

CHAPTER 4

Developmental Environments

LIVESTOCK-GUARDING DOGS

An ocean of grass extends westwards from Manchuria to the Hungarian Plain. Over its undulating horizons, mounted nomads moved their flocks on a restless search for food. In winter they sheltered under the lee of mountains from the *buran* or white wind of winter; in the spring they relaxed when the flowers lacquered the ground . . . Their migration was their seasonal ritual, their music the howling of mastiffs, clanging of bells, and pattering of feet. [Bruce Chatwin, *What Am I Doing Here*. New York: Penguin Books, 1990, p. 197.]

Dogs . . . are of the greatest importance to us who feed the woolly flock, for the dog is the guardian of such cattle as lack the means to defend themselves, chiefly sheep and goats. For the wolf is wont to lie in wait for them and we oppose our dogs to him as defenders. [from *Roman Farm Management: The Treatises of Cato and Varro* (circa 150 B.C.) *Done into English, with Notes of Modern Instances, by a Virginia Farmer* (Harrison Fairfax) New York: Macmillan, 1913, p. 247.]

IN THE NEST: SHAPING THE BEHAVIOR

There are several types of sheepdogs. There are the herding dogs, which conduct livestock from one place to another. And there are the livestock-guarding dogs, which cannot herd sheep, are not expected to herd sheep, but are expected to protect sheep from predators such as wolves, coyotes, bears, jackals, baboons, leopards, or any other depredator that

pastoralists might encounter. (Note that I use “sheep”—as Varro used “cattle”—as a synonym for all livestock.)

The herding dogs and the livestock-guarding dogs are an animal behaviorist’s dream team of study animals. Two types (breeds) of dogs are raised in the same environment—pastures; they are both selected to respond to the same environmental stimulus—sheep; but they respond in two very different ways. One herds the sheep, the other guards them. Since the two breeds behave differently in the same environment, then we can assume the differences between them are genetic.

Livestock-guarding dogs are probably among the oldest of the working dogs. Obviously, they cannot be older than domestic sheep and goats, which are the first livestock, dating from about eight thousand years ago. In Varro’s time (2,050 years ago), livestock-guarding dogs were common and economically important. They show up frequently in ancient writings and pictorial art.

They are probably also the most numerous of all the working dogs. There are millions of them throughout the world. We in the West think of them as rare breeds, such as komondors, kuvasz, or Great Pyrenees. When I started studying livestock-guarding dogs in the 1970s, I found practically nothing written about them in the United States. What there was often turned out to be wrong. Breed books claimed that these big sheepdogs were both guardians and herders. English-speaking peoples tend to think of sheepdogs as collies or herding dogs. Perhaps this confusion was because the English-speaking world had either rid itself of significant predators many centuries ago and had no need for livestock-guarding dogs, or, more likely, the breed-book authors had not really observed closely the behavior of the dogs with the flocks.

In fact, when twenty-four-year-old English biologist Charles Darwin encountered livestock-guarding dogs on his visit to Uruguay in 1833, he was “amused” with what he saw. It was as if he had made an original discovery unique to South America. He didn’t seem to realize that the raising and training procedures he reported on were standard the world over (except in the British Isles). He didn’t seem to realize that there are, and were in 1833, millions of these dogs, with four or five of them each working for just about every shepherd from Portugal to China, from Russia to South Africa.

But Darwin is such a keen observer and wonderful writer, I will

present his discovery in his own words. He manages to capture all the elements of the livestock guardians in just a few sentences.

While staying at this estancia, I was amused with what I saw and heard of the shepherd-dogs of the country. When riding, it is a common thing to meet a large flock of sheep guarded by one or two dogs, at the distance of some miles from any house or man. I often wondered how so firm a friendship had been established. The method of education consists in separating the puppy, while very young, from the bitch, and in accustoming it to its future companions. An ewe is held three or four times a day for the little thing to suck, and a nest of wool is made for it in the sheep-pen; at no time is it allowed to associate with the other dogs, or with the children of the family. The puppy is, moreover, generally castrated; so that, when grown up, it can scarcely have any feelings in common with the rest of its kind. From this education it has no wish to leave the flock, and just as another dog will defend its master, man, so will these the sheep. [Charles Darwin, *The Voyage of the Beagle*, New York: P. F. Collier and Son, 1909, p. 163.]

Note that he says nothing about their breed, special breeding, selection, or anything to do with genetics. Breed is not an issue. In fact, from Darwin's description one has no idea what the dogs look like or how big they are. My guess is they are not much more than useful village dogs, adapted to the flock. Darwin was such a good reporter, surely he would have said something if these dogs were really big or beautiful or strikingly special in some way.

