THE PRIMARY FUNCTION OF THE NOSE

Sir Victor Negus M.D.

Introduction

As with other organs, interpretation of the function of the nose has become confused because secondary functions have been added to that for which the organ was originally designed. It is of interest to consider the subject from the aspect of comparative anatomy and physiology, and thereby to arrive at conclusions based on the study, not only of man, but of the whole of the animal kingdom.

It may be that it will be found that the primary function of olfaction has been superseeded by that of respiration; and in fact it was my habit, until recent years, to teach students that conditioning of inspired air was now the most important duty of the nose.

In this respect it is interesting to compare the case of the larynx, so often referred to as the organ of voice, but on the evidence of comparative studies found to be an organ whose purpose is protection of the pulmonary airway and so designed and modified in respect of the habits of the various species as to be well adapted for sound production, although not originally evolved for this purpose.

In writing about the functions of the nose I have, in various communications, attempted to arrive at a solution of the problem, but it will be useful to condense the conclusions reached and to present them in the form of a summary.

Uses of Olfaction

The necessity of finding and sampling food bij purpose and not by chance has led to the evolution of the sense of smell, which includes the recognition of odours and flavours of food at a distance, unlike the sense of taste, which works only by contact.

This attribute can be seen in a very primitive form in amoeba, which by a sense serving the purposes of smell, discovers particles of food in its neighbourhood and, by purposive movements of pseudopodia, is able to engulf them.

There is no specialised organ in this protozoon, but one appears in fish, in the form of an olfactory recess on the snout. Fish are the best examples of this evolutionary progress because in the majority the recess serves the sense of smell alone and has no other function such as respiration, since there is no communication, in most fish, between the recess and the pharynx. Various

modifications are found to ensure the passage of sufficient water over the olfactory organ, but they are all designed for olfactory purposes and not for respiration.

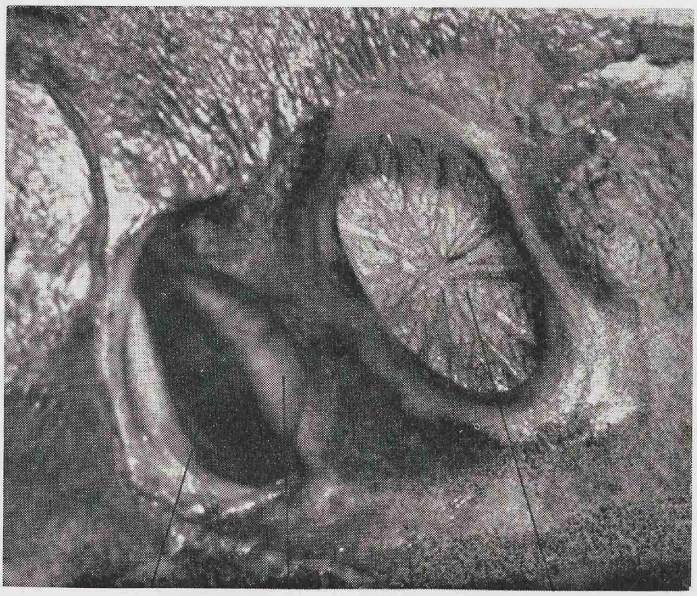

Fig. 1. **Olfactory Recess of a Pike (Esox lucius)**
Water is diverted by the flap on the olfactory epithelium in the lamellae of the recess.

Sharks are a good example of such an organ, there being a rosette made up of a number of lamellae carrying on them areas of olfactory mucosa and connected through an olfactory bulb and tract with the forebrain. A more highly developed form of olfactory organ is found in mammals, with its highest development in carnivores such as leopards, where the area of specialized mucosa and the number of receptors is very great.

Conveyance of Olfactory Molecules

It is essential in species which breathe air to have some means of carrying in a current of air by means of which olfactory molecules are conveyed to the specialised receptors; this arrangement is seen in its most simple form in Dipnoi or Lung Fish, which at times of drought survive in a mud case and carry on respiration with a simple respiratory apparatus. In a similar way the mammal carries a current of air through the nose by respiratory movements. It is essential that the odour should impinge on the specialised receptors in sufficient volume and with adequate velocity; the molecules must go into solution before they can be perceived.

