Reports

Natural Selection and the Origin and Evolution of Weeping in Man

Abstract. Tearless crying in the young of early man, with an increased dependency period, would repeatedly have caused dehydration of the mucous membranes, and thus have rendered them vulnerable to the insults of the environment. Tears are bacteriostatic as well as moistening. The hypothesis is advanced that natural selection favored those infants who could produce tears, and that in this way the function became established in man.

It is a curious thing that man is the only creature who weeps—the only creature who sheds tears when he is emotionally distressed. The shedding of tears as an accompaniment of emotional distress has been attributed to other animals, but the fact is that psychic weeping is not known to occur in any animal other than man.

Darwin gave the subject of weeping much thought in his *Expression of the Emotions* (*1*). He suggested that crying in the infant inevitably leads to engorgement of the blood vessels of the eye, and to a concomitant contraction of the muscles around the eyes in order to protect them. "At the same time the spasmodic pressure on the surface of the eye, and the distension of the vessels within the eye, without necessarily entailing any conscious sensation, will have affected, through reflex action, the lacrymal glands. Finally . . . it has come to pass that suffering readily causes the secretion of tears, without being necessarily accompanied by any other action."

As far as it goes this is sound enough, but it does not go far enough. Darwin nowhere ventures a suggestion as to how it has come about that man is the only animal that weeps. The conditions to which Darwin attributes the cause of weeping might have occurred in any number of other species possessing the necessary lacrimal and orbicular muscles. How, then, has it come about that weeping occurs in man alone? Does weeping have any adaptively valuable function in addition to protecting the engorged eye?

As is well known, human infants do not usually cry with tears until they are about 6 weeks of age. Weeping, then, would appear to be both phylogenetically and ontogenetically a late development in the human species. If, as seems probable, weeping was a trait acquired not *with*, but some time *after*, the assumption of hominid status, we have to ask ourselves what factor or combination of factors it was in the development of early man that may have been responsible for the appearance of weeping?

The length of the dependency period of the human child immediately suggests itself. During the earlier part of his dependency period the human infant is without speech or the ability to help himself. His principal means of attracting the attention of others when he is in distress is by crying. Even a fairly short session of tearless crying in a young infant has a drying effect upon the mucous membranes of its nasopharynx. Excessive intake and expulsion of air even in adults will quickly dry mucous membranes, and it is this intake and expulsion of air in the tearless crying infant that may be envisaged as closely associated with the origin and development of weeping. At this point we must briefly discuss the character of the nasal mucosa.

The mucous membrane of the nose lines the nasal passages and covers the scroll-like turbinates. At the entrance to the nasal passages the mucous membrane consists of thick stratified squamous epithelium; except for this small area the whole of the nasal passages is lined with pseudostratified columnar epithelium with many ciliated and goblet cells, except in the olfactory area. There are no ciliated cells in the lower part of the pharynx. The trachea, bronchi, larger bronchioles, and in part the smaller bronchioles, but not the pulmonary alveoli, are lined with ciliated cells.

The tunica propria binds the epithelium to the bony walls and affords space for blood and nerve supply, and for lymphatic drainage. In the tunica propria lie the small tubuloalveolar glands which produce a watery fluid and mucus, the latter containing the important bacteriolytic enzyme lysozyme. These glands are usually classified as serous, mucous, or mixed. The secretions of these glands and of the goblet cells of the tunica mucosa together form a protective investment of the air passages down to the ends of the bronchi. By virtue of the underlying ciliary action the secretions of these glands move in the mucous matrix as a continuous blanket toward the nasopharynx, pharynx, and hypopharynx, where they are swallowed.

It is the mucous membrane of the nose that constitutes the most immediate contact of the respiratory system with the external world. No living cells are so directly exposed to the insults and assaults of the environment. The nasal mucous membrane must withstand the impact of respired air laden with bacteria, dust, particles, and gases. Discharges from the eye entering by the nasolacrimal ducts trickle down over it. The air may be dry or moist, at subzero temperature or very hot, and changes in the temperature of the respired air may vary rapidly from hot to cold. The mucous membrane is adapted to meet all these contingencies.

