

THE MEIBOMIAN GLANDS*†
AN INVESTIGATION INTO THE SECRETION AND SOME ASPECTS
OF THE PHYSIOLOGY

BY

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VERY little information appears in the literature on the composition of the Meibomian gland secretion or the mechanism whereby it is distributed to the lid margin. The most recent work on ocular biochemistry (Pirie and van Heyningen, 1956) makes no mention of the subject, and the majority of text-books dismiss it with the statement that the secretion is of a sebaceous nature. Duke-Elder (1938), quoting Pes (1897), says that the secretion is rich in fats, fatty acids, and cholesterol. Schiefferdecker (1906) described the glands as being filled with glandular epithelium, the peripheral cells being fat-free and the polygonal central cells being loaded with fat. This is shown in Fig. 1 (opposite), which is a section from a gland obtained *post mortem* from an adult human and stained with Sudan 3.

Buschke and Fränkel (1905) investigated the physiology of the glandular action and found that in laboratory animals the secretion was increased by section of the cervical sympathetic. The glands could also be forcibly emptied by subcutaneous injection of physostigmine.

We have been unable to find reference to more modern work and the standard text-books make little mention of the question. We therefore considered that the question of the composition of the secretion should be restudied and the means of its controlled excretion in man reconsidered.

Investigations

Material.—Clinic patients, nursing and hospital staff, in-patients and school children, all free of any gland or lid disease, were used as donors.

The collection of sufficient secretion proved to be extremely difficult. It was first thought it could be collected in micro-pipettes inserted into the orifices of the glands, but this was defeated by its melting point. It solidified in the mouths of the pipettes, which could not be kept warm enough for it to run up by capillarity. Hence, it was collected (after excluding lid or gland disease) by expression with a glass rod, and was collected, as it solidified, with a Meibomian cyst curette. From 539 persons 200 mg. secretion was obtained.

Chemical investigation was carried out on the material and at the same time clinical observations were made on the mechanisms of expression by the lid muscles.

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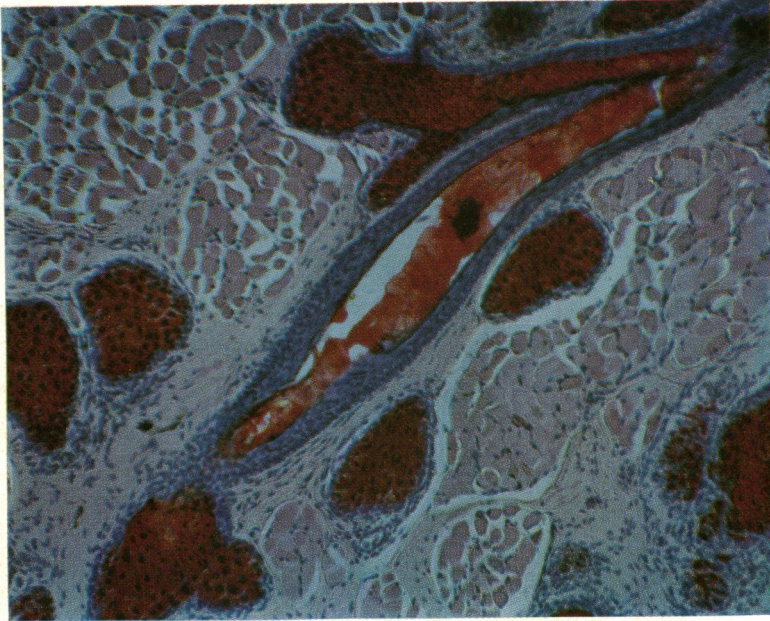


FIG. 1.—Section of a normal adult Meibomian gland, demonstrating lipid secretion in the duct. Sudan 3.

