

THE  
PHOTOGRAPHIC ANALYSIS  
OF A FEATHER

By  
JOHN S. GLADSTONE, F.Z.S.

LONDON:  
HENRY SOTHERAN & CO., 43, PICCADILLY, AND 140, STRAND, W.C.  
1918.



W. L. Selater

with the Author's

Kind regards.







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*teuart*  
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AT the suggestion of my cousin, H. S. Gladstone, a keen Ornithologist, I took up the examination of Feather Construction. He pointed out to me that up to date the illustrations in ornithological works were hand drawings and that a set of photographs would be of some value.

My cousin very kindly obtained for me from the Zoological Gardens, Regent's Park, a collection of feathers ranging from the Golden Eagle to the diminutive Parrakeet. In addition to these the shooting season provided feathers of British Game Birds, so I was able to examine specimens of practically all the orders of British Birds. After a lengthy study with the microscope the conclusion arrived at was that the construction of a feather is the same, whether it belongs to a Golden Eagle or a Sparrow. It was clear therefore that all that was necessary was to record typical species.

For the benefit of the uninitiated it may be well to recapitulate some of the details connected with feathers in so far as concerns the present work. The large wing feathers are called Primary and Secondary. Covering the base of both are layers of small feathers called Coverts. The general body covering feathers are called Contour. The last type dealt with is the Filoplumes, which are hair-like filaments close to the skin.

Plate I., Fig. 1, is a photograph of the Lesser Covert of a Grouse, enlarged six times direct in the camera without the aid of a microscope. This magnification is sufficient to show the general construction of a feather, which consists of a shaft (Rhachis) bearing a multitude of branches called barbs. Each of these barbs bears on both sides a diminutive set of branches called Barbules, and the whole mass is called the Vane.

One of the barbs has been specially separated to show the barbules which appear in the form of a shadow on each side of the barb. The barbules on the upper side are called Distal Barbules, those on the lower side are called Proximal Barbules. The distal barbules are armed with hooks (hamuli) which grip the proximal barbules belonging to the adjacent barb and form the resistance which is felt when the vane is pulled apart. If the disturbed vane is smoothed again into its original position the hooks at once resume their grasping function. In fact, the whole principle of the strength of the vane to hold firmly together against the resistance of the air when a bird is flying lies in this locking together of the barbs.

In Fig. 1 that portion of the vane consisting of barbs closely held together is called Pennaceous, while at the base the soft and downy structure composed of barbs separated one from the other is called Plumulaceous. In some cases a feather is entirely pennaceous and frequently entirely plumulaceous.

Plate I., Fig. 2. Some feathers are double, as from the umbilicus another feather rises at the back in a more or less developed form. This secondary feather is called the Hypoptilum, and the stem Hyporhachis. This photograph, which is of a Grouse Contour, was taken direct in the camera with a magnification of 2.75.

The hypoptilum lies close behind, and is covered by the main feather in nature. To make it more visible it was bent away to some distance. In this case the hypoptilum is entirely plumulaceous, but in some cases it is partly pennaceous.



Fig. 1.



Fig. 2.





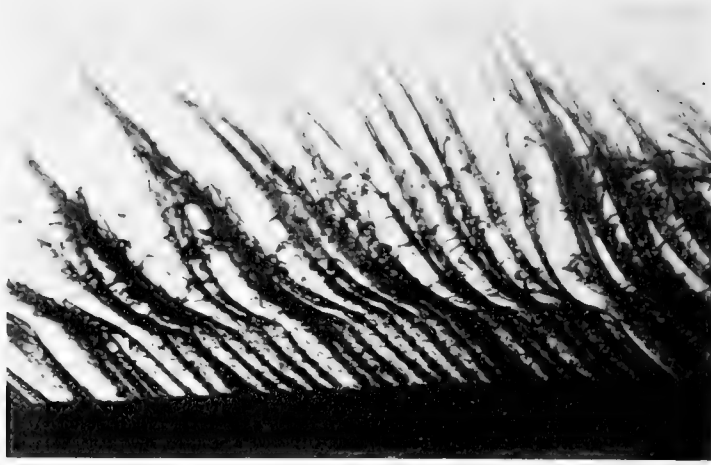


Fig. 1.

