sured serum IFN nor characterized the IFN made in vitro. We found that pokeweed mitogen (a B and T cell mitogen), but not phytohemagglutinin (a T cell mitogen), induced high levels (200 to > 2000 I.U./ml) of γ-IFN in mononuclear cell cultures from both IFN-negative patients and patients with α-IFN in their serum. Preliminary experiments suggest that SLE lymphocytes stimulated with Newcastle disease virus inactivated with ultraviolet radiation produce a conventional mixture of α-IFN's which is stable at *p*H 2. These results suggest that the acid-labile α-IFN in the serum of these patients may be synthesized by organ-bound lymphocytes or monocytes rather than by cells in the peripheral circulation. However, previous studies have also shown that the method of preparation of the cells before culturing, the nature of the accessory cells in the culture, and other factors may influence the type of IFN produced by leukocytes in vitro (*5*).

Our results strongly suggest that a particular type of α-IFN is specifically elevated in about 50 percent of all SLE patients. We do not know whether the acid-labile α-IFN found in SLE patients corresponds to any of the already known species of human leukocyte IFN or whether it is also found in patients with other diseases. Although IFN is more prevalent in patients with active SLE, we have not been able to correlate any individual serologic or clinical marker of disease with the presence of IFN in our group of patients. The presence of this form of IFN may be useful in the definition of subsets of SLE patients with hereditary or other factors in common which could contribute to development of the disease.

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9. Serum samples from 49 SLE patients and 19 healthy control individuals were provided by D. Koffler. Serum samples from 13 patients with drug-induced SLE and from three healthy controls were provided by E. Hess. The remaining samples were drawn from patients at the Clinical Center, National Institutes of Health.
10. Rabbit antibody to α-IFN was prepared by immunization with partially purified human leukocyte IFN (specific activity, > 10^6 U per milligram of protein). Serum samples obtained 106 days after the onset of immunization had a neutralization titer of 1:24,000 against standard α-IFN and 1:16 against standard β-IFN. The antiserum to rabbit β-IFN [described in J. Vilcek, S. Yamazaki, E. A. Havell, *Infect. Immun.* **18**, 863 (1977)] had a neutralization titer of 1:4000. Antibody to γ-IFN was prepared by immunization of rabbits with purified γ-IFN (a 20,000-dalton protein) isolated on sodium dodecyl sulfate–polyacrylamide gels [Y. K. Yip, B. Barrowclough, C. Urban, J. Vilcek, *Science* **215**, 411 (1981)]. The antiserum neutralizes γ-IFN components migrating at 20,000, 25,000, and 45,000 daltons. The titer of the antiserum to γ-IFN is about 1:400.
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Rediscovery of the Yellow-Fronted Gardener Bowerbird

Abstract. *The long-lost bowerbird* Amblyornis flavifrons *was found in the Foja Mountains of west New Guinea, and its bower and display were discovered. The bower is a stick tower on a rimmed moss platform, adorned with separate piles of fruit of three different colors. The displaying male extends toward the female a blue fruit set against his golden crest. These observations support a derivation of bower ornamentation from ritual courtship feeding and a transfer of ornamentation from the male's plumage to the bower.*

The most elaborate structures built by birds are the bowers of the family Ptilonorhynchidae (bowerbirds). These structures include walled avenues, huts 1 to 2 m in diameter, stick towers several meters high, carefully laid out lawns, and moss platforms with parapets. Bowers are decorated with colored objects such as fruits, flowers, shells, mushrooms, and (near human settlements) coins, marbles, bottle tops, and toothbrushes. At least four species orient their bower in a constant compass direction, and at least six use a tool to paint the bower with crushed plant matter, charcoal, or blue laundry powder (*1–4*).

Ever since 19th century explorers discovered bowers and mistook them for man-made structures, biologists have puzzled over the problems that bower building poses. These include the function and evolution of bowers, the roles of intelligence and aesthetic sense in their construction, the relation between bower ornamentation and male ornamental plumage, and the social system of the architects. Answering these questions has been hampered by the paucity of field observations of bowerbirds, in part because they are confined to New Guinea and Australia and often to remote areas there. Knowledge of the mating display at the bower is crucial for interpreting bower function. However, of the 15 species known or inferred to build bowers, the display is still unknown for seven, the bower itself for two.