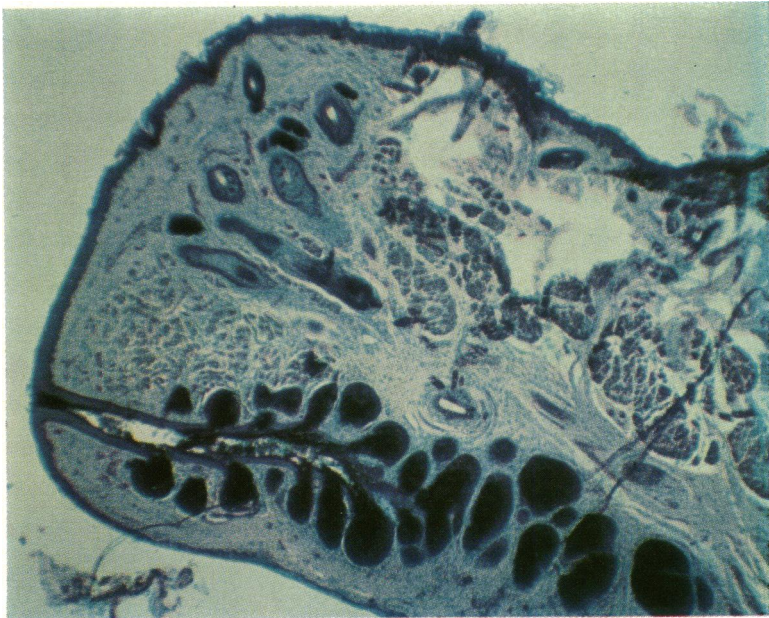


FIG. 3.—Section of normal neonatal Meibomian gland, showing lipid in cells and in duct. Sudan black.

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Chemical Studies

Melting Points.—The crude material melted slowly from 35–40°C., leaving some cell debris. A visual estimate indicated that about 80 per cent. of the material melts.

Ether Extractions.—The pooled collected fluid was extracted with ether, leaving only cell debris, and yielded on evaporation of the ether a light yellow, waxy solid which was microscopically amorphous. All further examinations were made on this ether-soluble material.

Elemental Analysis.—Micro-analysis gave the following results indicating less than 1 per cent. of elements other than carbon, hydrogen, and oxygen:

C 80.6 per cent. ; H 12.56 per cent. ; O 6.19 per cent.

Infra-red Analysis.—The infra-red absorption spectrum of the crude material showed absorption bands at 1,736 cm^{-1} corresponding to a carbonyl group, and at 3,000 cm^{-1} corresponding to a not fully substituted double bond.

Chromatography.—With the filter paper disc technique of Hack (1953), modified by Horáček and Černíková (1959), the following observations were made. Ether extract of Meibomian gland fluid (8.7 mg.) was dissolved in 1.74 ml. CHCl_3 :MeOH (4:1, v/v) to give a concentration of 5 mg./ml. 30 ml. of this solution was applied to Whatman No. 1 filter paper previously extracted with CHCl_3 :MeOH mixture. Bands were detected after elution and drying by staining with Sudan 2 (Table I).

TABLE I
BANDS DETECTED

Run	Elution Solvents	Bands
1	CHCl_3 :MeOH	One band at solvent front
2	Acetone	One band just behind solvent front and some material on start line
3	MeOH	No movement
4	(a) CHCl_3 :MeOH (b) Acetone	One band at first solvent front (Band I) One band behind second solvent front (Band II)
5	(a) CHCl_3 :MeOH (b) Acetone (c) MeOH	Same as in Run 4

Subsequent runs were eluted with chloroform-methanol followed by acetone as in Run 4, and the detection of specific lipid groups was carried out (Table II, overleaf.)

Band II, which contained the larger part of the total material, was a double band on staining with Nile blue, the slower migrating portion staining pink and the faster staining blue. It would appear that somewhat less than 50 per cent. of the total material is neutral fat, staining pink, and the remainder an unidentified lipid.

TABLE II
DETECTION OF LIPID GROUPS

Lipid Groups	Band I	Band II
Neutral Fats—(Nile blue)	—	+
Cholesterol—(acetic and sulphuric acids)	—	—
Amino Lipids—(ninhydrin)	—	—
Plasmalogens—(HgCl ₂ and 2:4-dinitrophenyl-hydrazine)	+	+
Choline Lipids—(K ₂ Cr ₂ O ₇ —diphenylcarbazine)	+	—
Free Acids—(AgNO ₃)	—	—

Discussion.—We have not been able to confirm the observation of Pes (1897) that the secretion is rich in cholesterol and fatty acids but find that neutral fats and an unidentified lipid constitute the major part of the material. Phospholipids are present, but from consideration of the micro-analysis, constitute less than 10 per cent. of the total secretion.

The Meibomian gland fluid differs from skin sebaceous gland secretion (Horáček and Černíková, 1959) in being free from cholesterol, free fatty acids, and amine lipids.