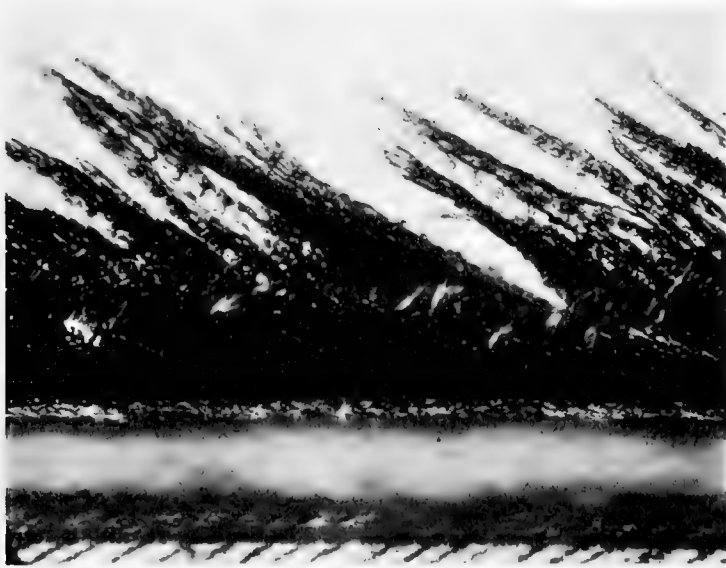


Fig. 2.

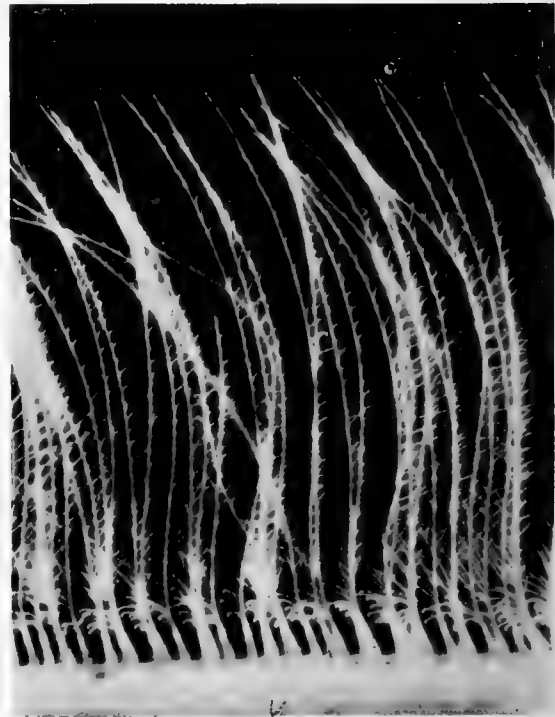


Fig. 3.

Plate II., Fig. 1, is the upper side of a portion of a Barb cut from a Primary feather of a Swan, enlarged 85 times through the microscope. The broad black band is the barb from which stand up the distal barbules, among which many hooks (hamuli) are visible. The chief feature is the graceful curve of the barbules and their more or less open appearance.

Plate II., Fig. 2, is the lower side of a portion of a Barb cut from a Golden Eagle Primary, photographed from the back with a magnification of 120 times.

The broad somewhat confused belt is the barb. The lighter irregular belt just above it is the light shining through the base of the distal barbules. At the bottom of the print the commencement of the proximal barbules may be seen. In contrast to the swan barbules it will be noticed that, instead of fine delicate structure, the golden eagle barbules are broad and dense. In the shadow of the barbules may be seen certain curved patches of light. These are hamuli, but the photograph was not taken with the object of defining them specially, as when photographing them through the microscope it is not possible to focus sharply objects in different planes.

Plate II., Fig. 3, is the upper side of a portion of a Barb taken from an Owl Primary, with a magnification of 60 times. The broad belt at the base is the barb from which spring the distal barbules. In Plate II., Fig. 1, it may be seen that the barbules extend a comparatively short distance beyond the hook region, while in the case of the owl they extend to such a great distance beyond the hook region that each barbule not only hooks on to the proximal barbules of the neighbouring barb but overlaps the surface of several barbs. This long extension of the distal barbules seems to be plumulaceous in its construction and thus gives the soft fluffy character to the plumage of the owl.

Plate III., Fig. 1, represents a Barb from a Pigeon's Primary extracted from the plumulaceous structure at the base of the pennaceous. This photograph was made with a magnification of 130 times. A large number of different plumulaceous barbs were examined and the barbules were found to vary from absolutely smooth to a bamboo-like form called "knotty dilations." In the case of the pigeon, as illustrated, these dilations take an angular shape which I have not observed on any other feather in my possession.

Plate III., Fig. 2, is a Barb cut from a Pigeon Primary at the point where the pennaceous develops into the plumulaceous. On the right hand it will be seen to be pennaceous and on the left plumulaceous. This photograph was made with a magnification of 93 times.