As for the bactericidal and bacteriostatic efficiency of the mucous membrane, this is well exhibited by the observation of Arnold *et al.*, quoted by Schlaegel and Hoyt (*2*), that 90 to 95 percent of viable bacteria placed on the nasal mucous membrane are inactivated in from 5 to 10 minutes. Bacteria placed in contact with nasal secretions outside the body were much less effectively dealt with. More than 20 years ago Burnet *et al.* (*3*) observed that nasal mucus inactivates poliomyelitis virus of every type in vitro. The bacteriolytic action of the nasal secretions is principally due to the enzyme lysozyme, discovered by Alexander Fleming in 1922.

By drying with a jet of air, the mucous membrane can be inactivated within a few minutes, and death of the ciliated cells can thus be produced. When, for any reason, drying is produced in the mucous membrane, the cilia tend to lose their function and

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Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

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soon die. This is followed by a piling up and drying of mucus, and permeability of the mucous membrane. In this state the gelatinous mass of mucus constitutes a most hospitable culture medium for bacteria, which may then in large numbers easily pass through the permeable nasal mucosa. The consequences of this are not infrequently lethal.

The hypothesis proposed here is that, in man, weeping established itself as an adaptive trait of considerable value in that it served to counteract the effects of more or less prolonged tearless crying upon the nasal mucosa of the infant. Infants who cried for prolonged periods of time during the early years of their lives without benefit of tears would stand less chance of surviving than those who cried with tears. Dry crying is dangerous because it renders the organism vulnerable to the invasions of harmful bacteria, and probably viruses, through a dried-out mucous membrane the autosterilizing functions of which have been reduced. Crying with tears, on the other hand, serves to keep the mucous membrane wet and to assist in maintaining as well as reinforcing its functions. Alexander Fleming showed (*4*) that tears contain, among other things, an enzyme elaborated by the lacrimal glands in high concentration—namely, lysozyme, which we have already seen is also secreted by the mucous glands of the nasal mucosa. Lysozyme is highly bactericidal. Caselli and Schumacher (*5*) demonstrated antagonism between lysozyme and electronegative viruses, and Orzalesi and Ciuffo (*6*) obtained very satisfactory results in the treatment of herpetic keratitis and inactivation of the virus with lysozyme. More recently, Ferrari *et al.* (*7*) found that lysozyme inactivates the viruses of many infections such as herpes simplex and herpes zoster, warts, vaccinia, and the like, and reported success in the treatment of diseases produced by these infections with lysozyme. Lysozyme, then, seems to hold some promise, as Fleming had originally expected, in the treatment of virus diseases, and the function of lysozyme in the human organism strongly indicates one of the functions of weeping, especially in the infant and child—namely, as a physiologically protective device against the depredations of potentially noxious organisms. In addition, it should be mentioned that tears contain sugar and protein which are nutritious both to the eye and to the paranasal and nasal mucous membranes. Weeping, furthermore, activates the mucosa, increasing the blood supply and causing the mucosal glands to secrete additional lysozyme.

It is suggested, then, that weeping originated as an adaptively valuable trait in a species in which the crying of the young is extended over a much longer period of time than in any other species, as a protective adjustment against damage to the nasal mucous membrane of the young, and the consequent reduction in fitness; that early in the development of man those individuals were naturally selected in the struggle for existence who were able to produce an abundant flow of tears as they cried, as a preventative of mucosal dehydration, while those who were not able to do so would be likely to succumb more frequently at all ages, and leave the perpetuation of the species increasingly to those who could weep.

