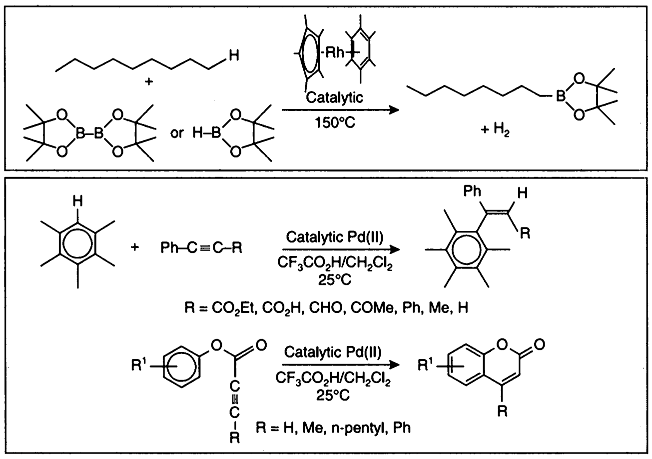
linear alkylborane products could be produced catalytically from alkanes and diboron reagents (R_2B-BR_2), but once again, light was required to drive the reaction (*7*). Chen *et al.* (*2*) now report a transition metal catalyst that can accomplish this same transformation at 150°C without the need for photochemical activation. This report represents a major advance in the ability to perform selective transformations of alkanes, as only terminal activation products are seen.



Catalytic functionalization of hydrocarbon C–H bonds. Both aliphatic and aromatic C–H bonds can be functionalized with the use of transition metal compounds. The alkylboron products (**top**) can easily be converted into a variety of derivatives, and the aromatic products (**bottom**) form in high regioselectivity and stereoselectivity.

The key to the reaction is the use of the catalyst ($(\eta^5$-$C_5Me_5)Rh(\eta^4$-$C_6Me_6)$). This species is believed to lose the hexamethylbenzene ligand under the reaction conditions and form the intermediate ($(\eta^5$-$C_5Me_5)RhH_2(Bpin)_2$). It is this intermediate that is believed to be responsible for the reaction with alkane to give H_2 and the organoborane product (see the figure). The catalytic reaction is characterized by high yields (80 to 90%) and high conversions (100%) of the diborane reagent, with low catalyst loadings (0.5 to 5%). The hydrocarbon substrate serves as the solvent, and both arenes and ethers appear to react in a similar manner. Exclusive selectivity is obtained for the straight-chain alkyl-borane products. The only other comparable metal-catalyzed chemistry of hydrocarbons that has been reported is the catalytic dehydrogenation of linear alkanes to alkenes and hydrogen, but selectivity for terminal alkenes has been a problem in this chemistry (*8*, *9*).

Jia *et al.* (*1*) present another remarkable demonstration of hydrocarbon functionalization in the form of the addition of a two-carbon unit from an acetylene to an aromatic ring. They have found that the simple Lewis acid palladium(II)acetate in trifluoroacetic acid/dichloromethane solution serves to catalyze the facile insertion of electron-deficient acetylenes into the C–H bonds of electron-rich aromatics (see the figure). Catalyst loadings of only 1 to 5% are required, and the reactions proceed at ambient temperatures to give selectively the trans-insertion products. An intramolecular version of the acetylene insertion reaction leads to the formation of bicyclic coumarins in good yield (70 to 90%). The study builds on the work by Sen with acidic solutions of Pd(II) for alkane functionalization (*10*) and shows vast improvement over any known alkyne/C–H insertion reactions (*11*). It provides many strong examples of how reactive small molecules such as alkynes can be incorporated into C–H cleavage reactions to generate products with a high degree of functional complexity.

The two reports described here extend hydrocarbon functionalization by homogeneous transition metal complexes to include facile thermal reactions with substrates that introduce reactive groups in high yields and selectivities. The work will stimulate others to find even more useful hydrocarbon functionalization schemes, with strong potential for industrial applications.

