

CHAPTER IX.

THE SPECIAL SENSES.

The Production of Sensations—Variety of Sensations—General Sensibility—Pain and Its Function—Special Sensation, Touch, Taste, Smell, Sight, and Hearing—The Hand, the Organ of Touch—The Sense of Touch—Delicacy of Touch—Sensation of Temperature and Weight—The Tongue the Organ of Taste—The Nerves of Taste—The Sense of Taste and its Relations with the other Senses—The Influence of Education on the Taste—The Nasal Cavities, or the Organs of Smell—The Olfactory Nerve—The Uses of the Sense of Smell—The Sense of Sight—Light—The Optic Nerve—The Eyeball and its Coverings—The Function of the Iris—The Sclerotic, Choroid, and Retina—The Tears and their Function—The Movements of the Eyeball—The Function of Accommodation—The Sense of Hearing and Sound—The Ear, or the Organ of Hearing—The External, Middle, and Internal Ear.

I. Production of Sensations.—We have already seen that the true centre of sensation is some organ within the skull, probably among the gray masses at the base of the brain; but the mind never perceives impressions at that point, but, on the contrary, always refers them to the external organs of sensation. Hence it is convenient to say, that those outer parts possess the property of sensibility. For instance, we say that we hear with the ear, taste with the tongue, and feel with the fingers. That

this is not the exact truth is proven by the fact, that whenever the nerve connecting one of these organs with the brain is severed, it at once loses its capacity for sensation.

2. Consciousness, another faculty of the brain, is necessary to complete a sensation. During sleep, and in other unconscious states, the usual impressions are presented to the ear, the nose, and the skin, but they fail to excite sensations, because the nerve-centres are inactive. In profound insensibility, from chloroform or ether, a limb may be removed without occasioning the least feeling.

3. Variety of Sensations.—All animals have some degree of sensibility. It is of course feeble and indistinct in the lower forms of life, but increases in power and variety as we ascend the scale. In the earth-worm, the nervous system is very simple, the sensibility being moderate and alike in all parts: hence, if its body be cut into two pieces, each piece will have the same degree of feeling as before. As we approach man, however, the sensations multiply and become more acute; the organs are more complex, and special parts are endowed with special gifts. These special organs cannot be separated from the rest of the body without the loss of the functions they are designed to exercise.

4. The lowest form of sensation, that of simple contact, is possessed by the lowest of the animal creation. The highest forms are those by which we are enabled to know the properties of external objects, such as shape, size, sound and color. Sensations are modified by use. They become more acute and powerful by moderate exercise; or, they are dulled by undue excitement. The former is shown by the acute hearing of the Indian, by the sharp sight of the sailor, and by the delicate touch of the blind. The latter is exemplified by the impaired hearing of the boiler-maker, and the depraved taste of him who uses pungent condiments with his food. Again, impressions habitually presented may not be consciously felt; as is the case with the rumbling of carriages in a neighboring street, or the

regular ticking of a clock. All sensations become less acute with the advance of age, especially hearing and vision.

5. General Sensibility.—There is a property possessed by nearly all parts of the human body which we call general sensibility. The brain is wholly insensitive, and may be cut or pinched without pain. The same is true of the nails, hair, the scarf-skin or external covering of the body, and a few other structures. In these parts no nerves are found. On the other hand, the sensibility of the true skin, and of mucous membranes, as of the eye and nose, is exquisite, these organs having a large supply of sensory nerve-fibres. The bones and tendons have less of these fibres, and are only moderately sensitive.

6. The sensibility of any part of the body, then, depends upon the number of nerves present; and, as a rule, the nervous supply is proportional to the importance of the part, and to its liability to injury. When, therefore, a surgical operation is performed, the most painful part of it is the incision through the skin; the muscles, cartilage, and bone being comparatively without sensation. Hence, if we could benumb the surface, certain of the lesser operations might be undergone without great inconvenience. This is, in fact, very successfully accomplished by means of the cold produced by throwing a spray of ether, or of some other rapidly evaporating liquid, upon the part to be cut.

7. Tickling is a modification of general sensibility. At first, it excites a pleasurable sensation, but this soon passes into pain. It is only present in those parts where the sense of touch is feeble. But all impressions are not received from without: there are, also, certain internal sensations, as they are called, which depend upon the condition of the internal organs, such as appetite, hunger, thirst, dizziness when looking down from some lofty position, drowsiness, fatigue, and other feelings of comfort or discomfort. General sensibility, whether of the internal or external organs of the body, chiefly depends upon the sensory fibres of the spinal nerve. The face, however, is

supplied by the sensory cranial nerves. The sympathetic system has a low grade of feeling in health; but disease in the parts served by it arouses an intense degree of pain.

