More on Ontogeny of Behavior

I have noticed that in our discussions everyone tries to talk at once, and sometimes everyone seems to be talking faster and faster. So I guess we have finally started doing something worthwhile in the staff meetings, although I would like it better if I didn't come away so frustrated and hyper that I can scarcely listen to the colloquium lecturer! This set of comments is a selfish effort to relieve my own personal frustration.

David began by asking me what I meant by plasticity, and I intended in my answer to say that I meant the opposite of nonplasticity -- the opposite of rigidity -- and nothing more. To me that is what the term means -- the dictionary definition is: formative, malleable, capable of being molded or modeled, pliable, impressionable. David said that wasn't specific enough to mean much. But it is completely specific because the term only means the opposite of rigidity. It isn't intended to describe any particular case of plasticity. Its entire meaning does no more than set it apart from rigidity or nonplasticity. To me that is simply the nature of language. One wouldn't say that the term "truth" is too general to mean anything because it doesn't specify whether or not the label on a cornflakes box is accurate. This feeling, and that intent on my part, is why when he asked me if I meant plasticity of any sort in any direction I answered by throwing out my hands and saying, "Of course." I wasn't thinking of any particular case of plasticity, such as the human embryo or juvenile. I don't think you can read my essay and imagine in your wildest dreams that, because I think plasticity in the general sense includes all kinds of it, I therefore think that humans are plastic in a way meaning that they can be made into anything at all. I can understand the frustration of a psychologist surrounded by other psychologists who act as though they believe that, and I guess that must be the origin of David's frame of mind (supporting evidence comes from the fact that Randy was softly denying that I meant any kind of plasticity in any direction; he must have understood what David meant). No such experience, however, was driving my definitions and answers, or the construction of my essay.

Barb said that learning must sometimes extend ranges of plasticity because she regards herself as more plastic (I think that's what she meant) now than before she became as educated or knowledgeable as she is now. To me that is not necessarily evidence of increased plasticity. I think that learning tends to create foci along ranges of plasticity (potentials of malleability), but I certainly agree that some of them can in turn open up new ranges of variability or malleability in the phenotype. Thus, learning language can create opportunities to use it in ways or across ranges of variability that didn't exist for the learner previously.

I think of learning as the regulation of phenotypic plasticity by establishing in the organism's neurophysiological and behavioral apparatus new relationships between different stimuli or new relationships to particular stimuli in the environment. In this sense learning represents reduction in the range of plasticity or variability in the organism's ontogenetic repertoire; the implication of plasticity that is contained in the everyday usage of the term learning derives from the fact that different things can be learned, so that learning can make organisms different from one another and can also change them individually across their life spans. Learning thus changes organisms because of their existing plasticity, and it incidentally causes the organism's plasticity to be more evident to us; but I don't think of it (at least usually) as an introduction of plasticity into the organism's makeup, or an increase in its plasticity. Instead it typically represents a decrease in possibilities, or plasticity along the particular axis involved in the learning. Thus, when I learn who my sister is, the possibilities with respect to whom I can appropriately respond in that context are reduced; when I learn to play a musical instrument or use language, the actions I take with respect to these things become patterned in ways that surely can be described as reducing the potential, restricting my actions, patterning my output so as to make it more predictable, more useful; this is accomplished by eliminating certain

possibilities that were available before. A monkey at a typewriter might eventually be able to write Shakespeare, because all possible movements and combinations of movement are available to him: that is plasticitiy. Learning to use language on the typewriter removes some of these possibilities, even if it thereby makes it easier to produce something marvelous, such as a bit of Shakespeare. This may be a confusing example in one respect (I actually think all examples are confusing because we think this way so infrequently), because the learning, say, of musical intervals and how they can be produced on a particular instrument actually opens up to the player the possibility of reproducing very large repertoires of music he has only been able to hear up to that time, as well as the possibility of being creative and developing his own music (meaning creating patterns of sound he never heard before, and that other people will respond to in predictable fashions; paintings and musical compositions, of course, are often in some large part "happy accidents," but they are usually more regulated happy accidents than the monkey duplicating Shakespeare). This is what I meant in the previous paragraph.

In adaptive terms, learning is a capability of the organism that enables it to select or focus on reproductively appropriate points or sections along a continuum (or a series of possible points) of potential phenotypic plasticity. Thus, I learn the characteristics of my sibling or my child or my parent; I learn how to avoid embarrassing myself in front of associates; I learn how to construct or use a particular weapon or tool. Each of these learning events patterns and focuses my *possible* reactions and movements. By restricting sets of such reactions or movements they cause the ones I perform to be adaptive. They also open the possibility of new ranges of plasticity involving other aspects of my environment: I can spend a lifetime responding in various ways to a relative; I may be required to learn new patterns of behavior to respond adaptively to the animal I have killed with a weapon or the crop I have raised with a tool.

In order for learning to occur, and for it to be reproductively appropriate, there must be intrinsic mechanisms that sensitize the organism to the conditioning stimuli, and in some caes restrict the sensitivity to appropriate times and places, and that establish the limits to which the organism will respond. Likewise, there may be mechanisms that inform the organism about the value of accepting particular points along the axis of plasticity.

The different "kinds" of learning typically described in textbooks represent attempts to describe the different ways that learning occurs: habituation, classical conditioning, operant conditioning, trial-and-error learning, insight learning, latent learning, short-term and long-term learning, imprinting, sensitive-period learning, etc. The only adaptive connotations available from concentrating on these different mechanisms of learning relate to how examples of each can be hypothesized or shown to be adaptive in particular circumstances. Adaptive hypotheses are of course assisted by information about the actual nature of the conditioned and unconditioned stimuli and their roles in the life of the organism.