The message inherent in Darwin's description is, Take any local puppy and raise it properly and you have a decent livestock-guarding dog. Uruguayan shepherds, or any shepherds, for that matter, knew how to achieve good guardians. One hundred and fifty years after Darwin's observations, when biologists Hal Black and Jeffrey Green were trying to teach modern-day ranchers in the western United States how to raise and train livestock-guarding dogs, they reproduced the recipe used by Navajos to develop their flock guardians. They acquired this recipe by observing Navajo sheepdogs. The Navajos were originally taught by Spanish missionaries that the proper way to care for sheep is to raise sheep-guarding dogs with them. The system sounds very much like Darwin's formula.

Raise or place mixed-breed pups in corrals with sheep, lambs, goats, and kids at 4-5 weeks of age. Feed the pups dog food and table scraps. Provide no particular shelters such as dugouts or doghouses (the pups will sleep among the sheep and will dig their own dirt beds). Minimize handling and petting. Show no overt affection. Return pups that stray to the corral (chase them, scold them, toss objects at them). Allow pups to accompany the herds onto the rangeland as age permits. Punish bad behavior such as biting or chasing the sheep or goats, and pulling wool by scolding and spanking. Dispose of dogs that persist in chasing, biting, or killing sheep. [Black and Green, 1985]

In both descriptions the critical factor for achieving the appropriate adult behavior is to start with very young pups and raise them with the target species, without other dogs around. Darwin says, "I often wondered how so firm a friendship had been established." How can a carnivore become a protector of a prey species? Then Darwin answers his own question by describing the essential developmental environment. Instead of the dog being raised in the house, where it becomes trustworthy, attentive to, and protective of its master, it is raised in the barn, where it grows up trustworthy, attentive to, and protective of sheep.

If Darwin had had a modern vocabulary, he might have written: the interspecific social bonding between sheep and dogs depends upon imprinting puppies during the *critical period* of socialization, which for dogs is roughly between four and sixteen weeks of age. By paying strict attention to the puppy's developmental environment, one shapes and conditions the dog's adult behavior in such a way that it displays normally intraspecific social behaviors (innate dog-dog behaviors) interspecifically (nurtured dog-sheep interactions). As a result of this rearing environment and imprinting, the dogs cannot display predatory routines toward sheep. We have seen this phenomenon already with village dogs in Pemba, which, being raised with chickens, don't kill them.

Most shepherds don't even realize they are manipulating the dog's behavior, just as most of us have little knowledge of how we change a dog's behaviors by raising it from puppyhood in our home. We buy an eight-week-old puppy, take it home, where it is isolated from other pups, and it grows up with us. People, then, become the dog's social attachment. Livestock-guarding dog pups are born in sheep barns, form

their attachments during their first few months of age, and grow up socialized to sheep.

The only difference between the commensal village dogs, which were difficult to lay a hand on, and our pet dogs, or livestock-guarding dogs, is the social environment they were raised in.

Will any breed of dog do? Can you take any dog and start at four weeks and make it into a livestock-guarding dog? No, not really. We raised a retriever according to the recipe, but she never developed the protective attitude that the guardians do, and she never forgot how to retrieve. None of the specialized breeds I discuss in Chapter 6 will make good livestock-guarding dogs. And I will explain why.

Marcus Terentius Varro might have been among the first to recognize this distinction, and his advice to farmers over 2,000 years ago is still irrefutably valid today.

Be careful not to buy a sheep dog from a professional hunter or a butcher, because the one is apt to be lazy about following the flock, while the other is more likely to make after a hare or a deer which it might see, than to tend the sheep. It is better either to buy, from a shepherd, dogs which are accustomed to follow the sheep, or dogs which are without any training at all. While a dog does readily whatever he had been trained to do, his affection is apt to be stronger for the shepherds than for the flock. [p. 249]

Livestock producers who rely on their guarding dogs come to the same conclusion. Breed, shape, and genetics are not as important as the developmental environment. I will modify that statement ever so slightly as I show how the breeds of livestock-guarding dogs evolved. But for the most part, while the dog is in its first few weeks of life, and growing its brain, it is making the cell connections and rearranging them in a specific way, according to the signals that are coming from outside. This development predetermines its adult behavior. In other words, imprinting changes the dog forever.

Austrian ethologist Konrad Lorenz was maybe the first to recognize the importance of this period of primary socialization, which he was able to articulate suitably and which he tested in his now-famous experiments with birds—observations that won him a Nobel Prize. Working with graylag geese, he demonstrated that socialization with another