8. The Sensation of Pain.—What then is *pain*? Is it identical with ordinary sensibility? There seems to be some necessary connection between the two feelings, for they take place through the same channels, and they are alike intense in the same situations. But sensibility habitually contributes to our sources of pleasure, the very opposite of pain; hence, these feelings cannot be identical.

9. Pain must, therefore, be a modification of the general sensibility which follows an excessive degree of excitement of the nerves; there being a natural limit to the amount of stimulation which they will sustain. So long as this limit is observed, the part excited may be said to be simply sensitive; but when it is exceeded, the impression becomes painful. This difference between sensibility and pain is well shown by the effects of sunlight upon the eye. The indirect illumination of the sun arouses only the former feeling, and is indispensable to our comfort and existence; while the direct ray received into the eye occasions great pain.

10. The Uses of Pain.—The dread of pain is a valuable monitor to the body. It puts us on our guard in the presence of danger; teaches moderation in the use of our powers; indicates the approach of disease; and calls attention to it when present. The word disease, in fact, according to its original use, had reference simply to the pain, or want of ease, which commonly attends disordered health. When we observe the serious mishaps which occur when sensibility and pain are absent, we cannot fail to appreciate its value. For example, a paralytic in taking a foot-bath, forgets to test its temperature, and putting his limbs into water while it is too hot, is severely scalded without knowing it.

11. Pain is, indeed, a present evil, but its relations with the future prove its mission merciful. Considered in the light of

results, pain has a use above that of pleasure; for while the immoderate pursuit of the latter leads to harm, the tendency of pain is to restrict the hurtful courses of life, and in this manner to protect the body.

12. As to painful sensation among the inferior animals, the plan of Nature seems to be, that the higher the intelligence of the creature, and the more complete its power of defence, the more acute is its sensibility. We infer, therefore, that animals low in the scale of existence, and helpless, are not very liable to suffer pain.

13. **Special Sensation.**—The sensations of simple contact and pain are felt by nearly all parts of the system, whether external or internal, and are the necessary consequence of the general sensibility. Besides these feelings, man is endowed with certain special sensations, which are positive and distinct in character, and which he can call into exercise at will, and employ in the pursuit of knowledge.

14. These distinct and active faculties are termed the special senses, and are five in number, viz., Touch, Taste, Smell, Sight, and Hearing. For the exercise of these senses, special organs are furnished, such as the hand, the tongue, the nose, the eye, and the ear. The manner in which the nerves of special sense terminate varies in the case of each organ, so that each is adapted to one set of sensations alone, and is incapable of perceiving any other. Thus the nerve of hearing is excited by the waves of sound, and not by those of light, while the reverse is true of the nerve of sight.

15. By some writers six senses are accorded to man; the additional one being either the sense of temperature, for as we shall presently see this is not the same as touch; or, according to others, the muscular sense by which we are enabled to estimate the weights of bodies. The latter also differs in some respects from the sense of touch.

16. **Organs of Touch.**—The sense of touch is possessed by nearly all portions of the general surface of the body, but it

finds its highest development in the hands. The human hand is properly regarded as the model organ of touch. The minute structure of the skin fits it admirably for this form of sensation: the cuticle, or scarf-skin, is fine and flexible, while the cutis, or true skin, contains multitudes of nerve-filaments, arranged in rows of *papillæ*, or cone-like projections, about one-hundredth of an inch in length. It is estimated that there are 20,000 of these papillæ in a square inch of the palmar surface of the hand. Now, although the nerves of the cutis are the instruments by which impressions are received and transmitted to the brain, yet the cuticle is essential to the sensation of touch. This is shown by the fact that whenever the true skin is laid bare, as by a burn or blister, the only feeling it experiences from contact is one of pain, not that of touch.

17. The office of the cuticle is thus made evident: it is to shield the nerve filaments from direct contact with external objects. At the tips of the fingers, where touch is most delicate, the skin rests upon a cushion of elastic material, and receives firmness and permanence of shape by means of the nail placed upon the less sensitive side. Besides these favorable conditions, the form of the arm is such, and its motions are so easy and varied, that we are able to apply the test of touch in a great number of directions. The slender, tapering fingers, with their pliant joints, together with the thumb, enable the hand to grasp a great variety of objects; so that great as are the delicacy and grace of the hand, it is not wanting in the elements of power.