Until the 1920's, vast numbers of skins of birds of paradise and bowerbirds were shipped from New Guinea by feather merchants. From these shipments, ornithologists described many taxa whose home grounds within the New Guinea region were kept secret by the merchants. By 1930, as a result of scientific collecting expeditions, these new forms had mostly been traced to their home grounds or shown to be hybrids, with a notable exception: the yellow-fronted gardener bowerbird *Amblyornis flavifrons*, a spectacular golden-crested bird known only from three adult male skins sold in 1895 to the Tring Museum by a plume merchant. The female remained unknown. A dozen expeditions searched remote areas of New Guinea for this species, without success (*2*).

In 1979 and 1981, I found *A. flavifrons* in the Foja (Gauttier) Mountains of west New Guinea, and discovered the bower, display, and female plumage. These observations are significant for understanding the nature and origin of bowers, because the group of five species that includes *A. flavifrons* (the so-called maypole builders) builds the most elaborate bowers, yet knowledge of the display has been lacking for three of the species and scanty for the other two.

From the north New Guinea lowlands rise several isolated mountain ranges, each supporting endemic taxa of birds. Of these ranges, the Foja Mountains are the third highest (about 2200 m) and the third richest in montane bird species (about 85). The climax habitat is forest that is lightly mossed above 1400 m, heavily mossed above 1900 m, and dominated by species of *Araucaria*, *Nothofagus*, *Podocarpus*, and oaks. While the adjacent lowlands contain sparse human populations, there are now no humans in the Foja Mountains, and there is no evidence of humans ever previously having visited except for the existence of the three *A. flavifrons* specimens. The inaccessibility of these uninhabited mountains is the reason why the origin of *A. flavifrons* has remained unknown until now. From a camp established by helicopter, I surveyed altitudinal transects of 570 to 1400 m in October 1979 and 980 to 2000 m in January and February 1981.

Amblyornis flavifrons was found from 1110 m (rarely, 940 m) to the highest altitude I reached, 2000 m. The population structure resembles that of numerous other birds of paradise and bowerbirds (*5*, pp. 30 and 31) in that displaying or calling adults are confined to the upper part of the altitudinal range, while a narrow band at high altitude and a broader band at low altitude contain only silent individuals in immature, female, and subadult male plumage (*6*). Bowers were found between 1650 and 1800 m, calling individuals between 1465 and 1865 m, and adult males above 1595 m except for one at 1110 m. I obtained 29 sight records and 16 voice records, representing about 22 different individuals. From the population density and area of suitable habitat, I estimate the population size to be a few thousand or less.

Except at the bower, *A. flavifrons* is solitary and lives mainly in the middle story and lower canopy (6 to 20 m above the ground), occasionally on the ground. It feeds on treeborne fruit, which it quickly snatches and carries off. Within the altitudinal range of the bowers, it is the largest common arboreal frugivorous bird of the Foja Mountains, except for two pigeon species.

Table 1. Evolutionary transfer of ornamentation and structural complexity from adult male plumage to bower. Birds of paradise of the genera *Diphyllodes* and *Parotia* are not ancestral to *Amblyornis* and *Prionodura* but are believed to be an independent example of an early stage in transfer.

Bird	Elaborateness*		
	Male ornamental plumage	Bower structure	Bower ornamentation
Diphyllodes, Parotia	6	1	0
A. macgregoriae	3	3	0, 1
A. flavifrons	3	3	2
A. subalaris	2	4	5
P. newtoniana	1	5	5
A. inornatus	0	6	6

*Numbers indicate elaborateness: 6, most elaborate; 1, least elaborate but still present; 0, lacking.