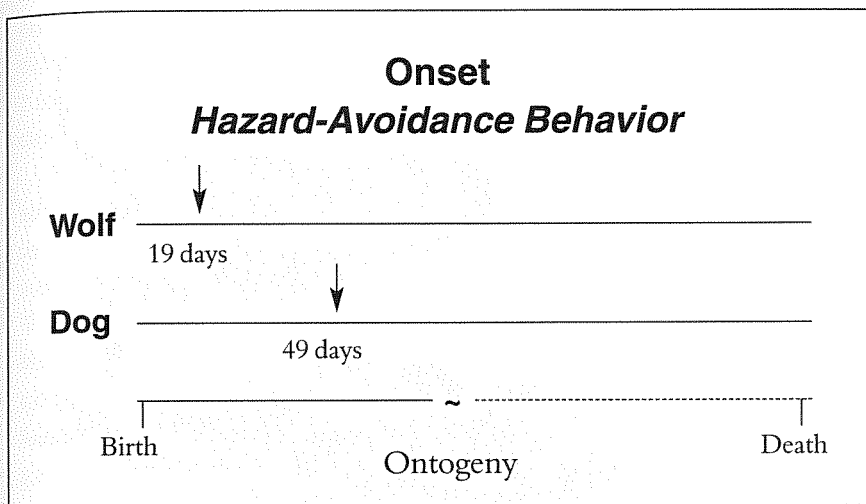
species (namely, with Lorenz himself) during a time-sensitive period of development resulted in the birds' being "imprinted" on him. Geese are a precocious species, walking and swimming within an hour of hatching. In some cases social bonding takes place within *minutes* of birth. In contrast, with Lorenz's jackdaws, an altricial (hatched in a helpless and naked state) species, the bonding was more gradual and occurred later in development. But if the bonding was done correctly, both species would prefer the company of their "foster parent."

Dogs have altricial young more like the jackdaws than the geese. Dogs are born without eye and ear function. Their survival, like that of the jackdaws, is dependent on parental care. They can't make it on their own. The concept of critical period resulted from the differences Lorenz recorded between the goslings, which can make it on their own and which form their social attachments immediately upon being born, and the jackdaws (and dogs), which need several weeks to form theirs.

Wolves, coyotes, jackals, and dogs all begin to form their social allegiances after their eyes open at thirteen days. With the onset of sensory functions, they have the capacity to form social relationships. By the time dogs are sixteen weeks old the window of social opportunity is greatly diminished or even closed. If they haven't seen sheep or people during that period, they will be forever shy of them. Wolves are different from dogs in that although they begin their social development at thirteen days, it is greatly accelerated and is closing rapidly by nineteen days. One of the reasons dogs can be so much tamer than wolves is a consequence of the much longer period during which dogs can form new attachments.

The period roughly between two and sixteen weeks, called the "critical period for social development," was originally described for dogs in a 1950 paper by John Paul Scott and Mary Vesta Marston, resulting from the notable studies at Bar Harbor, Maine. Critical period simply means that during this time, the pup is predisposed to and has the greatest capacity to learn particular social skills. It is in this period when dominance hierarchies are formed and dogs learn and practice their submissive behaviors. They learn to beg for food, whom to beg from, and how to turn begging into social greetings. They learn what species they belong to.

At sixteen weeks the social learning window closes. After that the dog has very poor abilities to develop or change its social skills. Essen-

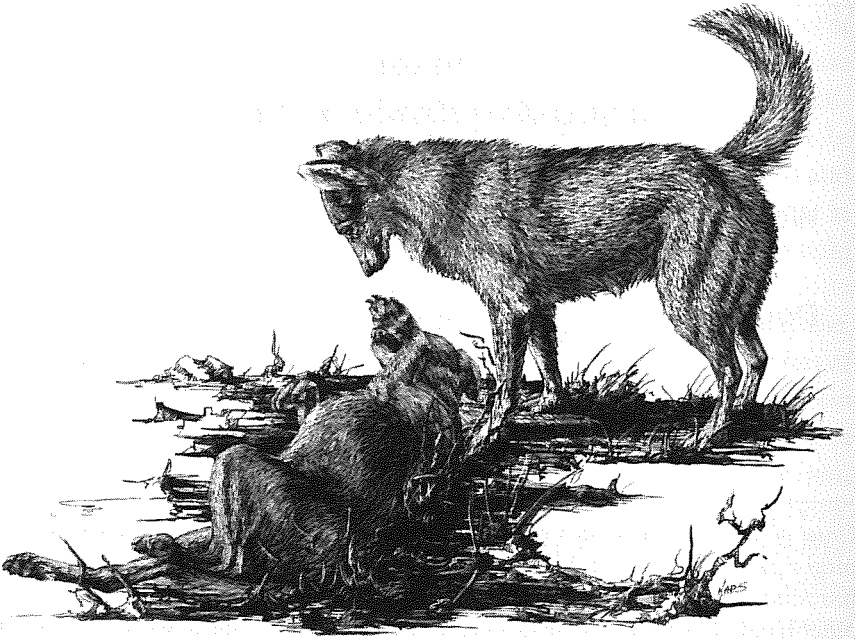


Onset of fear (hazard-avoidance) motor patterns in wolf and dog. The onset of fear motor patterns occurs at about nineteen days in wolves. If wolves haven't been introduced to people by then, it is doubtful they can ever be tamed. Dogs, on the other hand, don't have the onset of fear until the sixth to eighth week. It is much easier to make a pet out of a dog.

tially, at sixteen weeks, the dog's social personality is set for life. If a dog is shy of people at sixteen weeks then it will be shy the rest of its life. Can it learn not to be shy with intense training? It certainly could make some progress but it will always have a social "accent."