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PERSPECTIVES: NEUROSCIENCE

Strengthening Visual Connections

Max Cynader

It has long been known that the environment in which the mammalian cerebral cortex finds itself early in postnatal life has the potential to alter its structure, function, and its connections with other parts of the brain. The strongest evidence in support of experience-dependent modification of brain circuitry during a well-defined critical period of postnatal development comes from studies of vision. The Nobel Prize-winning work of Hubel and Weisel in the 1960s (*1*) established that preventing one eye of a kitten from seeing during the first 3 to 6 weeks of life resulted in a series of anatomical and functional changes throughout the visual pathways of the brain. The eye that was not used developed a markedly reduced visual capacity relative to the other eye. Rather than being a simple consequence of disuse, this appears to be the result of competition between the two eyes because when both eyes are covered the degree of cortical disconnection is not as great as when one eye is covered. Since the 1960s, we have sought to understand how and where in the brain this competition between the two eyes takes place. A report by Trachtenberg *et al.* (*2*) on page 2029 of this issue, presents new and surprising evidence that the primary location of binocular competition is not in granular layer IV of the visual cortex as originally thought but rather is located in the extragranular layers above and below it.

The cerebral cortex has six layers that are all interconnected, each layer having its own set of connections and a specific function. Layer IV is the major input layer of the cortex, receiving the bulk of neuronal projections from the lateral geniculate nucleus of the thalamus. The other five layers are referred to as the extragranular layers. Layer V sends connections to downstream output pathways and layer VI (which has a strong connection to layer IV) is an important feedback center, sending outputs back to structures from which cortical inputs have arisen.

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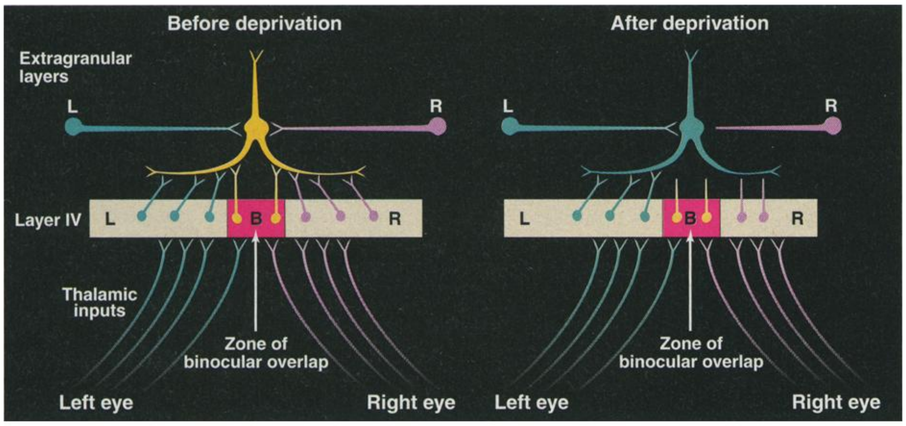
Trachtenberg and colleagues combined optical imaging and microelectrode recordings to measure electric signals in different parts of the primary visual cortex. In healthy 28-day-old kittens they confirmed many other reports that have pinpointed zones of the visual cortex (as viewed from above) that respond well to one eye, the other eye or both eyes. When they covered one eye of the young kittens for 24 hours, the cortical zones activated by that eye shrunk whereas those activated by the uncovered eye expanded. They positioned their microelectrodes within the relatively small areas of cortex that were still activated by both eyes despite the sensory deprivation.