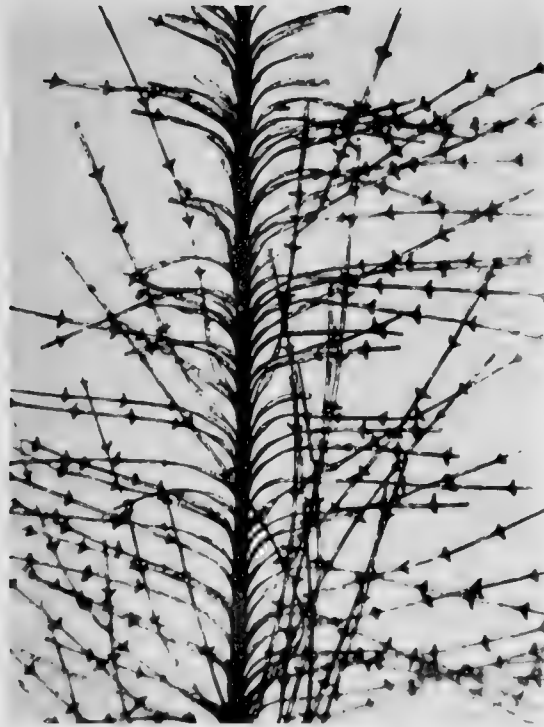


Fig. 1.

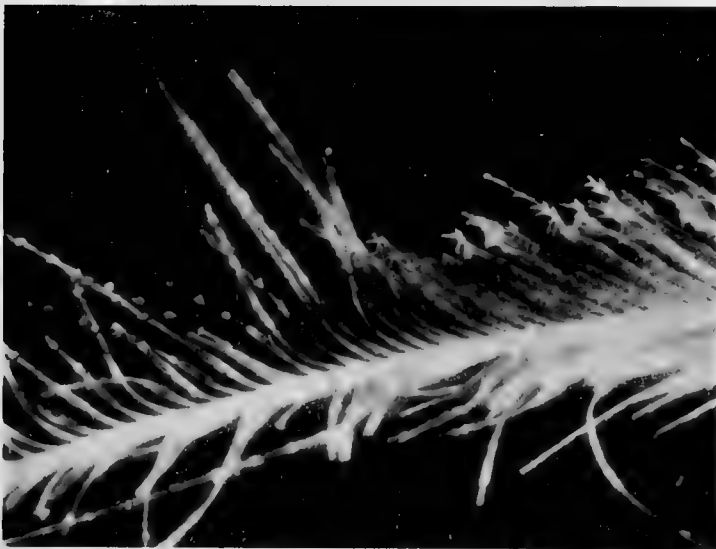


Fig. 2.







Fig. 1.



Fig. 3.

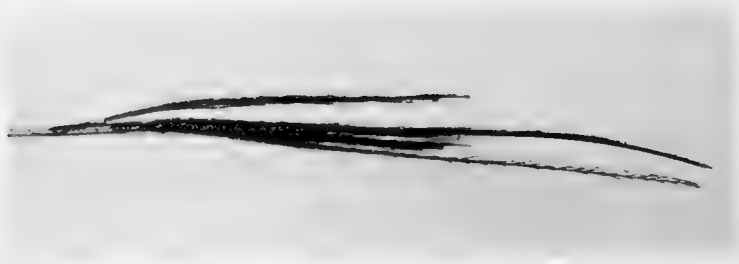


Fig. 2.



Fig. 4.

Plate IV., Fig. 1, is the Shaft of a House Martin Contour feather. This photograph has a magnification of 40 times. The object of this illustration is to show the irregularity in the spacing of the barbs. It will also be noticed that the barbs on the left spring obliquely and sharply from the shaft while those on the right curve downwards to the juncture.

Plate IV., Fig. 2, is the Head of a Filoplume from the Grouse, enlarged 25 times. Most of these filoplumes were found to have little in the way of feathery structure, but it will be seen in this case that there is a distinct plumulaceous character. The greater part of the filoplume consists of a long and slender filament. Had it been possible to include the whole of the filoplume, it would have been quite three times as long as the portion in the photograph.

Plate IV., Fig. 3. The distal barbules of one barb spread themselves over the proximal barbules of the nearest barb and effect adherence by means of hooks (hamuli). In most cases the barbules are so close to each other and the overlapping so dense that a representative photograph could hardly be taken ; it was therefore decided to make use of a Canary Contour feather with widely separated barbules. This photograph was taken with magnification of 130 times. The hamuli are not well developed, but they may be seen here and there. Both types of barbules point towards the edge of the vane, so that the hamuli on one of the distal barbules hook on to several of the proximal barbules.