18. **The Sense of Touch.**—Touch is the simplest of the senses. It is that which the child first calls into exercise, and it is that which is in the most constant use throughout life. We are brought by the touch into the most intimate relations with external objects, and by it we learn the greater number, if not the most important, of the properties of these objects; such as size, figure, solidity, motion, and smoothness or roughness of surface.

19. The sense of touch assists the other senses, especially that of sight, giving foundation and reality to their perceptions. Without it, the impressions received by the eye would be as vague and unreal as the figures that float through our dreams. A boy who had been blind from birth, at the age of twelve years received sight by means of a surgical operation: at first, he was unable to distinguish between a globe and a circular card, of the same color, before he had touched them. After that, he at once recognized the difference in their form. He knew the peculiarities of a dog and a cat by feeling, but not by sight, until one day, happening to take up the cat, he recognized the connection of the two sorts of impressions, those of touch and sight; and then, putting the cat down, he said: "So puss, I shall know you next time."

20. Of all the senses, touch is considered the least liable to error; yet, if that part of the skin by which the sense is exercised is removed from its customary position, a false impression may be created in the mind. This is well illustrated by an experiment, which dates from the time of Aristotle. If we cross

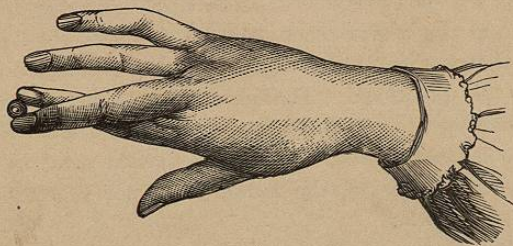


FIG. 34

the middle finger behind the fore-finger, and then roll a marble, or some small object, upon the tips of the fingers (see Fig. 34), the impression will be that two marbles are felt. If the fingers, thus transposed, be applied to the end of the tongue, two tongues will be felt.

21. **The Delicacy of Touch.**—Although the hand is the

proper organ of this sense, yet it is exercised by various parts of the body, their degree of sensibility being proportional to the number of papillæ they contain. The varying degrees of tactile delicacy of the different parts of the surface have been measured, in an ingenious manner, by means of a pair of compasses, tipped with small pieces of cork. The two points of the compasses are touched at the same moment to the skin, the eyes being closed, and it is found that, in sensitive parts, the distance between the points may be quite slight, and yet each be plainly felt; while, in less sensitive parts, the points of the compasses are felt as a single point, although they are separated one or two inches.

22. At the tips of the fingers, the distance between the points being one-twentieth of an inch, a double impression is felt. The distance must be twice as great, for the palm; four times as great, for the lips; and, on the forehead, it must be twenty times greater. At the middle of the back, where the touch is least acute, the points must be separated more than two inches before they can be separately felt. Therefore, the sense of touch in the fingers is said to be fifty times more delicate than upon the posterior surface of the body.

23. Exquisite delicacy of touch is attained by practice. This is shown in many of the lighter and more graceful employments of daily life. Without it, the skill of the painter, sculptor, and musician would be rude indeed. By training, also, the physician acquires the *tactus eruditus*, or discriminating touch; but among the blind, delicacy of touch is most remarkable, and it here finds its highest value; for its possession, in a measure, compensates the loss of sight by enabling them to read, by means of raised letters, to work with certain tools, and even to play upon musical instruments. A person born without sight, and without hearing or voice, may, by the education of the touch, be rescued from apparent imbecility, and be taught not only to read and write, but even to perform household and other useful labors.

24. Sensations of Temperature and Weight.—Each of these sensations has been described by the physiologists as a special sense, and they are rival candidates, so to speak, for the position and title of the sixth sense. In the sensation of temperature, or the thermal sense, touch bears a part, but the two feelings appear to be distinct. In proof of this, we observe, firstly, that they are not alike intense in the same situations; as, for example, the skin of the face and elbow, where the sense of touch is feeble, is very sensitive to impressions of heat and cold. Secondly, the ability to recognize temperature may be lost by paralysis, while the sensibility of touch remains unaffected. When the skin comes in contact with a very hot substance, the sensation felt is that of pain, not of touch. In like manner, a very cold substance causes pain, not the feeling of cold. So that a red-hot iron, and solid carbonic acid (the temperature of which is 108° below zero), feel alike; and each, if pressed slightly, will produce a blister.