Is there any variation in the closing of the social window? Of course. Individuals will differ within a breed, and the average for each breed will differ. In fact, at Wolf Park the puppy socializers remove the puppies from the den before their eyes open. Because wolves' social abilities mature so rapidly, the human puppy parents have to spend twenty-four-hour days with them from their thirteenth to nineteenth days. And that includes feeding, cleaning, and playing with them. You can see why Mesolithic puppy snatchers would have had such a hard time taming and training wolf pups. Removing pups from mom and taking care of them during that neonatal period are extremely difficult and time-consuming. Just bottle-feeding them is a chore.

When a future livestock-guarding dog is raised among sheep for its first sixteen weeks, then for the rest of its life it treats sheep as its primary social companions—it is imprinted on them in a way similar to



Dominant and submissive motor patterns emerge during the critical period of social development. (K. Doktor-Sargent)



Dog submissive behavior displayed to sheep. When a pup begins to show dog social motor patterns toward sheep, one can conclude it has successfully bonded with them. This Anatolian shepherd dog, displaying a classic dog submissive posture to these sheep, is developing into a fine guarding dog. (Photo by Jay Lorenz)

the imprinting of Lorenz's geese. The adult guardian dog follows sheep, greets them, and responds to their signals by showing dominance and submissive behaviors interspecifically. Sometimes these dogs even get sexually involved with sheep.

Some people say that the dog thinks it is a sheep, but that is probably wrong. It "knows" it is a dog. The behaviors it directs toward the sheep are dog social behaviors, not sheep social behaviors. If it thought it was a sheep it would display sheep social behaviors, which are very different. When dogs threaten they show their teeth and growl, while a sheep threatening a dog stamps its front foot. Growling as a social response is genetic, a dog characteristic. Dogs do not normally growl at their prey. Growling is directed at animals they need to communicate with. Thus, growling at sheep is a good sign that the dog has developed a social relationship with sheep during the critical period. Who they socialize with is learned, but dogs can learn this lesson only during the critical period, which is genetically timed.

When I talk to my dog I'm communicating by means of human social behaviors. I don't think I'm a dog. But there is a part of me that thinks my dog is human. I even think my dog knows what I'm talking about. I watched a Portuguese shepherd yelling in perfect Portuguese at his goat, which was browsing his neighbor's garden. The goat must have understood Portuguese because it hastily got out. It seems that livestock-guarding dogs, in the same way, think sheep are doglike and understand dog language. When I feed my dog, the sheep try to steal as much dog food as they can, and the dog growls at them, as if they could understand what it meant.

Typically, Old World shepherd dogs spend their first sixteen weeks with one or two littermates, a few adult dogs, including their mother, three hundred or so sheep, and a shepherd. The Italians have a word for this social triangle. It is called a *morra*. After the sixteen weeks are over, the dog has been physically shaped and behaviorally molded in such a way that it "needs" to spend the rest of its life with the *morra*. One would never think to purchase such a dog and take it back to a city apartment as a pet. It probably would be very uncomfortable and could never make a total adjustment to the nonsheep environment. Taking a wolf pup from the den at four to six weeks would produce a similar unsatisfactory result.

The practical aspects of critical period contribute much to our relationships with dogs. In fact, the first and most important aspect of cre-

ating a mutual relationship with dogs is not genetic at all, but rather the development of puppies in the environment they are expected to perform in as adults. Unfortunately, the critical period is often poorly understood, even by trainers whose job it is to shape a dog's behavior for a specific use as an adult. For example, a pervasive view describes the social behavior within a pack of wolves as genetic. Because of this, the reasoning of dog trainers goes: dogs are descended from wolves and wolves form packs, and therefore dogs understand wolf-pack behavior and should respond to the trainer as "alpha," or dominant, in its life.

But *is* wolf-pack behavior genetic? Not really. Pack behaviors, like all behavior, are epigenetic—above the genes. They are a result of behaviors learned during the critical period. Pack behavior is just one of many social options available to wolves. If dogs don't develop pack social behavior during their critical period, there is no sense in trying to simulate pack leadership after that social window closes. Pack behaviors are much more complicated than just hierarchies of social status. They are learned through social play and care-soliciting behaviors during the juvenile period. A trainer who pretends to be the alpha leader of a wolf pack—say, by turning a dog over onto its back and getting down and growling at its throat—is intimidating the dog, no doubt. But to a dog, the message is not what the trainer thinks it is. Teaching and learning are seldom facilitated by intimidation. A dog doesn't learn how to sit from a trainer who intimidates it, simply because the coercion diverts the dog's attention away from the task and toward its social status. An alpha wolf is not trying to teach a pack member anything, especially to sit. The fact that so many believe the wolf-pack homology, and use it in training a dog, is really a testament to how little is understood about canine behavioral development.