Clinical Studies

Observations on the Mechanism of Excretion.—The bundles of the muscles of Riolan, or pars marginalis muscles, are clearly seen arranged elliptically around the ducts leading to the orifice of the Meibomian gland (Figs 2 and 4, opposite). The action is not really sphincteric but limpet-like in character, as the interfascicular septa of the muscle are prolonged around the ducts to join with and become an integral part of the tarsal plate (Fig. 4). Thus on contraction the muscle is drawn towards the tarsal plate compressing the ducts and so preventing the outflow of secretion. Conversely, the contraction of the fibres comprising the pars palpebrae of the orbicularis oculi would promote the flow of secretion by a milking action (Fig. 2). Thus, these two muscles could be opponents and not necessarily physiologically part of the orbicularis oculi, although anatomically one may consider them to be so. It is not known whether, in man, the sympathetic nervous system controls the excretion as it appears to do in rabbits.

In the act of a blink, the glands are milked and a little secretion expressed. Its physical properties prevent the tears overflowing on to the lids and ensure their passage towards the lacus lacrimalis and the puncta. Between blinks, the muscle of Riolan is contracted, the orbicularis is relaxed, and the secretion moves up into the duct whose neck is closed.

Emotional disturbances which influence all glandular secretions must be considered. The baby, who usually cries frequently, puts a great demand on the Meibomian glands—their secretion is increased and they are rapidly emptied by the forceful blepharospasm seen when an infant cries—there is no chance of stagnation of the secretion with its attendant susceptibility to infection—thus, Meibomian cysts and abscesses are rare in healthy infants. The histology in

infants (Fig. 3, see col. pl.) appears identical with that in adults, except that occasionally there are a few muscle bundles on the outer side of the ducts in the adult.

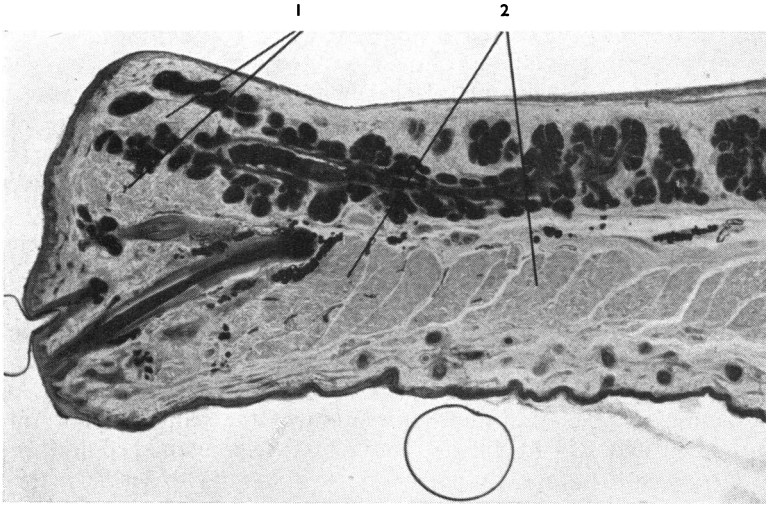


FIG. 2.—Section showing whole lid.
 (1) Bundles of muscles of Riolan around distal end of gland.
 (2) Pars palpebrae orbicularis.

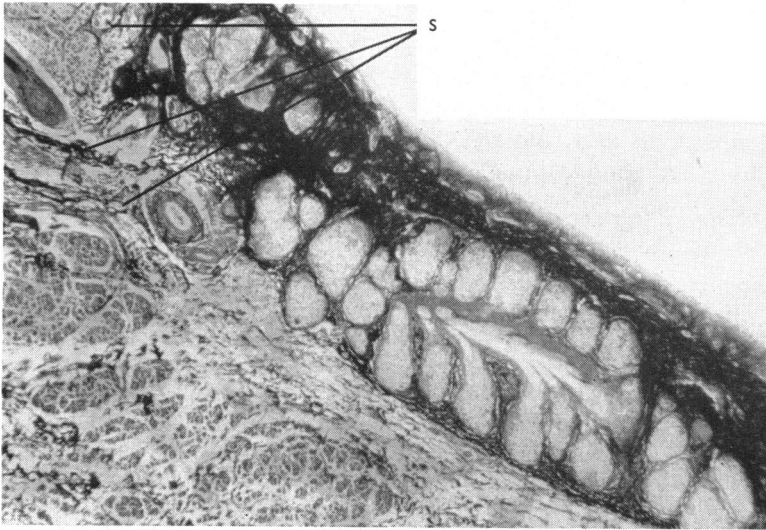


FIG. 4.—Section showing prolongations of interfascicular septa, S, to tarsal plate.