Plate IV., Fig. 4, is a portion of the underside of a Barb from a Heron Primary, photographed through the microscope by reflected light with a magnification of 120 times. It will be seen that the brightly illuminated hamuli hang in a belt about halfway along the length of the barbules.

Plate V., Fig. 1, is a Distal Barbule cut from the Barb of a Golden Eagle Primary, magnified 130 times. As it leaves the barb it resembles a flat strip of ribbon, but at a short distance it takes a twist to the perpendicular. On the right hand at the twist are two projections called teeth, the use of which does not appear to have been defined. On the lower side the hamuli may be observed, as also the filaments called barbicels. The twist to the perpendicular is obviously to give rigidity and press the hamuli against the proximal barbules.

Plate V., Fig. 2, is a Distal Barbule cut at the base of the Hamuli from a Barb of a Golden Eagle Primary, magnified 500 times. Here we see the formation of the hamuli clearly defined, and it may be recorded that the number of hooks examined on various specimens of barbules seems to vary from four to six.

Plate V., Fig. 3, shows a cluster of Hamuli on the Distal Barbules of a Swan Primary, magnified 637 times. A few barbicels may be seen among the hamuli.



Fig. 1.



Fig. 2.



Fig. 3.









Fig. 1.



Fig. 2.



Fig. 3.



Fig. 4.

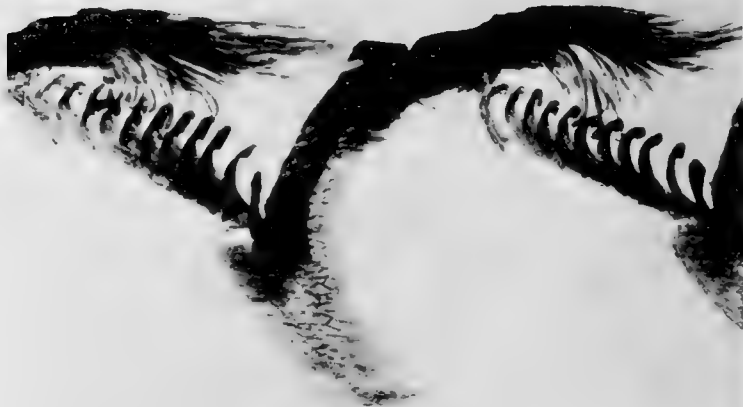


Fig. 5.

Plate VI., Fig. 1, is a Proximal Barbule cut from a Barb of a Golden Eagle Primary, magnified 90 times. On the upper side the dark line represents a curved edge which provides a ridge for the hamuli to catch on. This will be more clearly followed by reference to Fig. 2. On the lower side are seen a few teeth. The proximal barbules at the base of the barb terminate in a long filament, but towards the tip of the barb this filament practically disappears.

Plate VI., Fig. 2, is a transverse section of three Proximal Barbules cut from a Barb of the same Genus Primary, magnified 520 times. In this figure the turn over of the upper edge is plainly seen.

Plate VI., Fig. 3, shows an oblique section of a Proximal Barbule cut from a Barb of a Golden Eagle Primary, magnified 260 times. Here the continuous nature of the curved edge is more clearly shown as well as the rough texture of the surface of the barbule.

Plate VI., Fig. 4, is a transverse section of a Barb of a Golden Eagle Primary, magnified 105 times. The distal barbules project on the right and the proximal barbules on the left. It will be noticed that the barbules spring from a different level, the distal barbules being uppermost. The barb extends some way below the level of the barbules.

Plate VI., Fig. 5, is a transverse section of two Barbs of a Golden Eagle Primary, magnified 150 times. The two barbs in this instance appear in their original positions in order to show the interlocking between the distal and proximal barbules. The barb rises from the lower side of the photograph. On the left there is a notch, out of which springs the proximal barbule. As these barbules are set on the barbs at a very oblique angle, a transverse cut not only severs one barbule but also several more barbules which cross the plane of the cut; hence the appearance of so many. Following the barb upwards we arrive at a second notch, from which springs the distal barbule. This may be more clearly appreciated by reference to Fig. 4. The distal barbules overhang the proximal barbules, and the hooks may be seen gripping the curved edges of the proximal barbules.

The following portion of this work has been published in the April, 1918, issue of "The Ibis," and the plates are reprints of those which appeared in that Journal.

My attention has been concentrated on the glazed portion of the underside of the Primaries of certain birds. Chandler (University of California Publications, Zoology, xiii, 1916, pp. 243—446), referring to the subject states:—

“The ventral edges of the rami are produced into horny keels usually with no evident cell structure, known as the ventral ridges. Although in the great majority of birds the ridge forms only a narrow, inconspicuous border for the ramus, in a few birds it is extraordinarily developed as a very thin translucent film, which bends distally and overlaps the following ramus, giving a smooth, glazed appearance to the under surface of the feather which is conspicuous at the most casual glance.”