I found eight separate bowers or sets of bowers, located on ridge crests, spaced about 0.5 km apart, and each centered on a sapling or tree fern 0.5 to 4 m tall in the shaded understory (Fig. 1). Sticks about 20 cm long were piled about the sapling or fern, forming a tower 0.5 to 1.2 m high. A circular moss platform 1 m in diameter and with a raised rim was constructed about the base of the sapling or fern, and the adjacent ground was cleared of debris. On the platform were piles of blue, green, and yellow fruit. Each color was in a separate pile far from the two other piles. The yellow fruit was a species of fig, 6 mm in diameter; the blue fruit (see below) was about 20 mm in diameter and is the ripe fruit of a small tree unidentified taxonomically; the green fruit was the unripe form of the blue fruit. I encountered two sets of multiple bowers: a damaged bower and two fresh ones within 100 m, all owned by one adult male; and two disused bowers 1 m apart. These large structures were the work of a bird weighing about 120 g.

Near each bower I usually found one adult male calling from the lower canopy. Like most species of bowerbirds, *A. flavifrons* had varied, usually loud, and often weird calls and was a vocal mimic. The calls included: short high nasal screeches, rasps, clucks, wheezes, croaks, crackling sounds, whiplike sounds, and calls like the sound of shoveling gravel, crumpling paper, striking a tree trunk, suddenly letting the breath out, and clicking the tongue against the palate. There are also good imitations of calls of four local bird species: the honeyeater *Melidectes ochromelas*, flycatcher *Peneothello cryptoleucus*, cockatoo *Cacatua galerita*, and crow *Corvus tristis*. The first two of these species are common within the altitudinal range of the bowers; the last two are confined to lower elevations (where the bower owners may have learned the calls while living there as immatures).

I witnessed one display, which also provided the sole instance when I saw two bowerbirds together. On a forested ridge crest at 1715 m was a bower with the usual three piles of colored fruit. A crested adult male *A. flavifrons* was holding in its bill one of the blue fruits, while making a loud sound as of a large mammal walking on loose gravel. The fruit was about one-third the size of the bird's head and was held in the bill continuously for the next 20 minutes, as the bird called and then displayed to the female. When first observed, the male was on the ground near the bower, then it flew to a perch in the lower canopy, often giving rolling-gravel sounds, imitations of other birds, and varied other loud sounds. When a female appeared in the vicinity, the male flew to a sapling bent horizontal 1 m high and 6 m from the bower, gave a weak high-pitched two-note whistle, and went silent and stayed on this sapling for the rest of the display. The female periodically shifted perches at heights of 2 to 10 m, always remaining about 10 m from the male, sometimes perching vertically over him. Whenever the female shifted perch, the male turned so as always to face her and to have the blue fruit set against the background of his golden-orange crest pointed at her (Fig. 1). When the female was overhead, the male pointed his body vertically upward; when she flew to the understory, he held his body horizontally at her. Often he spread his crest laterally, raised and lowered it vertically, and rapidly shook his head from side to side so that his crest quivered. Finally the female flew off without the union having been consummated, and the male resumed loud calls and flew off himself.

These observations are significant for understanding behavioral origins of bower building, color choice, ecological prerequisites for bower building, relation between bower decoration and plumage, and the arena theory of bower evolution. Bowerbirds may be classified in several groups according to bower structure—maypole builders (the four *Amblyornis* species plus *Prionodura newtoniana*), avenue builders (the four *Chlamydera* species, three *Sericulus* species, plus *Ptilonorhynchus violaceus*), and the stagemaker *Scenopoeetes dentirostris* and the mat builder *Archboldia papuensis*.