Critical period for social behavior sounds like magic. Something permanent is actually happening in the dog's brain that causes it to become essentially unalterable after the period is over. For some reason, what is learned, and when it can be learned, is limited to that time period. Once "learned," the behavior cannot, easily or completely, be unlearned. Given how much we do know about teaching and learning, it would seem that we could teach the dog to behave differently. But the dog doesn't appear able to learn it. Proverbially, people do know this: you can't teach an old dog new tricks. But do they know why?

Some permanent change must be taking place during the critical

period. It really does look like a dog that is socialized with sheep is wired differently than that same set of genes growing up in a village without sheep. Could it be that the ability to learn is a genetic response to the environment? Could learning be genetic?

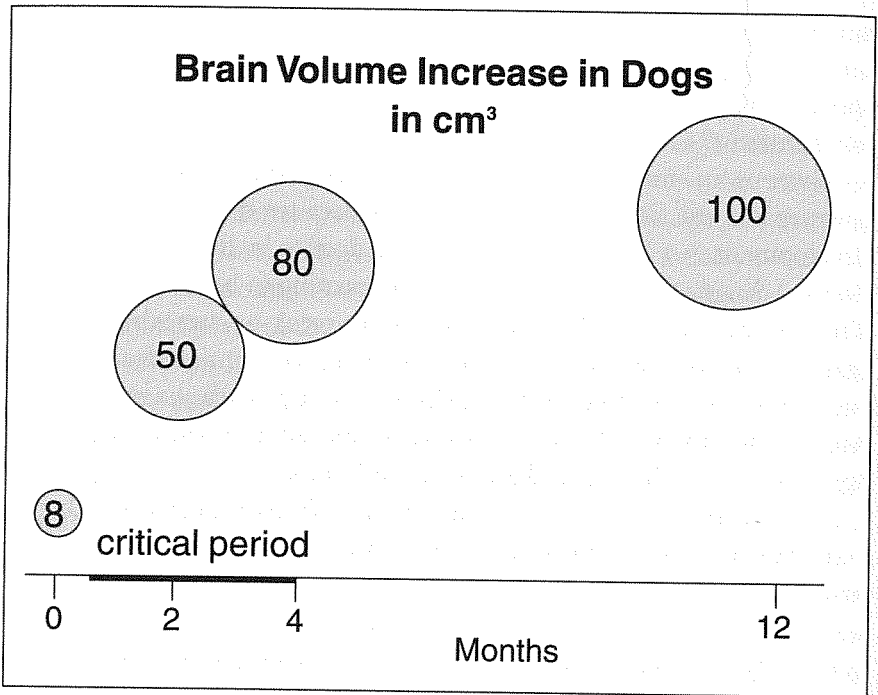
There is an important essential here. Early experience is vital not because it is the first learning, but rather because it affects the brain's development. A while back, I was training dogs to be livestock-guarding dogs—I *thought*. I thought the dogs were learning to be flock guardians. The critical period closed on the sixteenth week or thereabouts, so, I reasoned, if we got our dogs out with sheep any time before sixteen weeks we would be fine. But by keeping our pups with sheep, we were not teaching them to be flock guardians. Instead, the young dogs were "growing" their flock-guardian-behavior brains.

Brains grow, just like legs or any other body part. Legs not only *can* walk but they *must* walk in order to grow properly. Legs that do not walk while they are growing (critical period) wither and become useless. The same is true of brains. Brains grow in two ways: they get bigger, and they change shape. How much they grow and which way they change shape depends on the kinds of environmental stimulation they receive during their first sixteen weeks.

The period of the most rapid brain growth is also coincidental with the critical period for social development. A day-old livestock-guarding puppy has a brain volume of about ten cubic centimeters. That is about the size of the very end of my little finger. By the time the pup is weaned at eight weeks, it is sixty cubic centimeters. By the time it is sixteen weeks, its brain is eighty cubic centimeters and rapidly approaching full size at a little over one hundred centimeters. Tom, one of our original and favorite Italian sheepdogs, grew to a hundred pounds with a brain volume of a hundred and six cubic centimeters.

At birth a puppy has essentially all the brain cells it is ever going to have during its whole life.

If the puppy brain has essentially the same number of cells as the adult brain, how can it grow ten times bigger? The answer is that brain growth is almost entirely in the connections between the cells. Of all the brain cells present at birth, a huge number are not connected or wired together. What takes place during puppy development is the wiring pattern of the nerve cells. Some nerves make their connections spontaneously, driven by internal signals. Some nerves actually "look" for a



Brain growth chart. Most of the growth in a dog's brain is during the critical period of social development. After growth stops, it is difficult to change the wiring.

muscle to attach to. Other connections are motivated by external signals. External to the brain, that is. For example, the eye tells the brain how many cells it needs to have in order to run the eyeball. Big eyes need more cells than small eyes, and thus animals with big eyes tell their brain to connect up a greater number of cells for eye function.