My examination of the ventral ridge indicates that when present in complete form it extends about half the length of the barbs. It is widest at the rachis end and tapers to a fine point. Prior to perusal of Chandler's work I named this cover of the space between the barbs as the “Tegmen,” which for convenience I continue to use, as there is a considerable difference between a ventral ridge and a fully-developed tegmen.

The Tegmen is particularly developed in water- and game-birds as well as in the Turkey. The Heron has a dark brown ventral ridge which, though not large enough to form a complete tegmen, is sufficient to create the general appearance of tegmenous structure, but instead of a glazed surface it resembles brown velvet when the feather is held at a suitable angle to the light. I find this Heron-like structure is not uncommon, but as it does not come under the head of “a tegmen” the subject has not been specially studied.

I find three types of Barbs:—

1. The flat barb, which may or may not have a ventral ridge and gives no indication whatever of a tegmen.
2. The curved barb, which, having a coloured ventral ridge, gives a tegmenous appearance to the underside of a feather.
3. The flat or curved barb with fully-developed tegmen.

Type 1 includes the Passeres, Picariæ, Columbæ, Fulicariæ, Alectorides, and Pygopodes.

Type 2 is represented by the Accipitres, Steganopodes, Herodiones, Pteroclitcs, and Limicolæ.

Type 3 is found in the Striges, Anseres, Gallinæ, and Gaviæ.



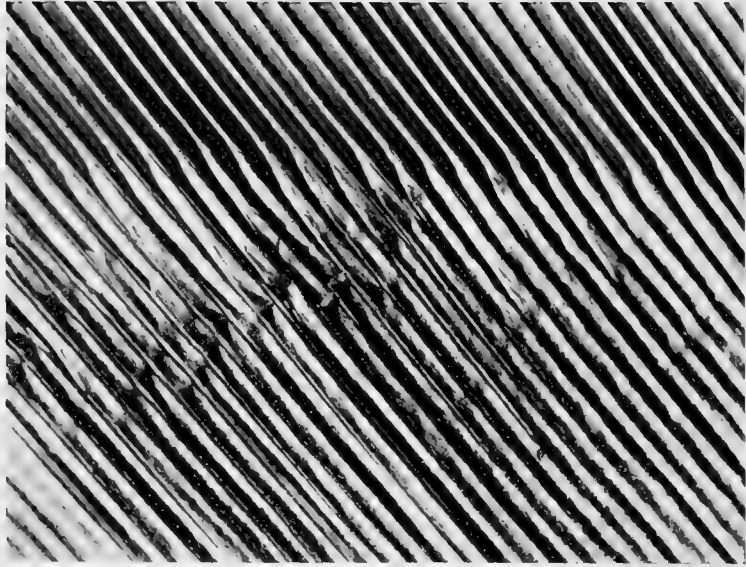


Fig. 1.

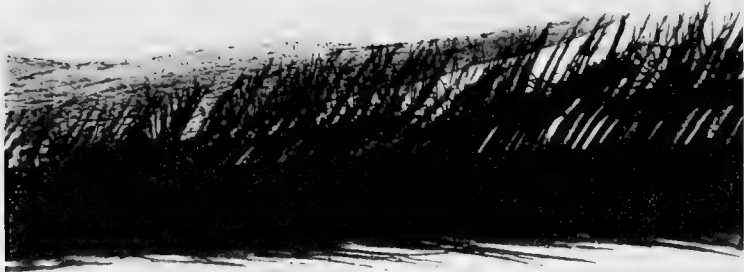


Fig. 2.

The following is a description of the photographs which I have prepared in studying this structure :—

Plate VII., Fig. 1, is a portion of the underside of a Pink-footed Goose Primary, magnified six times. The lower two-thirds of the illustration shows the tegmen covering the space between the barbs. The barbs in the upper one-third have open spaces between them with background of barbules.

Plate VII., Fig. 2, is a portion of a Barb from a Goosander Primary, magnified 55 times. This view shows the barb from the side, and it will be seen that the tegmen entirely covers the barbules on the left. Towards the right the tip of the tegmen has become detached from the barb, which is not usual.

The tegmen appears in two forms, (1) a flat cover, (2) a curved cover. There does not appear, however, to be any particular system about the construction, for while the Buzzard, Blackcock, Grey Partridge, Grouse, and Duck have a flat tegmen, the Turkey, Pheasant, Capercaillie, Goosander, Gull, and Owl have a curved tegmen.