In many other kinds of birds, males

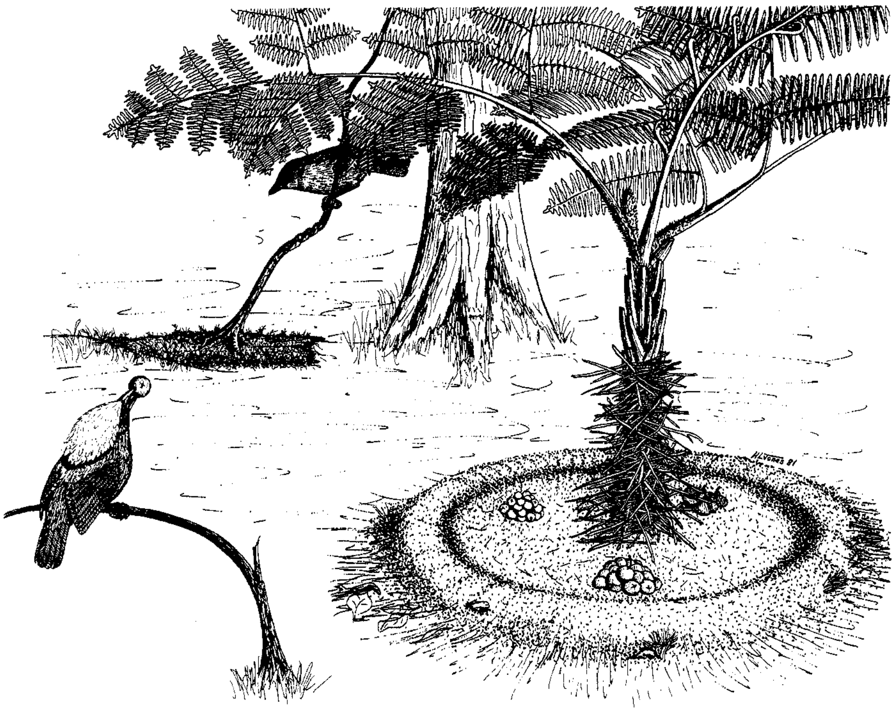

Fig. 1. Bower of *Amblyornis flavifrons*, female (on sapling in background), and displaying male with flared crest and holding blue fruit. The male has placed the sticks piled up about the tree fern, constructed the moss platform at the base, and placed the blue, yellow, and green mounds of fruit on the platform.

court females and stimulate them to ovulate by constructing real or mock nests and by ritualized offering of food (courtship feeding). If bower building developed as an exaggerated form of such courtship behavior, the bower may represent a gigantic courtship nest (*1–3*). The decoration of bowers by colored objects has been viewed as derived from courtship feeding, since males of all species of avenue builders for which the display is known pick up a decoration and hold it in the bill toward the female, and since these objects are sometimes edible (fruit). Although all five maypole builders are now known to decorate the bower with colored objects at least occasionally, the *A. flavifrons* display described here provides the first instance of display of a colored object by a maypole builder. The facts that this object is a large ripe fruit held in the bill throughout the whole display, and that fruits are the sole colored decorations at the bower, strengthen the case for considering decorations as evolved from courtship feeding. In the avenue builders and in the maypole builder *A. inornatus*, where decorative objects are more numerous and varied and the display fruit is often replaced by an inedible object (a bone, shell, flower, or a human artifact such as a cloth), this offering loses its original meaning.

Each bowerbird species has a characteristic color preference in its choice of display objects (for example, blue in *Ptilonorhynchus violaceus*, green in *Chlamydera cerviniventris*, pale in *C. maculata*). In some species the preferred color coincides with the color of the bird's own plumage, eye, or bill (*1*). For *A. flavifrons* the reason why it selects the three colors that it does is less obvious. The yellow fig selected by *A. flavifrons* suggests the color of the abdomen and male crest, but neither the green fruit nor the crucial blue fruit held pointed at the female during the display matches a part of the bird. However, the blue fruit is of a color that affords maximum contrast when seen against the background of the golden-orange crest during the display.

As with other social patterns, it is difficult to perceive unique, necessary, and sufficient conditions for the development of such elaborate courtship structures in bowerbirds. However, at least one necessary condition can be suggested: ample leisure time. The *A. flavifrons* adult males that I observed spent most of their time calling over the bower and little time feeding. Other adult male bowerbirds are similarly known to spend little time feeding and much time displaying, constructing their own bower, and wrecking or stealing from neighboring bowers. The female does the work of nest construction and feeding the young, except for *Ailuroedus* species, whose male builds no bower. This social system requires that birds be able to satisfy their food requirements in a short time. *Amblyornis flavifrons*, as one of the largest arboreal frugivorous bird species in its habitat, may be able to achieve this requirement by dominating smaller birds at trees that are concentrated sources of fruit of high nutritional quality. Elsewhere in New Guinea, the bowerbird *Chlamydera cerviniventris* was dominant in fruit trees, and bowerbirds in general are among the largest passerines of New Guinea and Australia.