Area of Olfactory Mucosa

In fish the actual area for the reception of olfactory stimuli is small, since the greater part of the lamellae in the recess is covered with glandular epithelium containing goblet cells. In a Newt, however, as an example of tailed amphibia, there is a nasal fossa communicating with the pharynx, lined with mucosa, olfactory in greater part, the remainder being ciliated.

Toads of tailless amphibia or Anura have a similar fossa, but the area is slightly increased by the presence of a projection from the floor covered with olfactory epithelium; this is the precursor of the convoluted turbinals of mammals and it is seen in a more elaborate form and with greater area in the slow worm (Anguis fragilis). Reptiles have poorly formed turbinal projections and so have birds, whose sense of smell is feeble.

Mammals have a greater area of olfactory mucosa, with a consequent increase in the number of receptors and an improved sense of smell, including perception of flavours, of use in finding and distinguishing between food materials and also for locating prey or avoiding enemies.

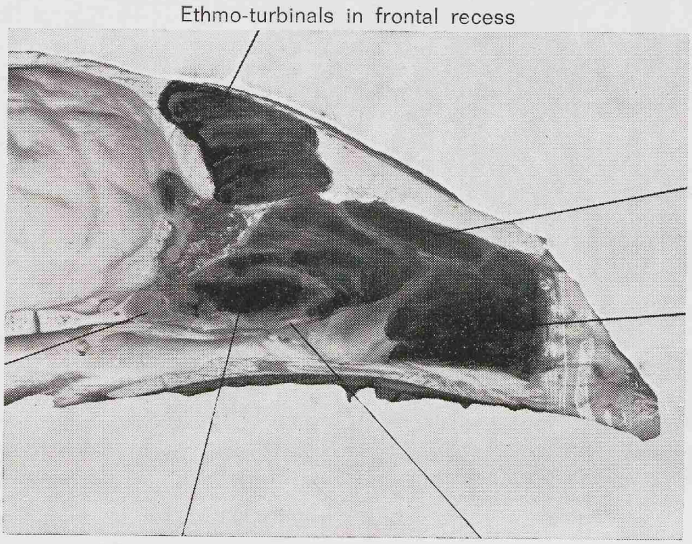

Fig. 2. **Common Badger. (Meles taxus)**
The enormous area of the ethmo-turbinal bodies is well seen.

Herbivora such as Ungulates have elaborate turbinals, convoluted and arranged in more than one row as endo and ectoturbinals; it is in carnivora, however, that the greatest area of olfactory mucosa membrane is present, with the object of locating animals on which they prey before the victim, with its smaller area, is warned of the approach of its enemy and is enabled to escape. Since the nasal fossae are limited by the size of the snout, and since the turbinals fill all the available space in Ungulates, for example, it has been necessary for the carnivore to evolve extensions outside the limits of the fossae; this it does by the formation of an upper storey enclosed by boney

walls and constituting frontal sinuses, not merely as excavations of the frontal and nasal bones, but as newly designed and superimposed cavities. There is also backward extension of olfactory turbinals into the sphenoid region, with the production of a sphenoid recess or sinus; the total area of sensitive mucosa is greatly enlarged by these two adaptations.

