THE RETINA AS YOU HAVE NEVER SEEN IT BEFORE

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Introduction
New instrumentation for examination of the fundus has made this procedure readily available, cost effective and much easier for the general practitioner. The next step is the recognition of the many variables in the appearance of the normal canine and feline fundi. And lastly, practitioners need to know when the structures of the fundus are abnormal and what those abnormalities mean.

Normal Ocular Fundus of the Dog
The fundus of the eye refers collectively to the optic papilla or disk; retinal vasculature, including primary and secondary veins and arterioles; the tapetum lucidum; and the nontapetum nigrum. The retina extends anteriorly to its termination at the ora ciliaris retina. This is the junction of the nervous tunic (pars nervosa) and the pars plana of the ciliary body. The ora ciliaris retina is closer to the iris in the superior and nasal quadrants, making it difficult to examine in these areas.

The optic papilla in the dog is 1.5 ± 0.5mm in diameter and usually protrudes slightly vitreal, above the surface of the retina. In some breeds, and individuals, notably poodles, cocker spaniels, and Shetland sheepdogs, the disk may be depressed slightly from the surface of the retina. The color of the disk varies from white to pink. The shape may be circular, triangular, or quadrangular. Both the color and shape are determined in part by the extent of myelination anterior to the lamina cribrosa. In some cases, myelin can be seen extending well out from the optic disk in a radial fashion following the major veins, appearing as gray streaks in the nigrum and white streaks in the tapetum. This has been referred to as medullary rays. In some extreme cases, the amount of myelin causes the disk to appear larger than normal. This is a frequent finding in the Boston terrier and golden retriever, which have a large quadrangular optic disk. This condition has been referred to as pseudopapilledema. In all cases, myelin accounts for the irregular margins of the disk.

The physiological cup is the large depression located near the center of the disk. The optic pit is a small depression in the central portion of the physiologic cup and is a vestige of the embryonic hyaloid canal and artery. This appears as a gray or black spot in the center of the disk. In the 6 to 8 week old puppy, the optic disk appears small compared with the retinal vessels, and the borders appear indistinct.
The disk is located near the junction of the tapetum and nigrum and slightly nasal and ventral to the longitudinal axis of the eye. In the giant breeds and gazehounds, it is often completely located within the tapetum, and in toy breeds, it is frequently surrounded by the nigrum. If the disk is located in the tapetum, it may be completely surrounded by a pigmented ring due to focal absence of tapetum and the exposure of normal choroidal pigment. A complete or crescent ring of hyper-reflectivity may be present around the disk. This is termed peripapillary conus and is due to a thinning of the peripapillar retinal layers, which causes increased reflectivity of the tapetum.

The dog has a visual streak in the tapetal region slightly superior and temporal to the optic disk. This is usually only detectable histologically as an area of decrease vessels and an increase density of photoreceptors, ganglion cells and rhodopsin. This oval area extends slightly nasally and temporally and is believed to be the area of increase visual acuity. This area may be the first location of tapetal hyperreflectivity in early cases of progressive retinal atrophy in some breeds.

The retinal vessels are located in the nerve fiber layer, the second inner-most layer of the retina. The continuation of the nerve fiber layer comprises the optic nerve.

There are 3 to 5 primary retinal veins. However, the most common distribution is four primary veins located dorsal, ventral, ventrotemporal, and ventronasal from the optic disk. The veins join within the disk to form an incomplete or complete anastomosing venous ring or circle. The physiologic cup is located within the ring. The venous circle may pulsate and disappear during examination. This pulsating is independent of the heart or respiratory rate. It has been suggested that it results from pressure exerted on the thin sclera by contraction of the extraocular muscles. This may be demonstrated by applying digital pressure to the globe, which causes blanching of the vessels on the nerve head.

Retinal veins are larger and darker red than the arterioles. Frequently, a light streak can be seen in the center of the vein. This is a normal reflection from the internal limiting membrane overlying the surface of the vessel. The secondary veins can be seen branching from the primary veins and may play a part in the venous circle.

Retinal arterioles are approximately one half to one third the diameter of the primary veins. The number of arterioles varies, with the number reported to be as high as 20. The arterioles originate from the periphery of the optic disk and tend to be more tortuous than the veins. In some breeds such as the Airedale, the arterioles may have an increased tortuosity. The arterioles are brighter red than the veins. On close examination, a light streak may also be seen on the arterioles.
The tapetum is a multi-cell layer located deep to the retinal pigmented epithelium and is actually the inner layer of the choroid. It is located in the dorsal half of the fundus, tri-angular in shape, with the most acute angle located nasally. The tapetum does not extend to the peripheral retina, and it is surrounded by the nigrum. The tapetum comprises approximately one-third of the fundus oculi, depending on the breed.

The tapetal cells do not contain pigment but selectively resorb and reflect different light waves, resulting in the apparent color. The tapetum is dark at birth; gradually changes to gray shades before becoming blue at 7-8 weeks and then reaching its mature color at approximately 16 weeks of age. As the dog matures, the tapetum will take on the adult color of various shades of blue, green, yellow, orange or red.