Gilliard (*2, 3*) noted that bower complexity and decoration vary inversely as plumage ornamentation of adult males among both maypole builders and avenue builders. He interpreted this trend as an evolutionary transfer effect: male ornate plumage to woo females was lost as the female's attention became transferred to the ornaments of the bower itself. For example, among the four previously known species of maypole builders, *Amblyornis macgregoriae* has the longest adult male crest and the simplest and least ornamented bower (a stick tower on a moss platform, few or no ornamental objects); *A. subalaris* has a shorter crest and more complex and ornamented bower (floored and domed hut around a stick tower, forecourt decorated with fruits and flowers); *Prionodura newtoniana* has a still shorter crest and larger bower (two towers up to 2.5 m high, joined by a bridge and decorated with moss, lichens, fruits, and flowers); and *A. inornatus* lacks a crest (male similar to female) but has the most elaborate bower (large hut around a column, large forecourt with hundreds of ornaments segregated by color). The comparisons suggest the focus of the display shifting from the colored crest to the bower ornaments. In this sequence *A. flavifrons* falls between *A. macgregoriae* and *A. subalaris* but nearer the former (Table 1). The crest is as long as in *A. macgregoriae*. The bower structure, with its stick tower and moss platform, is similar to that of *A. macgregoriae*, except that the *macgregoriae* bower is always built around a sapling while the *flavifrons* bower uses either a sapling or a tree fern. The bower ornaments of *A. flavifrons* are more numerous, consistent, and diverse than in *A. macgregoriae* but less so than in *A. subalaris*. The giant (up to 2.5 m high) twin-maypole bower of *Prionodura newtoniana* may be an extension of the habit of *A. flavifrons* and *A. macgregoriae* occasionally to build two separate maypole bowers close together, such as a pair 1 m apart that I saw in the Foja Mountains. Birds of paradise of the genera *Diphyllodes* and *Parotia* may correspond to an evolutionary stage intermediate between other birds of paradise and *A. macgregoriae*. Their adult male plumage is more ornamented than that of any bowerbird: iridescent breast shield, wirelike ornamental feathers protruding from the head or tail. Unlike other birds of paradise, these two genera construct terrestrial display courts that deserve the name "bower," but that lack ornamentation and are simpler than the bower of any species of Ptilonorhynchidae.

The spatial arrangement of bowers is relevant to the possible role of arena behavior in bowerbird evolution (*2*). Arena behavior, evolved independently by numerous species of birds, mammals, frogs, and insects, means the clustering of displaying males at traditional display courts, to which females come for insemination and where males are in visual or vocal contact with each other. At least one population of bowerbird (*Archboldia papuensis sanfordi*) clearly has its bowers clumped in arenas, but this appeared to me not true of *Amblyornis flavifrons*. I found bowers along both ridges that I climbed, the bowers or sets of bowers were about equally spaced along the ridges, and the distance between bowers was such that I could not hear the calls of one bower-owning male from the next bower.

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6. The live appearance of adult male *A. flavifrons* is as follows: stocky build; tail slightly notched, extending 4 cm beyond the folded wings; bill entirely black, legs and iris dark; upper parts, head, and upper breast dark brown, contrasting with the warm, orange ochraceous lower breast and belly; crest originating at the base of the bill and extending over the whole forehead and crown to cover the upper back; crest yellow viewed from the side, orange-yellow viewed from other angles. The crest is more orange in living birds than in the 1895 specimens, partly because of differences in arrangement of the feathers (underfeathers more orange and less yellow than superficial ones), and partly because of postmortem fading and yellowing, as documented for *A. macgregoriae* and *A. subalaris* [E. T. Gilliard and M. LeCroy, *Bull. Am. Mus. Nat. Hist.* **123**, 1 (1961); (*5*), p. 343; R. Schodde and J. L. McKean, *Emu* **73**, 51 (1973)]. The subadult male acquires the orange underfeathers of the crest before the superficial yellower feathers. The previously unknown female, and probably immatures of both sexes, resemble the adult male, except for lacking the crest. *A. macgregoriae* differs in that the underparts are dirty olive-brown with no hoodlike contrast between upper and lower breast, the lower mandible is pale horn rather than black, the tail is rounded rather than notched, and the crest of the adult male arises from the middle of the crown rather than from the base of the bill and is more orange to red-orange (less yellow). Specimens of *A. flavifrons* were not collected as this is forbidden: *A. flavifrons* is on Indonesia's list of protected species, and the Foja Mountains are part of a national park. Copies of my tapes of the vocalizations have been deposited with the Cornell Laboratory of Ornithology.
7. I thank H. Makabory for collaboration in the fieldwork, M. LeCroy for suggestions, and the National Geographic Society, World Wildlife Fund, and Lievre Fund for support.