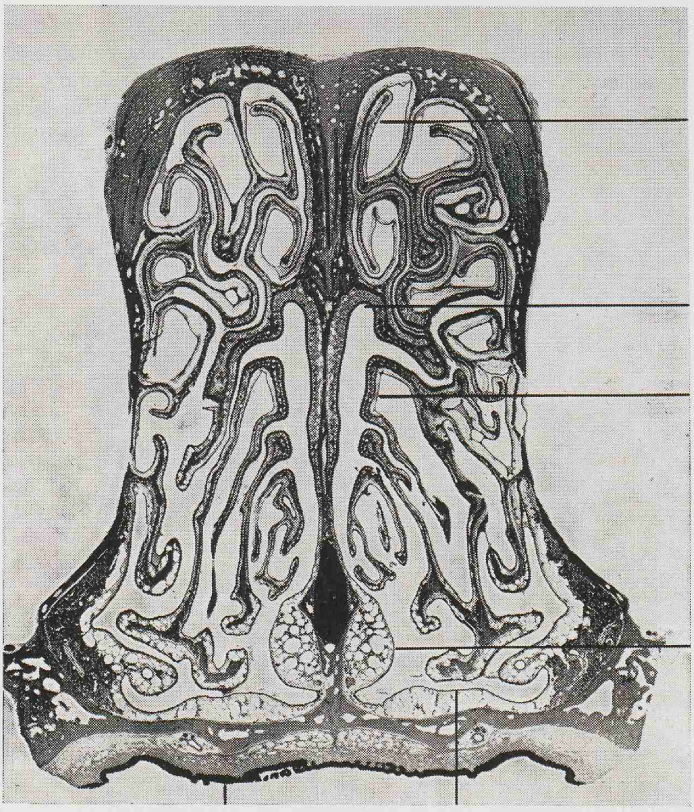

Fig. 3. **Transverse Section of the Snout of a Cat (Felis domestica)**
Upward extension of olfactory ethmo-turbinal bodies into the frontal sinuses is illustrated.

Recession of Olfactory Area

When the sense of smell diminishes in importance as a result of an arbored habitat, where scent does not lie and where vision assumes greater importance, the olfactory area diminishes. Various stages can be seen in Primates, the greatest relative area being present in the Tupaia, the tree shrew, gradually becoming less in Lemurs and Galagos and in old and new World monkeys; it is less still in Baboons and Gibbons and least of all in Chimpanzees, Gorillas, Man and Orang, in this order.
The intimate relation of structure to function is well illustrated in a series

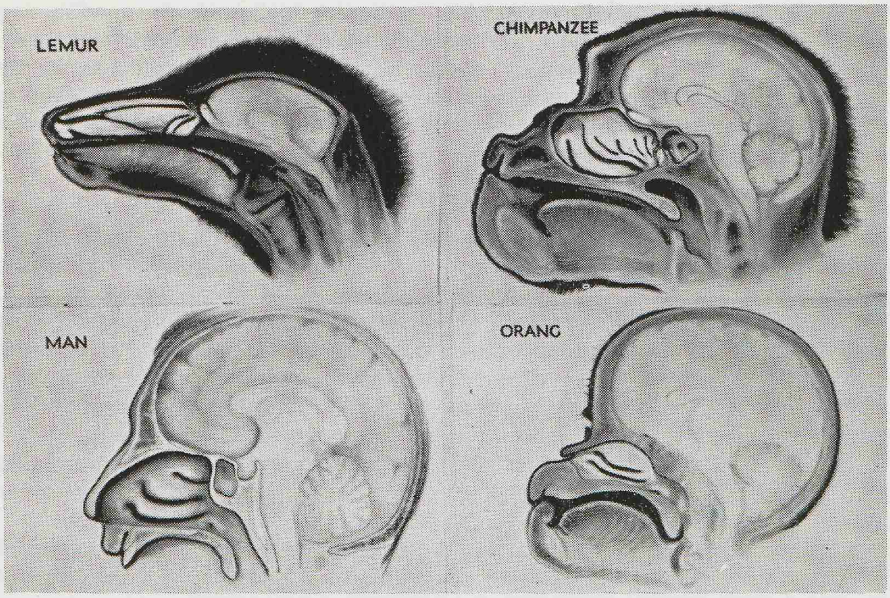

Fig. 4. **Olfactory Areas in Primates**
In lemur the ethmo-turbinals are extensive, but in higher primates there is marked regression. Chimpagnee (Anthropopithecus troglodytes) has a single ethmo-turbinal plate with furrows indicating fused endo-turbinals.
In Man (Homo) and Orang (Simia satyrus) the olfactory area is extremely limited.

commencing with fish and progressing through amphibia, reptiles, herbovorous and carnivorous mammals, with a diminution in primates from tree shrews to the higher apes and Man.

This naturally points to the use of the nose as an organ to serve the sense of smell and taste, with variation in the olfactory area in direct relation to the necessities of the species; it is desirable now to see whether other functions have been taken on by the nose in addition to or in place of that of olfaction.

The Aair Conditioning Mechanism of the Nose

Air reaching the ultimate recesses of the respiratory tract, that is the air sacs and alveoli, must be saturated with moisture if exchanges of oxygen and carbon dioxide are to be carried on efficiently by diffusion. Moisture is derived from the internal atmosphere, from the nose by secretion of serous glands and by transudation and also from the respiratory passages, which are provided with glandular tissue and with powers of providing moisture by transudation.