Plate VIII., Fig. 1, is the sectional surface of seven Barbs (in their original position) of a Turkey's Primary, magnified 22 times. Here the impossibility of securing good definition over the whole had to be met with an average focus. The distal and proximal barbules are seen interlacing above and from them depend the seven barbs, each barb terminating in the curved form of tegmen which should close the space between the barbs, but in arranging the subject it was difficult to avoid disturbance.

Plate VIII., Fig. 2. The above explanation applies to this illustration, which represents a Pink-footed Goose's Primary. The barbules extend along the upper surface and the tegmen appears as a flat cover on the lower side. In the original position the construction was that of a series of tubes, but in order to show the tegmen the barbs had to be slightly separated.

Plate VIII., Fig. 3, is a section similar to the above from a Heron's Primary. The section was cut outside the semi-tegmenous area. This photograph was made to show an instance of "no tegmen." The barbules are seen above and the vertical pointed barbs below, showing the absence of tegmen at the tips.

It is curious that although the tegmen appears on the Pheasant, Blackcock, Grey Partridge, Capercaillie, Ptarmigan (summer and winter plumage), and Turkey, it is not found on the Domestic Fowl or Red-legged Partridge. The Partridge, Grouse, Blackcock, and Pheasant being so closely allied, it is remarkable that, as far as my investigations go, I should not have found the tegmen in the Red-legged Partridge. It is beyond the scope of these notes to go deeper into this subject, but it seems to me that the absence or presence of the tegmen may well prove to be a diagnostic character which so far has escaped the attention of systematic ornithologists.

The Red-legged Partridge has on the inner vane of the primary a narrow ventral ridge with a smooth edge, while towards the base of the outer vane the ventral ridge is larger and has a strongly fringed edge.





Fig. 1.

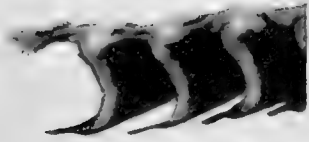


Fig. 2.



Fig. 3.

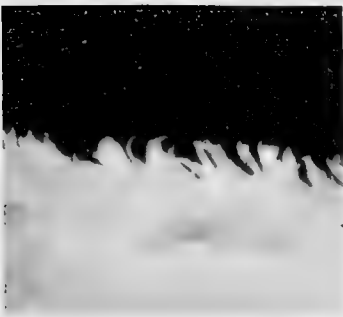


Fig. 4.

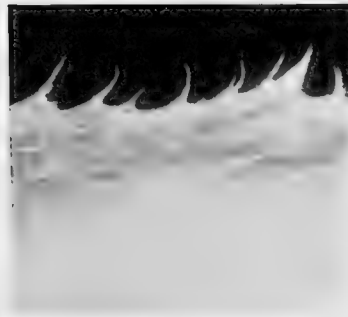


Fig. 5.





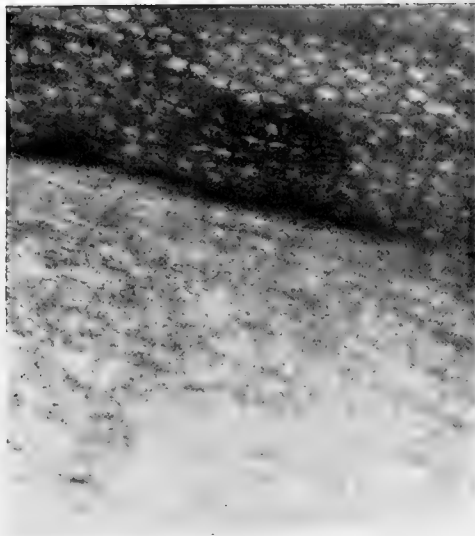


Fig. 1.

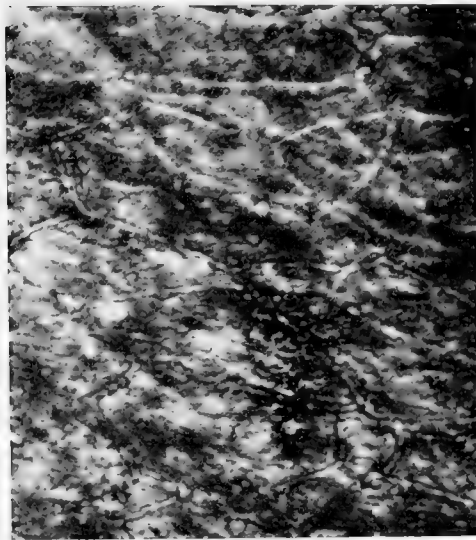


Fig. 2.

Plate VIII., Fig. 4, with magnification of 150 times, shows an example of this fringed edge.