25. The muscular sense, by some considered distinct from touch, gives rise to the sensations of weight, and other forms of external resistance. That this feeling exists, is shown by the following simple experiment. If the hand be placed flat upon a table, and a somewhat heavy weight be put into it, touch alone is exercised and a feeling of pressure results; but if the hand be raised, a certain amount of muscular effort must be put forth, and thus the sensation of weight is recognized. Through the muscular sense, precision of effort is rendered possible; for by it we learn to adjust the force exerted to the weight of the object to be lifted, moved, or carried. Without it, all our movements would necessarily become ill-regulated and spasmodic.

26. The Organ of Taste.—The *tongue* is the special organ of the sense of taste; but the back part of the mouth also possesses this faculty. The tongue is a muscular organ, the muscles composing it being so numerous and interwoven as to give it the freedom and variety of motion which it possesses.

It can curve itself upward or downward; it can extend or contract itself; and, with its point, can sweep the cavity of the mouth, in all directions, in the search for scattered particles of food.

27. The upper surface of the tongue is peculiar, being marked by the presence of innumerable *papillæ*, some of which are of microscopic size, resembling those that abound in the fingers, and in other parts of the body that have the sense of touch. Others are much larger, and give to the tongue its roughness of feeling and appearance. Through the medium of these papillæ, the tongue receives impressions of touch and temperature, as well as taste; indeed, its extremity is fully as delicate, in respect to tactile sensations, as the tips of the fingers themselves. It can recognize the two points of the compasses when separated not more than one-twenty-fourth of an inch; the back of it is much less sensitive to touch, while at the same time it is more highly sensitive to impressions of taste.

28. Each lateral half of the tongue resembles the other in structure, and each receives the same number of nerves—three. One of these regulates motion, the other two are nerves of special sense. One of the latter supplies the front half of the tongue, and is called the *gustatory* nerve. This is a branch of the great cranial nerve, called the “fifth pair,” which ramifies in all parts of the face. The back of the tongue is endowed with the power of taste through a nerve known as the *glossopharyngeal*, because it is distributed both to the tongue and throat. This difference in the nervous supply of the tongue becomes significant, when we learn, as we shall presently, that each part of it perceives a different class of flavors.

29. The Sense of Taste.—Taste is the special sense by means of which we discover the savors, or flavoring properties of the substances, which come in contact with the tongue. Mere contact with the surface of the tongue, however, is not sufficient, but contact with the extremities of the nerves of taste within the papillæ is required. In order that the sub-

stance to be tasted may penetrate the cells covering the nerves, it must be either liquid in form, or readily soluble in the watery secretion of the mouth, the saliva. The tongue must be moist also. If the substance be insoluble, as glass or sand, or the tongue dry, the sense of taste is not awakened. In sickness, when the tongue is heavily coated, the taste is very defective, or, as is frequently expressed, "nothing tastes aright."

30. All portions of the tongue are not alike endowed with the sense of taste, that function being limited to the posterior third, and to the margin and tip of this organ. The soft palate, also, possesses the sense of taste; hence, an article that has an agreeable flavor may very properly be spoken of as palatable, as is often done. All parts of the tongue do not perceive equally well the same flavors. Thus, the front extremity and margin, which is the portion supplied by the "fifth pair" of nerves, perceives more acutely sweet and sour tastes; but the base of the tongue, supplied by the *glosso-pharyngeal* nerve, is especially sensitive to salt and bitter substances. The nerve of the front part of the tongue, as before stated, is in active sympathy with those of the face, while the relations of the other nerve are chiefly with the throat and stomach; so that when an intensely sour taste is perceived, the countenance is involuntarily distorted, and is said to wear an acid expression. On the other hand, a very bitter taste affects certain internal organs, and occasions a sensation of nausea, or sickness of the stomach.

31. Relations of Taste with other Senses.—Taste is not a simple sense. Certain other sensations, as those of touch, temperature, smell, and pain, are blended and confused with it; and certain so-called tastes are really sensations of another kind. Thus an *astringent* taste, like that of alum, is more properly an astringent feeling, and results from an impression made upon the nerves of touch, that ramify in the tongue.

32. Taste is largely dependent upon the sense of smell. A considerable number of substances, like vanilla, coffee, and gar-

lic, which appear to possess a strong and distinct flavor, have in reality a powerful odor, but only a feeble taste. When the sense of smell is interfered with by holding the nose, it becomes difficult to distinguish between substances of this class. The same effect is frequently observed when smell is blunted during an ordinary cold in the head. Sight, also, contributes to taste. With the eyes closed, food appears comparatively insipid; and a person smoking tobacco in the dark is unable to determine by the taste whether his cigar is lighted or not. Accordingly, it is not a bad plan to close the nose and shut the eyes when about to swallow some disagreeable medicine.