In the case of higher apes and Man, where the olfactory area has diminished to a size comparable to that of reptiles, the air conditioning area is very small. The olfactory mucosa covers only a small part of the ethmo turbinal and septum; the remainder can give up serous secretion and transudate, and also mucus. But the total area of the flattened and narrow turbinals, which form one

row only, is very small in comparison with the elaborate air conditioning mechanism of most mammals. This restricted air conditioning area is sufficient for the respiratory needs of apes and man and consequently, it can be assumed that for the purposes of respiration, a very restricted air conditioning apparatus is adequate; consequently some other purpose must account for the expended area of most mammals.

Air Conditioning in Relation to Olfaction

To return to mammals with keen powers of scent, it is found that there is elaboration of the maxillo turbinal system and that this body has a permeable mucous membrane with numerous large blood sinuses in the submucosa. Partial emptying or filling of these vascular spaces leads to shrinkage or swelling of the maxillo turbinals as may be seen in an exaggerated form in the noses of cats perfused with adrenaline or histamine and compared with the normal. The degree of swelling can be very great and when accompanied by increased transudation the output of water vapour will be considerable.
It has already been noted that a small air conditioning area, as in apes and man, is sufficient for respiratory purposes and consequently some other reason for the enormous area of keen-scented mammals must be found.
The elaboration of the maxillo turbinals bears a direct relation to the area of olfactory mucosa; in rodents and ungulates these turbinals take the form of double scrolls, while most carnivora, such as members of the dog tribe and some of the cat tribe have a branching turbinal body, the total area of which is very great.

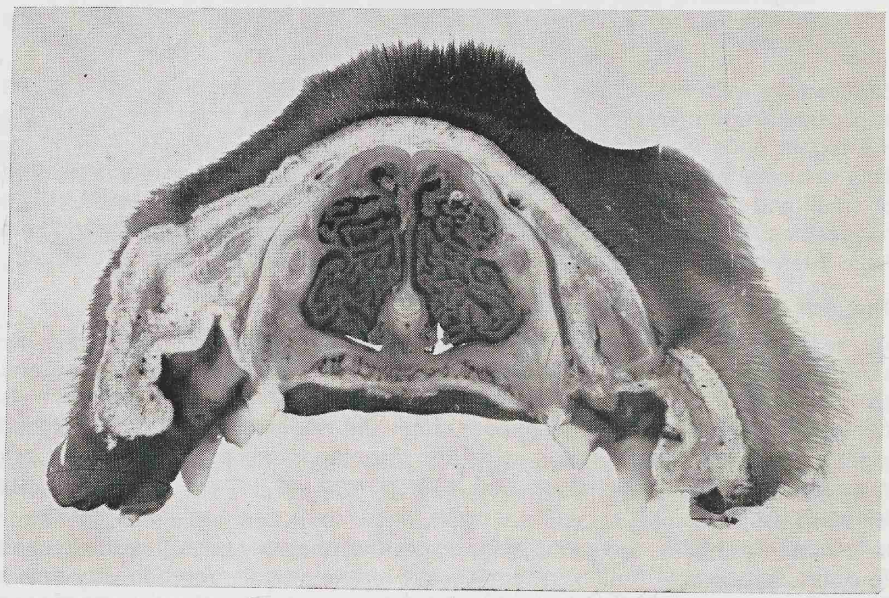

Fig. 5. **Transverse Section of the nose of a Dog (Canis familiaris)**
The section cuts across the branching maxillo-turbinal body and illustrates its extensive area and the manner in which it fills the snout.

This direct relationship of the air conditioning and olfactory areas indicates a functional relationship, it being essential that for the entrapping of olfactory molecules an efficient supply of water vapour at the front of the nose is essential. Saturation of the incoming current of air entraps olfactory molecules and a process of absorption to water vapour molecules enables the odorous material to be retained in the nose and deposited on the olfactory receptors.