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Selective, Naloxone-Reversible Morphine Depression of Learned Behavioral and Hippocampal Responses

Abstract. *Morphine administered intravenously causes immediate and complete abolition of a simple learned response (classically conditioned nictitating membrane extension in rabbit) and of the associated learning-induced increase in hippocampal neuron activity. Both effects are completely reversed by low doses of naloxone. Morphine has no effect at all on behavioral performance of the unconditioned reflex response.*

Currently there is widespread interest in the effects of opiates and endogenous opioids on learning and memory processes (*1, 2*). At present, these effects are complex and not well understood (*3*). Indeed, the effects of the original opiate—morphine—on learning and memory processes are not clear (*2, 4*). A major source of difficulty is that, in most learning experiments, drug effects on memory and on performance cannot easily be distinguished. Classical conditioning has the advantage of permitting relatively direct and independent measurement of drug effects on the learned response—the conditioned response (CR)—and on performance—the unconditioned response (UR). If a drug abolishes the CR but does not affect the UR, performance variables relating to the execution of the behavioral response can be excluded. We now report such a selective action of morphine on a simple conditioned response.

In previous work, we have decribed a learning-induced increase in hippocampal unit activity that develops in simple learning situations and that invariably predicts behavioral learning. This response is independent of performance and relates only to the learned response: over a wide range of conditions that influence the development, maintenance and extinction of the learned behavioral response, alteration of the learning-induced hippocampal response precedes and accurately predicts subsequent alteration of the learned behavioral response (*5, 6*). In short, the hippocampal response seems to have the properties of a relatively direct measure of the inferred processes of learning and memory retrieval in the brain. The present experiment provides a further test of this hypothesis.

Methods of training and recording have been described in detail (*5*). Rabbits are restrained and given classical conditioning training with paired tone conditioned stimulus (CS) (1 kHz, 85 dB, 350 msec) and corneal airpuff unconditioned stimulus (US) (210 g/cm pressure, 100 msec, coterminating with CS) trials at a rate of approximately one per minute, eight paired trials and one CS-alone test trial per block, 13 blocks per day. Control animals are given the same number of stimuli but explicitly unpaired in a pseudorandom sequence with an interstimulus interval of approximately 30 seconds. The nictitating membrane extension response is measured with a micropotentiometer attached to the membrane and digitized for computer analysis. Multiple unit and isolated single unit activity is recorded from the CAl pyramidal cell layer of the dorsal hippocampus using permanently implanted microelectrodes (or a permanently implanted microdrive system). The largest unit discharges (multiple unit recording) or all unit discharges (single unit recording) are detected with a discriminator circuit and stored in the computer in 3-msec time bins for each trial for analysis. Standard scores of the conditioned increase in unit activity are computed from the background and CS period activity.

In the present experiments, animals were trained to a criterion of eight CR's in any nine successive trials, given two blocks of additional training, and then injected with morphine intravenously (ear vein). A rough dose response was determined in pilot animals injected with 1, 5, or 10 mg of morphine per kilogram of body weight in constant volume (0.25 ml/kg). The 1.0 mg/kg dose had no effect on the learned behavioral response and served as a vehicle control. The 5 and 10 mg/kg doses both had profound effects on behavior. In these experiments, morphine doses were as follows: 13 paired

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