The Grey Partridge has on the inner vane a tegmen with a smooth edge, and on the outer vane a ventral ridge more or less fringed.

Plate VIII., Fig. 5, with magnification of 150 times, is given as a sample of this type of fringe.

The Grouse outer vane has a tegmen with a trace of fringe here and there. The Pheasant outer vane has a ventral ridge with rough edge and irregularly fringed. The Blackcock outer vane has a tegmen with light fringe commencing about half-way from the base. The Capercaillie outer vane has a tegmen with rough edge, with very little trace of fringe.

The presence of tegmen is not restricted to the primaries, for I find it on the tail-feathers of the Grouse and Blackcock, while in the Capercaillie it is most marked. It does not appear on the tail-feathers of the Pheasant, Grey Partridge, or Red-legged Partridge.

Plate IX., Fig. 1, was made to show the difference in structure between the Barb and Tegmen. The dark mottled portion is barb, and the lower and lighter portion is tegmen. This subject was made from a barb cut from a Pink-footed Goose Primary, with magnification of 50 times.

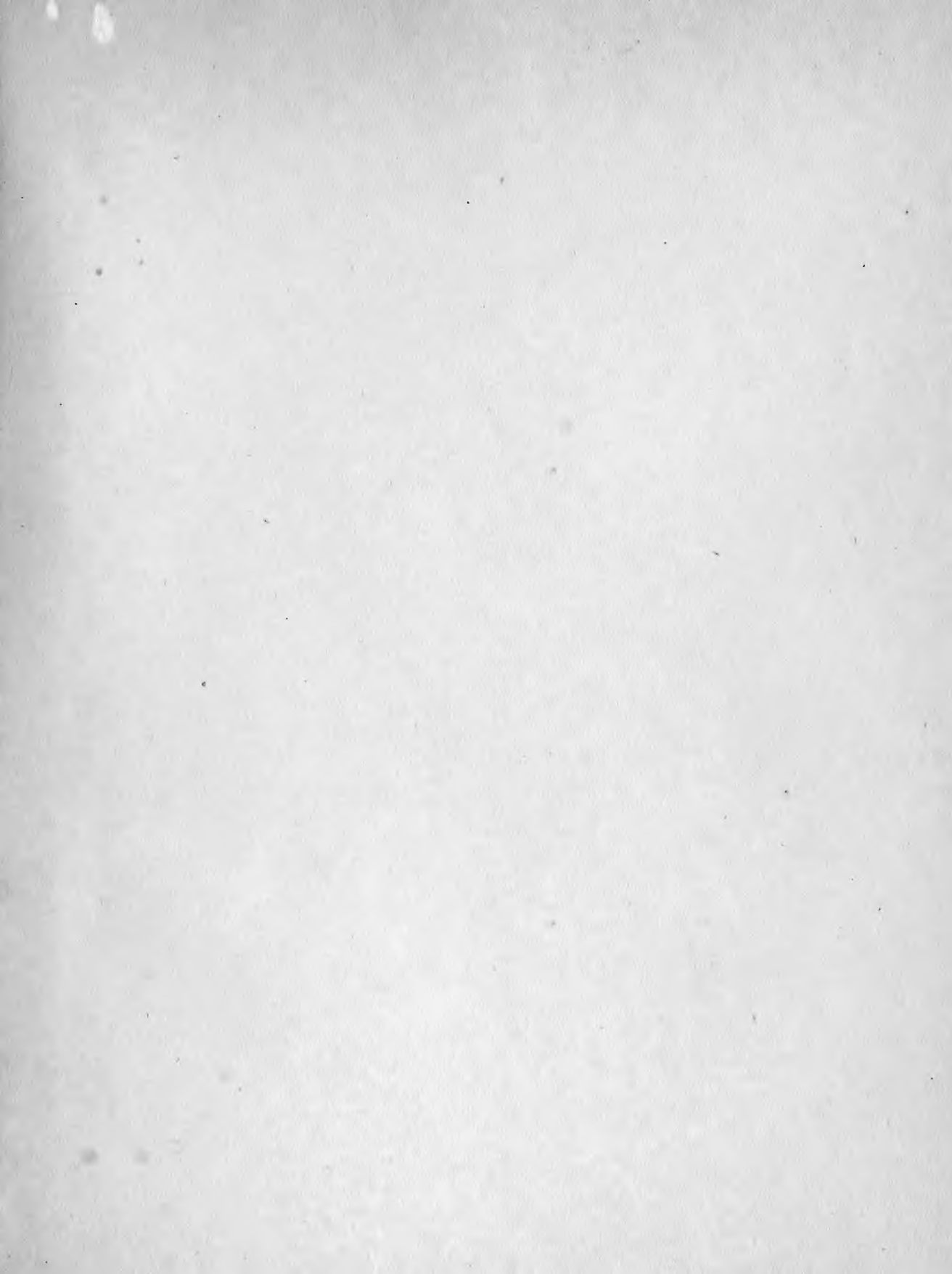
Plate IX., Fig. 2, is an attempt to show the superficial structure of the Tegmen of a Pink-footed Goose. It was made with a magnification of 500 times.