It is not only the size of the eye to which the brain must accommodate, but also the activity of the eye. The brain accommodates to the eye by growing the appropriate connections for both its size and its activity. The brain of a puppy raised in the dark doesn't make as many connections. A puppy raised in the dark has a smaller brain than one raised normally. A puppy that is raised in an impoverished environment has a smaller brain. It has the same number of cells, but not as many get wired together. Experiments with kittens showed that animals raised with horizontally striped glasses during development of the eyes cannot, as

adults, see in the vertical plane. They walk into table legs as if they can't see them.

The onset of other sensory functions, too, happens in the critical period. Animal behaviorist Ed Bailey notes the importance of olfactory imprinting for establishing a bond with a young pup. He advises prospective owners to visit the litter from five weeks of age on, handling the chosen pup and allowing it to imprint on specific smells. Darwin in Uruguay noted that the guarding-dog pups were given "a nest of wool . . . in the sheep pen." From birth, they lived amid the feel, sight, sound, smell, and taste of sheep. Among gun-dog breeders, it is known that young pups can easily be accustomed to the sound of a gun firing nearby, if they are exposed to this and other loud noises before the onset of fear.

At this point, it should be clear that the sight, smells, and sounds of sheep influence the growth of a brain in a manner distinct from the influences on the brain of a puppy that grows up in a city apartment. If the puppy doesn't see sheep until it is eight weeks old, it has a differently shaped brain than one that sees sheep from four weeks old. At sixteen weeks old, almost all the connections have been made, and the brain is about to stop its major growing. A puppy that sees sheep for the first time at sixteen weeks can make some tiny growth adjustment to those environmental signals, but not as many.

It is complicated and would take massive computers to figure out all the possible variations. But at the same time it is conceptually relatively easy to visualize what is happening. Why is it that no two animals truly look alike or think alike? Simply because no two animals can grow up in identical environments. No two animals can occupy the same space at the same time, which means they cannot receive identical environmental signals, and therefore they do not get wired up identically. As a result, they do not have the same capacity to think and behave. Even if the impoverished pup gets taken to an enriched environment as an adult, it cannot learn to cope with that environment because it does not have the necessary cell connections. Once the dog gets to sixteen weeks it has made (or has not made) just about all the social connections it is ever going to make.

Understanding brain growth should dispel the nature/nurture controversy once and for all. It is never, ever either nature *or* nurture, but always both at the same time. But liver cells make more liver cells

because that is the environment they respond to. Behavior is always epigenetic—above the genes—an interaction between the genes and the developmental environment. It is a synergism of gene products and the climate, producing a unique organism. No two look or behave alike.

Development of the growing brain is a cascade of billions of events that are internally (nature) and externally (nurture) motivated. To say, however, that the cascade of growth events is genetic is to miss the point.

In 1976, when I started studying livestock-guarding dogs, I assumed that since the behavior of guardian dogs was so dissimilar to that of border collies, then guardian dogs must be preprogrammed to be livestock guardians. I thought livestock-guarding-dog behavior was genetic. That was what everybody was telling me. These breeds, everyone said, had been selected to guard sheep. We were also constantly asked, “Which breed is best?” The implication was, which breed has the best genes?

At the same time, during our research program with the guardians, we received many telephone calls from producers with the following complaint. The caller had purchased an older pup—say, a four-month-old Pyrenean from a breeder who told him it was a traditional livestock guardian—and he couldn’t get the dog to stay with the sheep even though the dog was from “good” breeding stock. Our first question to him: Was the dog in with sheep for its first four months? No? Then it had the wrong brain shape. You can’t satisfactorily teach a dog a new social trick.

Raising puppies, and especially raising them for special jobs as adults, requires attention to detail. When people raise pups as pets, they often get them at about eight weeks old, take them home, feed and cuddle them, housebreak them, take them for walks, and play with them. What they are doing (and they’re usually not aware of it) is providing specialized brain-growing conditions that shape the dog’s future behavior. If I were buying a puppy for a pet, I would check its early environment and make sure it wasn’t raised in a kennel or in the laundry with only its mother and littermates for immediate company during that first eight weeks. I’d be very suspicious of a department-store dog that was twelve weeks old, wondering if the dog had time left to grow the brain I was looking for. I’d also suspect that if I locked the pup up in the house alone each day while I went to work, I’d get a small-brained dog without enough connections to be a good social companion.

Critical period needs to be explored even further. It implies so much more than simply animal-to-animal socialization. For example, one reason Konrad Lorenz's geese stopped imprinting shortly after birth was because they experienced the onset of a fear response. Fear is a threshold response, meaning that a stimulus has to exceed a certain level before it provokes a response. Take any signal. The animal could respond to the signal by approaching it curiously, or the animal could try to escape or avoid whatever produced the signal. Take a sound. The same sound could be loud or it could be barely perceptible, depending on the ear's development. As the sense organ begins to function, what might be a loud sound to an adult is a soft sound to an immature ear. Animals avoid loud sounds and could ignore or investigate soft sounds. They could habituate to sounds that were continuous. Fear is in great part an avoidance of novelty.