33. Influence of Education on the Taste.—The chief use of the sense of taste appears to be to act as a guide in the selection of proper food. Hence its organs are properly placed at the entrance of the digestive canal. As a general rule, those articles which gratify the taste are wholesome; while the opposite is true of those which impress it disagreeably. This statement is more exact in reference to the early years of life than to later years, when, by reason of mischievous habits, the sense of taste has become dulled or perverted. The desires of a child are simple; he is fully satisfied with plain and wholesome articles of diet, and must usually "learn to like" those which have a strongly marked flavor. Accordingly, it is far easier at this age to encourage the preference for plain food, and thus establish healthful habits, than later in life to uproot habits of indulgence in stimulating substances, after their ill effects begin to manifest themselves.

34. The tastes of men present the most singular diversities, partly the result of necessity and partly of habit or education. The Esquimaux like the rank smell of whale oil, which is a kind of food admirably suited to the requirements of their icy climate; and travelers who go from our climate to theirs are not slow to develop a liking for the same articles that the natives themselves enjoy. The sense of taste is rendered very

acute by education, as is shown in an especial manner by those who become professional "tasters" of tea and wine.

35. The Sense of Smell—the Nasal Cavities.—The sense of smell is located in the delicate mucous membrane which lines the interior of the nose. That prominent feature of the face, the nose, which is merely the front boundary of the true nasal organ, is composed partly of bone and partly of cartilage. The upper part of it is united with the skull by means of a few small bones; to which circumstance is due its permanence of shape. The lower portion, or tip of the nose, contains several thin pieces of cartilage, which render it flexible and better able to resist the effects of blows and pressure. Behind the nose we find quite a spacious chamber, separated from the mouth by the hard palate, forming the "roof of the mouth," and also by the soft palate (see Fig. 35); and divided into two cavities by a central partition running from before backward.

36. These nasal cavities, constituting the true beginning of the air-passages, extend from the nose backward to the upper opening of the throat, and rise as high as the junction of the nose with the forehead. The inner wall of each cavity is straight and smooth; but from the outer wall there jut into each cavity three small scroll-like bones. The structure of these bones is very light, and hence they have been called the "spongy" bones of the nose. In this manner, while the extent of surface is greatly increased by the formation of these winding passages, the cavities are rendered extremely narrow; so much so, in fact, that a moderate swelling of the mucous membrane which lines them, as from a cold, is sufficient to obstruct the passage of air through them.

37. The Nerve of Smell.—The internal surface of the nasal passages is covered by a delicate and sensitive mucous membrane. Its surface is quite extensive, following, as it does, all the inequalities produced by the curved spongy bones of the nose. The upper portion of it alone is the seat of smell, since that part alone receives branches from the "first pair" of cranial

nerves, or the olfactory nerve, which is the special nerve of smell (see Fig. 32). In Fig. 35 is shown the distribution of

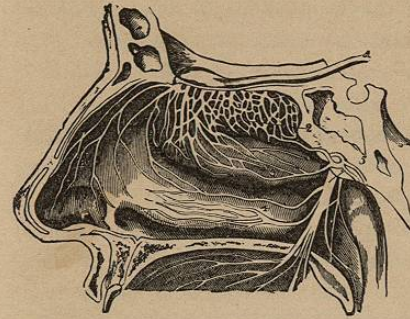


FIG. 35.—SECTION OF THE RIGHT NASAL CAVITY.

this bone by means of numerous small openings. The engraving represents the outer surface of the right nasal cavity; the three wave-like inequalities, upon which the nervous network is spread out, are due to the spongy bones. The left cavity is supplied in the same manner.

38. The nerves which ramify over the lower part of the membrane, and which endow it with sensibility to touch and pain, are branches of the "fifth pair" of nerves. An irritation applied to the parts where this nerve is distributed occasions sneezing, that is, a spasmodic contraction of the diaphragm; the object of which is the expulsion of the irritating cause. The manner in which the olfactory nerve-fibres terminate is peculiar. Unlike the extremities of other nerves, which are covered in by a greater or less thickness of tissue, these come directly to the surface of the mucous membrane, and thus come into very close contact with the odorous particles that are carried along by the respired air.

39. The Uses of the Sense of Smell.—Smell is the special sense which enables us to appreciate odors. Touch, as we have seen, is largely concerned with solid bodies; and taste, with fluids, or with solids in solution. Smell, on the other hand, is