The variety of colors and configurations of the mature tapetum is endless. This is especially noticeable at the peripheral tapetal and nontapetal junction. The color of the tapetum frequently changes shades as it approaches the nontapetal area. At the nasal and temporal tapetum, it is not uncommon to find dark areas of choroidal pigmentation. Islands of tapetal cells may also be present well within the nontapetal area. Against the dark background, these islands of tapetal cells appear very bright. Dogs with a naturally short hair coat have a well-defined border between the tapetal and non-tapetal areas, whereas dogs with a naturally long hair coat have a poorly-defined border between the tapetal and non-tapetal areas with tapetal islets extending intermittently down into the nontapetal area.

On close examination of the tapetum, small black or brown spots may be seen intermixed with the normal tapetal color. This has been referred to as beadiness or stippling and is especially prominent at the peripheral tapetum. One explanation for this has been the thinning of the tapetum, resulting in the presence of choroidal pigment.

Normally the retinal pigmented epithelium contains pigment only in the nontapetum. The presence of certain amounts of pigment in this layer overlying the tapetum has also been suggested as a possible cause of stippling. Pigment in the epithelium may also cause the dull appearance of the tapetum seen frequently in breeds such as the golden retriever. This would have to be confirmed histologically. Long posterior ciliary arteries pierce the sclera nasal and temporal to the optic disc. They course anteriorly within the sclera to the ciliary body, and may result in a change in tapetal reflectivity. When viewed with decrease light intensity, this may be misinterpreted as tapetal hyperreflectivity.

The nigrum occupies the largest proportion of the fundus oculi. It is found ventrally and completely surrounds the tapetum. The color of the tapetum may
be black, dark brown, gray or various shades of red. The color is determined by the amount of pigment in the retinal pigmented epithelium and the choroidal pigment. If there is little pigment in these areas, the choroidal vessels provide a red or reddish-brown cast common to dogs with a yellow iris such as the English springer spaniel, Weimaraner, and dalmatian.

In the nontapetum, a reflection is seen similar to that from the surface of a lake. This is a normal phenomenon and is believed to be the reflection of light off the internal limiting membrane of the retina.

The function of the tapetum is questionable. It has been suggested that it is an aid to vision in dim light by reflecting the light back through the retina. The tapetum is greatly reduced in size, termed tapetal hypoplasia, in many toy breeds such as the dachshund, schnauzer and Chihuahua, and in individuals that carry the blue merle factor for hair color and pattern. The tapetum may be totally absent in some individuals. Some individuals with a long hair coat may have only multiple focal islands of tapetal cells in the normal tapetal area. Dogs that are atapetal or have tapetal hypoplasia have no detectable visual deficit.

If a dog is atapetal and albinoid, (decrease choroidal pigment and pigment in the inferior retinal pigmented epithelium) the entire fundus will be red. This is a frequent finding in blue-eyed Siberian huskies and old English sheepdogs. This is due to the choroidal blood vessels, which in some cases can be clearly seen with white sclera visible between the vessels. The choroidal vessels are not as dark as the primary retinal veins and appear to radiate from the optic disk. It is not uncommon to have one albinoid fundus and one normally pigmented, especially in a dog with different colored irides.

If the dog is atapetal and heavily pigmented, the entire fundus will be dark. In these individuals, the optic nerve appears white or pale against the pigmented background.

Between these extremes are many degrees of tapetal hypoplasia and decreased pigment in the choroid and pigmented retinal epithelium. In some cases, there may be only one area where red streaks will be seen in the tapetal or nontapetal area and this is referred to as a tigroid fundus. Superiorly, this would be due to lack of choroidal pigment in addition to tapetal hypoplasia. Inferiorly, the pigment is lacking in both the choroid and retinal pigmented epithelium. The tigroid or albinoid fundi are frequently misinterpreted as retinal hemorrhage or detachments. The retinal pigmented epithelium (RPE) and the remaining 9 layers of the retina (sensory retina or nervous retina) are derived from different embryonic layers. That explains why in inflammatory diseases of the posterior segment resulting in a retinal detachment is more correctly termed a retinal separation as the RPE separates from the sensory retina. The sensory layers of the retina contain no pigment. Beside the vessels, one can see through the retina to the underlying tapetum or choroidal pigment and vessels. If the
choroidal layer lacks pigment, the white sclera will be seen. The retina acts like a neutral density filter over the tapetum. When the retina is atrophic or detached and becomes disinserted at the ora, the underlying tapetum will reflect more brilliantly, a condition which is called tapetal hyperreflectivity.

As previously mentioned, the retina terminates anteriorly at the ora ciliaris retina. This area is difficult to view with a direct ophthalmoscope, even through a widely dilated pupil. The area is best viewed in the temporal and inferior fundus. Histologically, the area is well defined because the sensory elements of the retina end and the pigmented epithelium continues as one of the two epithelial layers covering the ciliary body and processes, posterior iris and terminating at the pupil margin as the iris ruff.