Before the onset of fear responses, animals do not show fear to novel shapes and sounds. For a newborn puppy, everything is novel. But after the onset of fear, new novel shapes and sounds cause avoidance behaviors—call them hazard-avoidance behaviors. Gun-dog trainers expose their pups to gunshots before the puppies grow the “fear” portions of their brains. Shooting guns around puppies for their first six weeks grows a brain that expects those sounds from the environment. Gunshots become normal. But if the gunshots are not introduced until after the onset of fear (which in this case might simply be the threshold where the sound is perceived as loud), the dog will perceive them as hazards to be avoided. A gun-shy dog is not much use on the hunt. And as always, once you have a gun-shy dog, there is not much that can be done about it. (That is not to deny that some dogs are more sensitive than others, regardless of the environment.)

Fear turns on at different times in different breeds, and even among individuals within a breed, due to individual development rates. Six to eight weeks is an average age for one breed to display fear responses, while the next might not display them until eight to ten weeks.

Each behavioral system—fear, submission, investigation, play—has its own rate of development, and varies among breeds. Each is dependent on glandular development and hormone secretions, as well as motor coordination and sensory perception. And each feeds back on the puppy to change not only the shape of the brain but the shape of all the other developing organs. And after that each new signal works on

that new shape, changing it in a novel way. And so on. The bones of active puppies are a different shape than those of inactive pups. One can change the growth rate of glands by exercising them, and thus change the threshold timing of specific behaviors.

During the critical period of socialization, border collies and some bird dogs show the onset of predatory behaviors. Ten-week-old border collies begin to eye and stalk objects in their environment. They then incorporate eye-stalk-chase games into their play routines with other border collies. Thus, part of their social play has predator-versus-prey components. Sheep are very sensitive to predator-versus-prey behaviors and avoid animals that display eye-stalk games.

If livestock-guarding dogs ever display predatory behaviors, they generally do not appear until the dog is five or six months old. By then, their window of social development is closed. Therefore they cannot integrate those predatory behaviors into their social play. That in itself makes their breed personality very different from collies.

The basic predatory behaviors (called predatory motor patterns) of a dog are:

orient/eye/stalk/chase/grab-bite/kill-bite/dissect.

Not all breeds of dogs have a complete set of predatory motor patterns. In fact, one of the clues about the status of the village scavenger on Pemba is that this dog didn't display any, at least not to village livestock or chickens.

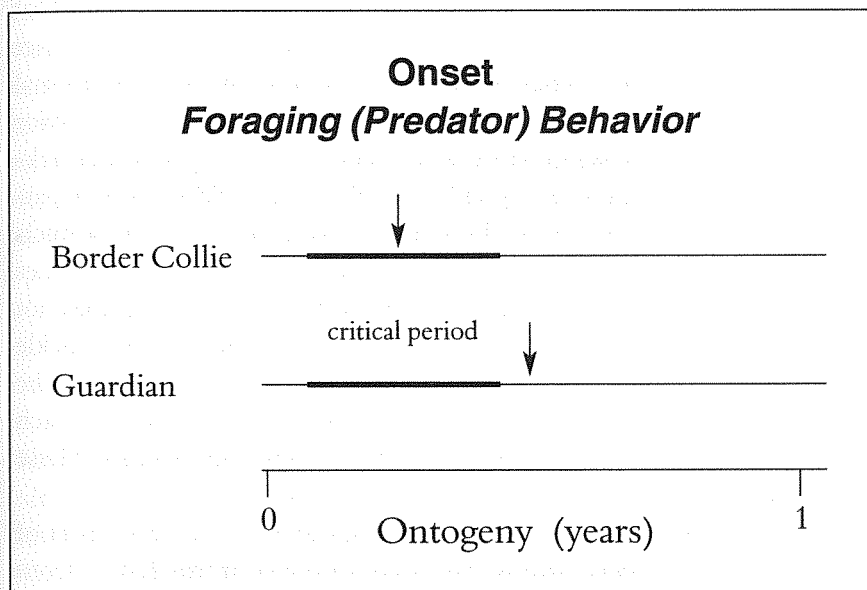
Dogs and carnivores in general don't show kill behaviors to animals they grow up with, or individual animals they know. Ethologist Paul Leyhausen, in his book *Motivations of Human and Animal Behavior*, described an example of this phenomenon. He had a wild golden cat (*Profelis temminckii*), to which he fed rats. One rat avoided being caught and hid under the cat's bed. That rat became "friends" with the cat. The cat ate each new rat but not its friend—until at four months the rat was removed, to be put back, much larger, three months later. The friendship was over.

