the end organs either of touch or of temperature, nor even by irritating directly the filaments of a sensory nerve. Even if sensory nerves are cut or bruised, as in surgical operations, there may be no sensations of pain; and it has been found that muscles, vessels and even the viscera, such as the heart, stomach, liver or kidneys, may be freely handled without giving rise to any feeling of pain, or indeed to any kind of sensation. These parts, in ordinary circumstances appear to be insensitive, and yet they contain afferent nerves. If the sensibility of these nerves is heightened, or possibly if the sensitiveness of the central terminations of the nerves is raised, then we may have sensations to which we give the name of pain. In like manner the skin is endowed with afferent nerves, distinct from those ministering to touch and to temperature, along which nervous impulses are constantly flowing. When these nervous impulses reach the central nervous system in ordinary circumstances they do not give rise to changes that reach the level of consciousness, but they form, as it were, the warp and woof of our mental life, and they also affect metabolisms, that is to say, nutritive changes in many parts of the body. They may also, as is well known, affect unconsciously such mechanisms as those of the action of the heart, the calibre of the blood-vessels and the movements of respiration. If, however, this plane of activity is raised, as by intermittent pressure, or by inflammatory action, or by sudden changes of temperature, as in burning, scalding, &c., such nervous impulses give rise to pain. Sometimes pain is distinctly located, and in other cases it may be irradiated in the nerve centres, and referred to areas of skin or to regions of the body which are not really the seat of the irritation. Thus irritation of the liver may cause pain in the shoulder ; disease of the hip-joint often gives rise to pain in the knee ; and renal colic, due to the passage of a calculus down the ureter, to severe pain even in the abdominal walls. These are often termed *reflex pains* and their interpretation is of great importance to physicians in the diagnosis of disease. Their frequent occurrence has also, directed attention to the distribution in the skin and termination in the brain of the sensory nerves. It is also noticeable that a sensation of pain gives us no information as to its cause; we simply have an agonizing sensation in a part to which, hitherto, we probably referred no sensations. The acuteness or intensity of pain depends partly on the intensity of the irritation, and partly on the degree of excitability of the sensory nerves at the time.

*Pain.—*In addition to sensations of touch and of temperature referred to the skin, there is still a third kind of sensation, unlike cither, namely, pain. This sensation cannot be supposed to be excited by irritations of the end organs of touch, or of specific thermal end organs (if there be such), but rather to irritation of ordinary sensory nerves, and there is every reason to believe that painful impressions make their way to the brain along special tracks in the spinal cord. If we consider our mental condition as regards sensation at any moment, we notice numerous sensations more or less definite, not referred directly to the surface, nor to external objects, such as a feeling of general comfort, free or impeded breath- ing, hunger, thirst, malaise, horror, fatigue and pain. These are all caused by the irritation of ordinary sensory nerves in different localities, and if the irritation of such nerves, by chemical, thermal, mechanical or nutritional stimuli, passes beyond a certain maximum point of intensity the result is pain. Irritation of a nerve, in accord­ance with the. law of “ peripheral reference of sensation,” will cause pain. Sometimes the irritation applied to the trunk of a sensory nerve may be so intense as to destroy its normal function, and loss of sensation or anaesthesia results. If then the stimulus be increased further, pain is excited which is referred to the end of the nerve, with the result of producing what has been called *anaesthesia dolorosa.* Pains frequently cannot be distinctly located, probably owing to the fact of irradiation in the nerve centres and subsequent reference to areas of the body which are not really the seat of irritations. the intensity of pain depends on the degree of excitability of the sensory nerves, whilst its massiveness depends on the number of nerve fibres affected. The quality of the pain is probably produced by the kind of irritation of the nerve, as affected by the structure of the part and the greater or less continuance of severe pressure. Thus there are piercing, cutting, boring, burning, throbbing, pressing, gnawing, dull and acute varieties of pain. Sometimes the excitability of the cutaneous nerves is so great that a breath of air or a delicate touch may give rise to suffering. This *hyperalgia* is found in inflammatory affections of the skin. In *neuralgia* the pain is characterized by its character of shooting along the course of the nerve and by severe exacerbations. In many nervous diseases there arc disordered sensations referred to the skin, such as alternations of heat and cold, burning, creeping, itching and a feeling as if insects were crawling on the surface (formication). This con- dition is termed *paralgia.* The term *hypalgia* is applied to a diminution and *analgia* to paralysis of pain, as is produced by anaesthetics.

*Muscular Sense.*—The sensory impressions considered in this article are closely related to the so-called muscular sense, or that sense or feeling by which we are aware of the state of the muscles of a limb as regards contraction or relaxation. Some have held that the muscular sense is really due to greater or less stretching of the skin and therefore to irritation of the nerves of that organ. That this is not the case is evident from the fact that disordered move­ments indicating perversion or loss of this sense are not affected by removal of the skin (Claude Bernard). Further, cases in the human being have been noticed where there was an entire loss of cutaneous sensibility whilst the muscular sense was unimpaired. It is also known that muscles possess sensory nerves, giving rise, in certain circumstances, to fatigue, and, when strongly irritated, to the pain of cramp. Muscular sensations are really excited by irritation of sensory nerves passing from the muscles themselves. There are specialized spindle-like bodies in many muscles, and there are organs connected with tendons which are regarded as sensory organs by which pressures are communicated to sensory nerve-filaments. We are thus made conscious of whether or not the muscles arc contracted, and of the amount of contraction necessary to overcome resistance, and this knowledge enables us to judge of the amount of voluntary impulse. Loss or diminution of the muscular sense is seen in chorea and especially in locomotor ataxy. Increase of it is rare, but it is seen in the curious affection called *anxietas tibiarum,* a painful condition of unrest, which leads to a continual change in the position of the limbs (see Equilibrium).

(J. G. Μ.)