Consider, as a model of ontogeny, a tree. When is it most plastic? Surely when it is but a single-stemmed sprout just emerging from the soil, for then all possibilities available to a tree of that species (with that genetic makeup) are still available to it. Later it will be a magnificent, huge, burgeoning, blossoming creation. But is it at that point more malleable, more plastic -- does it have more potential in more different directions? I don't see how. Every time a twig grows to a point of dividing, and divides, plasticity is reduced, potential is reduced.

but new possibilities are created as the tree develops too

A tree's ontogeny, in the sense of its overall morphological development, is evidently governed by simple decisions such as "always turn (and grow) toward the highest intensity of light." A human's behavioral ontogeny must be governed by infinitely more complicated kinds of commands, and surely not all of them as nearly equal in import as those governing a tree's form. But maybe the principle is roughly the same. Think about analyzing an adult tree by digging your way into the tangle of its ontogeny and reconstructing the reason for every decision. The job of doing that for a human's behavior is so much more complex as to be virtually

I think we (everyone) needs to think of ontogeny by dividing it into different "kinds," in a way compatible with adaptiveness. This is the "start" that exists in my mind:

1. *Canalized singularly (monomorphically)*: only one phenotype occurs, at least in the "normal" range of environments, and typically that phenotype is created by ontogenetic events unrelated to the event(s) for which the phenotype is functional. Presumably this happens because the event being reacted to is so predictable that it is not necessary, and presumably not even useful or adaptive, to use any contingencies of that event itself to program the relevant phenotype. Because anything will do, the least expensive and most reliable thing is used. It is easy to see why we are tempted to refer to such aspects of the phenotype as "genetically determined," forgetting that there are innumerable ontogenetic events that could knock it off course, so that it must be produced accurately, at least sometimes, only as a result of continual and considerable ontogenetic canalizing efforts (even if these canalizing efforts involve mechanisms for turning on certain genes only at certain times during ontogeny). Phenotypic events of this sort appear to be abundant, but close inspection will probably reveal that few do not involve significant -- and probably adaptive -- variations. Thus, I would be extremely surprised to discover that there are no variations at all among humans with regard to fear of snakes -- the example probably most brought forward from human behavior.

2. *Canalized multiply (polymorphically)*: multiple possibilities depending on reliable indicators that distinguish for the organism different conditions important to it. Neither the stimuli nor the reasons for the behavior are novel in any way. Thus, day length tells many organisms when to turn on and off their reproductive cycles, and it tells many organisms which of two or more morphs to assume, because it predicts vastly different seasons. In this kind of canalization, the stimuli used and the environmental events encountered are not only highly predictable but they also are not novel. Day length is a reliable predictor of seasonal changes that are also reliable every single year; the reason day lengths are useful to organisms is that the organisms benefit from behaving differently in different seasons or they benefit from taking up different morphological and physiological forms as well as different behaviors. Another such pattern is shown by migratory locusts, which use, among other things, their own density (which predicts things like food availability, especially in places like the Sahara) to "decide" (developmentally) which of two extremely different phenotypes to assume (these phenotypes differ in shape, size, color, color pattern, number of eggs laid, sizes of eggs laid, habitat occupied, wing length, tendency and ability to fly, whether or not they swarm and fly together or are solitary, how long they live, and many other attributes -- they were originally described as different species). Whether or not correct, a suggestion of canalized "dimorphism" is contained in the recent paper by Belsky et al on effects of father-absence in families on the development and behavior of girls.

3. *Environmentally adjusted (canalized?) polyethisms* (or polymorphisms) in the production of which novel stimuli are utilized, and novel relationships of stimuli, or novel objects of behavior, or both, are involved. This category needs to be expanded by considering all kinds of learning and all combinations of kinds of learning -- using learning to cover essentially everything that might fit into this category. I find it difficult to expand on this category satisfactorily, even though that is obviously the big task. It's what must be done to continue trying to further understanding of possible and probable backgrounds ofhuman behavior. Psychologists are more able to do this than I; they just must keep their ruminations connected to adaptiveness.

I see the overall ontogeny of behavior as typically involving all three of these kinds of events or phenomena, often sequential in the order given here during the individual organism's ontogeny. I also imagine that most complicated human behavior involves indefinitely long sequences of

events of the third kind occurring one after another with each depending on those that preceded it (think of just the sequences involved in language learning). Underlying every such sequence, however -- and maybe even every such event in a sequence -- there have to be mechanisms that sensitize the organism to the particular stimuli that are relevant, that cause this sensitivity to be temporally and circumstantially appropriate, that establish the limits of the response, and that inform the organism about the value of accepting particular but different points or subranges along different axes of plasticity. I see these underlying mechanisms also as taking all three forms (1,2,3 above). But for every sequence (at least) that takes the third form there will be underlying it at least one (probably many) that take the first or second form.

Consider kin recognition through associative learning (e.g., a mother recognizes as her offspring the individual she first sees following parturition). The learning individual must have a mechanism that tells it when (or under what circumstances) to accept the first individual it sees as its offspring. It will almost surely be prepared to reject (one way or another) individuals that fall outside certain limits in their appearance or performance. And at least in any organism that treats different kin differently, there must also be a way of devaluing the individual appropriately for nepotism or whatever future interactions are appropriate. Because it is fairly easy to see how all of these underlying mechanisms could work in recognizing relatives via associative learning, andd difficult to see how they all could work in other proposed mechanisms such as through use of similarity or difference in regard to a few traits of the phenotype, is one of the reasons I expect nepotism to be dispensed on the basis of kin recognition accomplished by social learning (the other reason is that social learning may be the only mechanism actually demonstrated so far).

This is just an initial flow of words, but if I take time to make it better you won't get it before the next meeting. It doesn't need to be discussed; I just wanted to say it.