We had five chickens that our Alaskan husky Sitka "knew." She never touched them. They got old and I added two more. Sitka killed and ate both new ones and still didn't touch the old ones. Breeders of working foxhounds know how this works, and place their puppies out to be raised by farmers known as puppy walkers. Since these hounds don't

develop their hunting instincts until after the time during which they have been socialized with farm animals, the adult foxhounds, thus raised, can chase a fox through the farmyard and never look at a chicken, even one they don't know. The knowledge and use of critical period by foxhound breeders greatly improves hunter-farmer relationships.

The very best livestock-guarding dogs never develop any predatory motor patterns. The less than the best (which is practically all of them) display one or two predatory motor patterns (most likely chase and grab-bite), but very weakly.

What that means is that many an imperfect dog makes a very good sheep guardian if the owner has paid strict attention to the development of the animal during the critical period. But with other animals the good guardian may not be so circumspect. Some will chase and sometimes kill wildlife. In Texas, one of our Maremmano-Abruzzeses, named Dolly, was a wonderful guarding dog—trustworthy, attentive, and pro-



Onset of predatory motor patterns: border collies and livestock-guarding dogs. Border collies have an early onset of predatory motor patterns that they incorporate into their social play. Predatory behaviors of livestock guardians onset after the social window has closed. Their play behavior is not as rich in behavioral elements as that of border collies.

tective with mohair goats. But she would catch and kill a rabbit, and then carry it around for days until it wore out. Then she would get another. She had the chase and kill motor patterns, but not dissect. Therefore she could kill animals she hadn't been socialized with, but she couldn't eat them because she was missing one of the essential elements of predatory behavior. The rancher's interpretation was that Dolly just needed a soft pillow, for he often observed her resting her head on the rabbit carcass.

Just as the social motor patterns have a critical period, so do the predatory ones. Each of the patterns of eye, stalk, chase, grab-bite, kill-bite, and dissect emerge independently from one another during their own critical subperiod. One day you observe the kitten eyeing the ball of yarn. Days later it does the chase and the pounce. Eventually it ceases displaying the behavior to yarn and turns its attention to mice. It appears that the animal is learning to kill, or practicing to be an adult, by playing the eye-stalk games with the yarn. Actually, something much more elaborate and serious is going on.

Motor patterns need to be reinforced the first time they appear. Not all of them, but many, if they are not reinforced during the onset period, drop out of the repertoire, never to appear again. If the animal performs the new pattern then it will persist. Presumably the behavior is "growing," and if it is not stimulated it does not grow properly. Suckling in newborn puppies is a good example. The suckling motor patterns, sometimes called the suckling reflex, turn on in most mammals slightly before birth. If the puppy doesn't suckle within a few minutes after birth, the behavior extinguishes, presumably because it does not grow the proper nerve connections. The puppy that does not suckle within a few minutes after being born loses the ability to perform the sequence. It cannot be taught to do it later. Not only can you not teach an animal to suckle, you cannot teach one to chew and swallow. These are innate motor patterns that develop or onset later.

I've seen cases of livestock-guarding dogs that showed the onset of the chase motor pattern, but if they were removed immediately from the sheep pasture, the behavior dropped out of the repertoire, never to appear again. I've also seen cases of livestock-guarding dogs, with the onset of chase, running at the sheep. My sheep, which had a long history of being socialized with dogs, didn't run in response to the chase. If the sheep don't run, the dog can't chase them. Even though the dog

has the potential to chase, it needs the environmental signal in order to display the behavior.

The layering and interacting of developmental events that produce an adult working dog are precisely unfathomable. The complexity of the developing dog's behavior should remind the reader how passé is the nature-versus-nurture controversy. Although it was once a compelling question for behaviorists, scientists now understand why nature cannot ever be separated from nurture. When we look at the critical period for social development, we realize that the genetic nature of the dog is being shaped by the environment in which it is growing up. If there is no environmental stimulation, there is no epigenetic response.

Most good working-dog people make their own dogs. I might buy myself a border collie pup, but that is when my work begins. I have to shape the behavior of that pup from an early age in order for it to be the herding dog I want.

With livestock-guarding dogs, the shaping often comes naturally. The dog is born in a sheep culture. The rest is natural. To the people who call me and ask, "What breed of dog is best?" I reply, "None of them will work at all if they are not raised with sheep during the critical period. The only thing you are looking for is a breed of dog that has a weak tendency to show the predatory motor patterns, a breed where the predatory motor patterns drop out if not reinforced, and dogs four or five weeks old that can be socialized properly. A village scavenger can have all those qualities. Go capture a village pup and raise it with sheep."

THE TRANSHUMANCE: DISTRIBUTING AND MIXING GENES

The behavior of a good working sheepdog is the interaction of a number of environmental, genetic, and epigenetic events, occurring during development. The behavior of the original livestock guardians is not predicated on any genetic evolution of these sheepdogs. And yet we now think of them as breeds—breeds selected to be large, white, and protective. Often, when livestock-guarding dogs are discussed, the topic hinges on which breed is best. Our research at Hampshire College focused on breeds, and we compared the success rates among several hundred each of Italian Maremmano-Abruzzeses, Anatolian shepherds,