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References and Notes

1. C. Darwin, *The Expression of the Emotions in Man and Animals* (London, 1872), p. 126.
2. T. F. Schlaegel and M. Hoyt, *Psychosomatic Ophthalmology* (Baltimore, 1957).
3. F. M. Burnet, D. Lush, A. V. Jackson, *Brit. J. Exptl. Pathol.* **20**, 377 (1939).
4. A. Fleming, *Proc. Roy. Soc.* (*London*) **B93**, 306 (1922); *Lancet* **1**, 217 (1929).
5. P. Caselli and H. Schumacher, *Z. ges. exptl. Med.* **26**, 417 (1955).
6. F. Orzalesi and P. Ciuffo, *Rass. med. sarda* **54**, 344 (1953).
7. R. Ferrari, C. Callero, G. Podio, *Nature* **183**, 548 (1959).
8. This report is adapted from a paper presented at the University Seminar in Genetics and the Evolution of Man, Columbia University, December 1958.

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Parietal Eye Nerve in the Fence Lizard

Abstract. A nerve from the parietal eye of the western fence lizard, *Sceloporus occidentalis*, is described as leaving inconspicuously from the third-eye and extending caudally under the dura mater and then ventrally along the left anterolateral surface of the epiphysis to the habenular commissure of the brain. The existence of a parietal nerve must be considered in interpreting the effects of parietalectomy.

A parietal or parapineal nerve from the third-eye of the western fence lizard, *Sceloporus occidentalis*, was not noted in a brief anatomical study preliminary to our investigation of the effects of its removal (parietalectomy) upon behavior (*1*). Unlike the parietal nerve of *Sphenodon* (*2*), *Lacerta* (*3*), and *Chalcides* (*4*), that of *Sceloporus* has an inconspicuous route. In a recent and more thorough study of the "eye" of this form, by means that included electron microscopy (*5*), a parietal nerve was traced in serial sections stained either with hematoxylin and eosin or by Pearse's trichrome-PAS technique. The fine nonmedullated fibers which compose the nerve appear to assemble behind the retina, in a manner not yet determined, course medially and posterodorsally *within* the connective tissue capsule of the "eye," and emerge from its margin where it is attached to the dura mater and integument. Thus, the ventral aspect of the "eye" presents no evidence of the nerve, grossly or microscopically. The parietal nerve extends caudally in intimate association with the anterior pineal artery (*2*, *6*) on the under surface of the dura mater, which is closely applied to the skin in the region of the "eye." Observed in cross section, the diameter of the nerve is seen to be about one-half that of the arterial lumen. At the tip of the epiphysis, or pineal sac, the two structures part company, the artery to the right, the nerve to the left. Both may be traced ventrally between the anterior face of the epiphysis and the posterior wall of the dorsal sac. In sagittal-parasagittal series the nerve is easily followed for a short distance below the tip of the dorsal sac. Ventral to this level the fibers of the nerve seem to spread out, and they are traced farther with difficulty. A few transverse and frontal series provide evidence, however, that the fibers proceed to the base of the epiphysis and enter the habenular commissure.

This description agrees with that of Dendy (*2*) for *Sphenodon*, but not with that of Nowikoff (*3*) for *Lacerta* and *Anguis*, in which the parietal nerve is stated to course to the right of the mid-line. On the other hand, we trace the unpaired anterior pineal artery to the right side of the epiphysis, whereas Dendy (*2*) finds it on the left side of *Sphenodon*, as does Steyn (*6*) in *Cordylus* and *Mabuya*. Finally it should be noted that several workers, including most recently Steyn (*7*), have concluded that a parietal nerve is absent in adult lizards.

In connection with a comparative study of the pineal complex in various reptiles, we have identified the parietal nerve in the following: *Callisaurus draconoides*, *Crotaphytus collaris*, *Draco volans*, *Phrynosoma coronatum*, *P. douglassi*, *Sauromalus obesus*, *Uma inornata*, and *Xantusia vigilis*. The nerve in these forms varies somewhat in size, point of departure from the third-eye, and path to the habenular region of the diencephalon. We have not examined an adequate number of specimens to determine right-left relationships. In the zebra-tailed lizard (*Callisaurus draconoides*) and in the chuckwalla (*Sauromalus obesus*) (two specimens and one, respectively), a small