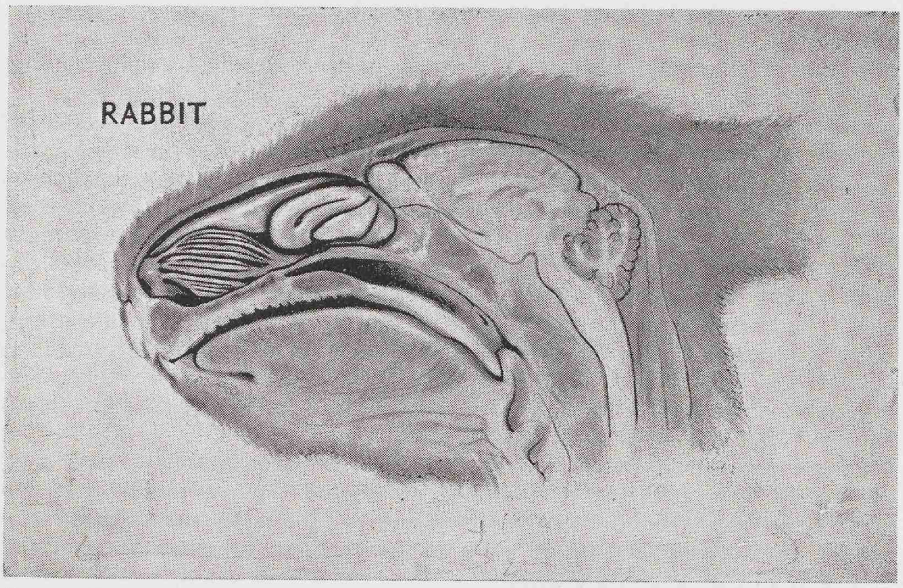

Fig. 6. **Sagittal Section of the head of a Rabbit (Lepus cuniculus)**
The drawing illustrates the anterior air conditioning part of the nose, with a widely branching maxillo-turbinal body and the posterior olfactory part occupied by ethmo-turbinal bodies.

Observation of this relationship points to the principal function of the nose as being olfactory, as it was in more simple species.

Ciliary Action

Although it does not detract from the truth of these observations as the primary function of the nose, it is desirable to consider whether ciliary action, with its capability of removing dust and bacteria and of carrying lysozymes for the inactivation of organisms, has assumed an important function on the part of the nose of protecting the lower respiratory passages. The importance of this mechanism cannot be denied but it must not be over exaggerated.
The lower passages have their own ciliary lining and supply of mucus necessary for removal of the many bacteria that pass through the nose in the inspiratory air stream; when breathing is carried on through the mouth the nose is ineffective. In atrophic rhinitis, when cilia are absent from the nose, it is possible for the trachea and bronchi and the air sacs and alveoli to remain healthy, even though they are more vulnerable to infection.

Some animals have no cilia in the nasal fossa and some birds, such as gannets, do not breathe through the nose.

Shape of the Nose

The nasal fossae are elongated or shortened in accordance with the length of the snout, in order that the nostrils shall open close to the mouth. This is well seen in enteaters, where the long snout, with nostrils at its tip, is thrust into an ants nest, intended food being recognised by smell.

Most ungulates, for example deer and antelopes, horses and oxen, have long snouts to enable them to reach food on the ground, while carnivora such as wolves and dogs are similarly provided to reach out to seize their prey.

Animals with the ability to seize food in their paws and to bring it to the mouth usually have shortened snouts, as in the cat tribe and in most primates.

The anterior elongation of the nasal fossae, as in dogs, has the function of carrying air to the air conditioning and olfactory areas, which are situated further back in the nose, so that a long snout does not necessarily indicate a more elaborate turbinal system and a superior sense of smell.

In a primate such as orang, with nostrils at the base of its snout, the latter is long in comparison with that of man; in the latter, recession of the snout, with decrease in the palatal and buccal areas, has left the nose projecting beyond the face, but still with nostrils closely related to the mouth. The European, with his diminished palatal area shows this projection more markedly than the Negro with his prognatous jaw.

The nose is elongated for other purposes, as for grasping objects in elephants, but neither this modification nor those of lengthening or shortening of the snout already referred to alter the conclusion that the nose was originally and still is an olfactory organ, with the added function of assisting with the efficiency of the respiratory tract.

Sir Victor Negus M.D.
Hill Farm. Haslemere (Surrey),
England