When viewed ophthalmoscopically, the area is delineated by a somewhat irregular line formed by the darker pigmentation of the ciliary processes. In addition to a possible circumferential arteriole in this area, clusters or isolated elevated cysts may be seen. This is termed peripheral cystoid retinal degeneration and is a common aging process. As mentioned, this would be difficult to view with direct ophthalmoscopy but would be an alarming finding if only a glimpse of the area is caught.

**Normal Ocular Fundus of the Cat**
The ocular fundus of the cat consists of the same structures as the dog. One general statement that can be made concerning the fundus of the cat is that there is less variation in location and shape of the optic nerve, coloration of the tapetum and appearance of retinal vessels between individuals than you find in the canine.

The optic disk is gray, circular and approximately 1 mm in diameter. The disk is depressed slightly below the surface of the retina. Myelination of the optic disk is scant in cats compared with dogs, and seldom extends beyond the lamina cribrosa or cribiform plate. On rare occasion, it does extend from the disk in the nerve fiber layer. The myelin will appear gray to white; it may completely obscure the optic disc, physiological cup and some retinal vessels and will radiate from the disk as an irregular sunburst often referred to as medullary rays.

On close examination, the surface of the disk will appear sieve-like in the normal cat. This is the normal appearance of the lamina cribrosa and is seen because of the scant myelin. Also, fine lines may be seen radiating from the disk. These are the axons of the ganglion cells that make up the nerve fiber layer and optic nerve.

Usually the optic disk is found totally in the tapetum. It is frequently surrounded by a darker circle of tapetum, usually green. Complete or partial peripapillary conus is often present.
The tapetum in the cat is larger, thicker and reflects light more brilliantly than in the dog. This may account for reports that cats see better than dogs in very dim light. The color of the tapetum is frequently yellow or green. As in the dog, the color changes as the nigrum is approached. Beadiness or stippling is a common feature of the cat, especially when viewed with reduced illumination.

The nigrum in the cat is usually brown or black but may be reddish or gray. In albinoid cats and Siamese, choroidal pigment may be lacking, resulting in the appearance of choroidal vessels. Focal tapetal hypoplasia is not uncommon in the Siamese. In these cases, red streaks (tigroid fundus) will be seen which must be differentiated from retinal hemorrhage.

There are usually three primary retinal veins that originate from the margins of the disk and extend dorsal, ventrotemporal and nasoventral. The dorsal and ventrotemporal veins tend to arch temporally. The primary veins branch as they approach the peripheral retina.

The retinal arterioles are smaller in caliber and brighter red than the primary veins. Three arterioles usually leave the margins of the disk in association with the primary veins. The arterioles may be intertwined with the veins. Other arterioles originate independent of an associated vein.

Histologically, the cat has an area centralis. This area is located approximately 1.5 disk diameters above the optic disk and about three disk diameters temporal to the disk. This area is relatively void of blood vessels and is frequently a darker green than the surrounding tapetum. This is an area of increase cone density and visual acuity.

**Interpretation of Some Abnormalities of the Fundus**

**Vascular**

- Lipemia: lipid metabolic defects
- Attenuated vessels: retinal atrophy/degeneration, anemia
- Dilated vessels: polycythemia, hyperproteinemia
- Tortuosity: cardiovascular disease
- Hemorrhage: multiple layers and etiologies

**Tapetal Reflectivity**

- Diffuse hyperreflectivity: retinal atrophy, retinal detachment with disinsertion at ora
- Focal hyperreflectivity: chorioretinopathy
- Decrease or dull reflectivity: edema, i.e. active retinitis/detachment

**Optic Disc**

- Coloboma, glaucomatous cupping atrophy, hypoplasia, papilledema, optic neuritis
Hemorrhage
Subretinal large, dark, retinal vessels visible over hemorrhage; retina may be elevated
Intraretinal deep, small, circular
Intraretinal nerve fiber layer flame shape, follows and may obscure vessels; may extend over disc
Pre-retinal between retina and vitreous face; frequently circular with RBC settled inferiorly i.e. boat hemorrhage obscures view of retinal components
Vitreous hemorrhage difficult or impossible to view retina and may settle inferiorly; varies with degree

Retinal detachments may be small focal detachments referred to as bullous detachments; may be total detachment with or without disinsertion of the retina at the ora ciliaris retina; depending on associated hemorrhage and exudate, the retinal vessels may not be visualized; retinal vessels may go in and out of focus in the detached area

**Chorioretinitis versus Chorioretinopathy**

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<td>Borders of lesion</td>
<td>poorly demarcated</td>
<td>sharply defined margins</td>
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<tr>
<td>Detail</td>
<td>blurred</td>
<td>sharp</td>
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<tr>
<td>Tapetal</td>
<td>hyporeflective and gray to pink</td>
<td>hyperreflective with pigmented border</td>
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<tr>
<td>Nontapetal</td>
<td>gray to white</td>
<td>depigmented, clumping</td>
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