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The photographic work through the microscope was done with daylight as the illuminant. A certain amount of detail has been lost in reproduction, but this was inevitable.

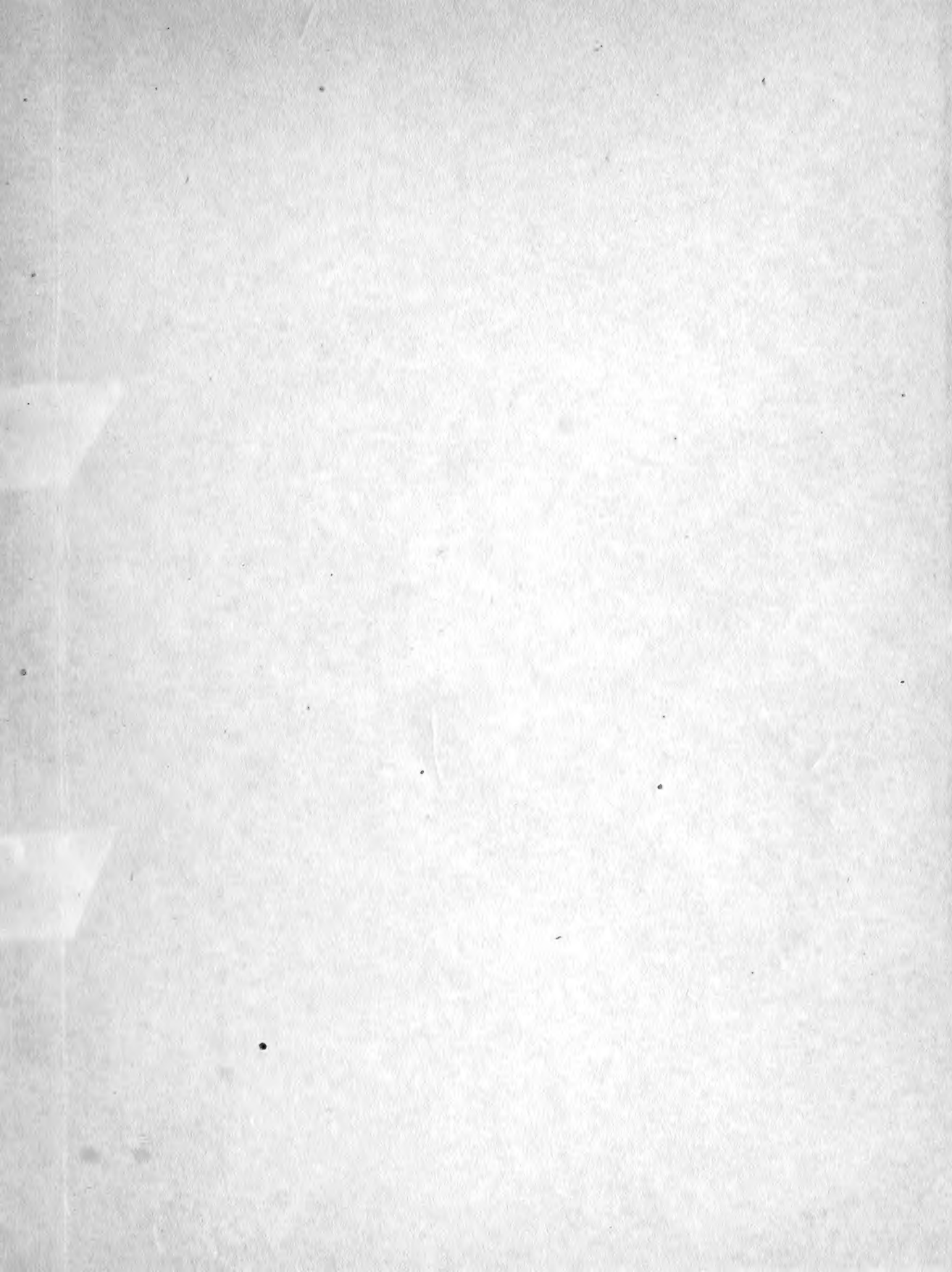
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The photographic analysis of a feather.