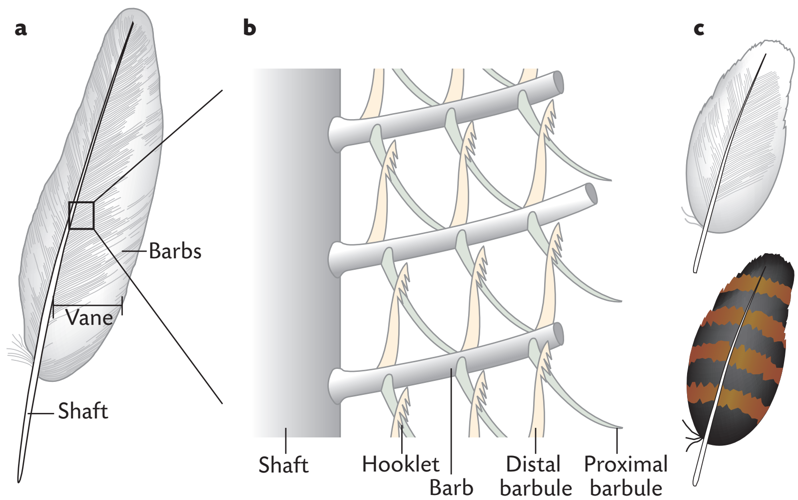

Figure 17.7 Structure of feathers. **a** Flight feather from the wing. **b** Microscopic structure of barbs and barbules forming a coherent surface (the vane) of a flight feather. The hooklets, which are present only on the barbules on one side of the barb, hook onto the smooth barbule from the adjacent barb. **c** Feathers that develop from the same feather follicle can have different pigmentation, depending on the season of the year. The winter feathers on the breast of the willow grouse are white (no pigment), while the summer feathers exhibit a series of bands with different pigmentation.

Wing and tail feathers are replaced once a year

In laying hens, long daily periods of artificial light suppress molting

One and the same papilla can produce feathers with varying colors during different seasons

Some birds use the precursors of vitamin A for coloring

Molting

Large feathers, such as wing and tail feathers, are replaced once a year. In contrast, the smaller contour feathers covering the body surface may be replaced several times a year in species that change their coats seasonally. Like the replacement of fur in mammals, replacement of feathers in birds, molting, is triggered by hormonal signals that are seasonally synchronized through the photoperiod. For laying hens, long daily periods of artificial light promote continuous egg production (p. 733) and suppress molting. Laying hens that commence a natural molt are taken out of industrial egg production.

Care of Hair and Feathers

Grooming helps to maintain the structure of fur and feathers. The insulating properties of fur and feathers depend heavily on daily grooming to remove dirt, parasites, and other foreign objects. Particular behavior patterns such as rolling in mud and sand bathing are also important parts of body care in many species. Domestic animals that are restrained, and animals kept in small cages, often have limited opportunity to meet their needs for skin care. Dirty hair and feathers, poor insulation, and behaviors characteristic of frustration are common symptoms of the poor welfare in animals unable to perform normal grooming.

?

21 Describe the general structure of feathers.

22 What is structured coloration of feathers?

23 Discuss the importance of carotenoids in the coloration of animals.

Feather pigmentation

The melanins in avian feathers are similar to those in the hairs of mammals. As noted, melanin pigments can have a variety of black, brown, and red colors, depending on the extent of polymerization that occurs when they are synthesized. The different feather papillae can therefore produce feathers with widely differing coloration. One and the same papilla can also produce feathers with strikingly different patterns and colors during different seasons (Fig. 17.7c), such as black or brown-striped in the spring and white in the autumn. In addition to coloration, the melanin pigments also give a lustrous shine to the feather coat as light is reflected off the barbs.

Factors other than melanin also contribute to the color of feathers. Blue and shiny colors are not derived from pigments, but are due to reflection, refraction, and diffraction of light that strikes minute particles (diameter $< 0.6\ \mu m$) or air bubbles that are incorporated into the feathers. Coloration that is not based on pigments are called structured coloration.

In some birds, the precursors of vitamin A, the carotenoids, contribute to the coloration of the skin and feathers, such as the characteristic yellow color in canaries and the red color in ibis. The same carotenoids are responsible for the yellow and red color on the beaks and legs of chickens, ducks, and geese. No animal can synthesize carotenoids, which thus have to be supplied through the feed. The carotenoids are taken up from blood and transported by the keratinocytes to the skin surface. Like their reptilian relatives, all birds