Casting light on cortical connections. Changes in nerve connections between the different layers of the visual cortex after the right eye of young kittens is covered for 24 hours. The left panel illustrates cortical wiring before sensory deprivation of the right eye. Inputs from the lateral geniculate nucleus of the thalamus, carrying signals from the left and right eye, enter the visual cortex and terminate in layer IV. Layer IV is divided into zones of left eye preference (L), right eye preference (R), and a zone of binocular overlap (B). The layer IV neurons then make further connections with the extragranular cortical layers. The neuron in the center of the left panel receives horizontal inputs from distant extragranular layer neurons influenced via left and right eye pathways. After right eye deprivation (right panel), the overall territory in layer IV devoted to the right eye shrinks, whereas that associated with the left eye expands, but there is still a zone of binocular overlap. It would be expected that the neuron located directly above this binocular zone would also respond in a binocular fashion. However, Trachtenberg *et al.* (2) find that this neuron responds only to visual stimuli presented to the left eye. This could be because the extragranular connections from the left eye neuron have been strengthened and those from the right eye extragranular neuron have been correspondingly reduced, or it could be that the layer IV neurons in the right eye zone have lost connections to the neuron in the center, whereas those from the left eye have retained or strengthened their connections.

The investigators first constructed broad-scale maps of cortical ocular preferences using optical recording methods. By focusing their optical imaging system on layer IV they were able to identify zones of the visual cortex in which the responses were still driven by input connections from both eyes, despite the 24 hour deprivation period. Having identified these binocular zones in layer IV, they then used microelectrodes to sample the responses of cortical neurons in all six layers of the visual cortex in the region corresponding to the layer IV binocular zone. They found that cortical cell responses to visual stimuli presented through the deprived eye were lost in the extragranular layers above and below layer IV even though layer IV had remained binocular.

This information adds a new level of complexity to the problem of binocular competition. Earlier work emphasized the importance of changes in connections between the thalamus and layer IV, and the segregation of thalamic inputs during development (*3*, *4*). If changes are first found in the extragranular layers, then the potential mechanisms by which new connections are made or lost become more complex. Trachtenberg *et al.* suggest that the well-documented changes in layer IV are "guided by higher cortical stages." The task for the future will be to understand exactly what this means.

Before sensory deprivation, neuronal inputs from the lateral geniculate nucleus—the major relay station in the thalamus between the eyes and the cortex—converge on layer IV, with each eye having its own territory as well as a zone of binocular overlap. The cells in the extragranular layers receive inputs from layer IV as well as long range horizontal connections from other cortical columns (the vertical functional units of which the cortex is composed) in the visual cortex. After a short period of deprivation, it appears that a binocular zone is still retained in layer IV, but that immediately above it, within a cortical column that would normally be expected to have the same ocular preference throughout, the neurons have preferentially shifted their connections to the nondeprived eye. Trachtenberg and coworkers suggest that this finding reflects changes in the long-range horizontal connections within the extragranular layers. For example, after sensory deprivation of the right eye for 24 hours, left eye neurons (in the center of the right panel of the figure) in the extragranular layers would lose their inputs from right eye neurons. Another possibility is that the neurons in layer IV that receive binocular input or that receive right eye input lose their ability to influence the cells immediately above them, whereas the left eye layer IV neurons retain this capacity (see the figure). Future experiments will need to distinguish between these two possibilities and to determine whether they are, in fact, mutually exclusive.

Depriving one eye of vision eventually causes changes in all layers of the visual cortex, in the locations where the thalamic inputs representing the two eyes terminate, and in cells of the thalamus that project to layer IV. Ongoing studies will need to define the mechanisms by which alterations within the extragranular layers are communicated back to layer IV and to other levels of the visual pathway, thus bringing about these long-term changes.

Studies of the plasticity of the visual cortex during the critical period of postnatal development are particularly germane in light of recent controversies about the importance of early childhood experience in determining cortical competency in adults. These controversies—which have profound implications for early childhood education, parenting, and child care (*5*)—have been characterized more by polemics than by solid neuroscience research. The visual cortex represents the best model system that we have for understanding how sensory stimulation of the early brain influences brain circuitry and function throughout life. Its study should increase our knowledge of the ways in which early sensory inputs determine the long-term capabilities of the brain.

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