Effect of Prolonged Concentration on Excretion.—It was noticed that those doing prolonged close work blinked at a much slower rate than the average, which was once every three seconds. Three groups of nurses were examined by expression immediately after writing a 2-hour examination paper—not a sign of secretion was gathered from any group, the glands were empty and no secretion could be

obtained until they had spent 10 minutes consciously, but not forcibly, blinking. This observation may have some bearing on the discomfort experienced by some people when watching television.

Influence of the Size of the Eye on the Excretion.—The *myope*, unconsciously or consciously, improves his vision by a slow clonic semi-contraction of his lids, thus producing a stenopaic slit. It is an action involving the whole of the palpebral portion of the orbicularis—he does not blink so often, but he effectively empties the glands—there is no stagnation and Meibomian cysts, etc., are relatively rare. This slow clonic contraction is anatomically forced upon him because of the size of the globe, the lids having to travel further to achieve the slit.

Contrast this with the *hypermetrope*—the older subject beyond childhood when crying is not often encountered. He also achieves clearer vision by using the slit unconsciously, but to achieve this, because of the small eye, the lids do not have the same distance to travel and, nature always being economical in conserving energy, he does this by a tonic, as opposed to a clonic, contraction of the Riolan muscle. This tonic contraction, we believe, is pre-potent over the opposing action of relaxation and contraction of the palpebral portion of the orbicularis oculi and Riolan muscles, and thus Meibomian secretion outflow is impeded during most of the patient's waking hours. This leads to the typical appearance of the established case in which the purplish rolled lid-edge is due to the muscular spasm plus engorgement of the veins and glands and is very often accompanied by scale or flakes, the latter being usually very evident on waking in the mornings. These flakes are composed of the Meibomian secretion, which is a clear oily fluid at body temperature and a white amorphous waxy solid at one degree less. Sleep relaxes the sphincteric action on the gland ducts and as the intraglandular pressure of the secretion is thus raised, is sufficient to cause far in excess of the normal to exude onto the lids and eyelash roots during sleep. The patient on waking may find the lid margins or lashes stuck together, whilst collections of the white and quite hard substance are found at the canthi.

Discussion.—These encrustations on the lids could conceivably lead to blepharitis in three ways:

- (a) The mere mechanical presence of the fatty substance.
- (b) The irritation of the skin by breakdown products, *e.g.* fatty acids.
- (c) The establishment of bacterial infection under the scales.

We suggest that the diminished outflow during the day is the reason why Meibomian glandular infection is so commonly seen in hypermetropes, for the stagnation produced allows pathogens to gain access to the orifices of the glands.

These remarks apply mostly to the low hypermetropes, for the high ones do not seem to develop a spasm of the Riolan muscle. A common symptom is marked pruritus—this is relieved, usually for several days and sometimes for weeks, by glass rod massage and forcible closure of the lids about twenty times morning and night.

However, of the lower hypermetropes—with or without astigmatism—some are much more prone to marked crusting of the lids than others, and these do not have the morning aggregation in the canthi. In such cases we found that on closure of the lids the posterior margin of the upper lid abutted on the anterior margin of

the lower lid, thus the Meibomian secretion, on being emitted from the glands during sleep, did not flow to the canthi in the intermarginal groove, but flowed outwards by capillary action to the lashes where it solidified and formed flakes. This condition was common to several members of many families examined and is associated with the type of squamous blepharitis which is not relieved by spectacles or by curing seborrhoea. We think it should be called "hereditary palpebral mal-occlusion".

Differential Histochemistry

Specific staining techniques demonstrate that no protein or carbohydrate substances are present in the secretion, which consists solely of lipid staining material.

Summary

The physical properties of the secretion of the Meibomian gland are described.

The secretion consists of lipid material, including neutral fats, an unidentified lipid, and some phospholipid. Cholesterol and free fatty acids are absent.

Certain postulates are made concerning the physiology of the Meibomian glands, an hereditary palpebral mal-occlusion is suggested as one cause of squamous blepharitis, and a method of relief for one form of pruritus palpebrae is described.

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