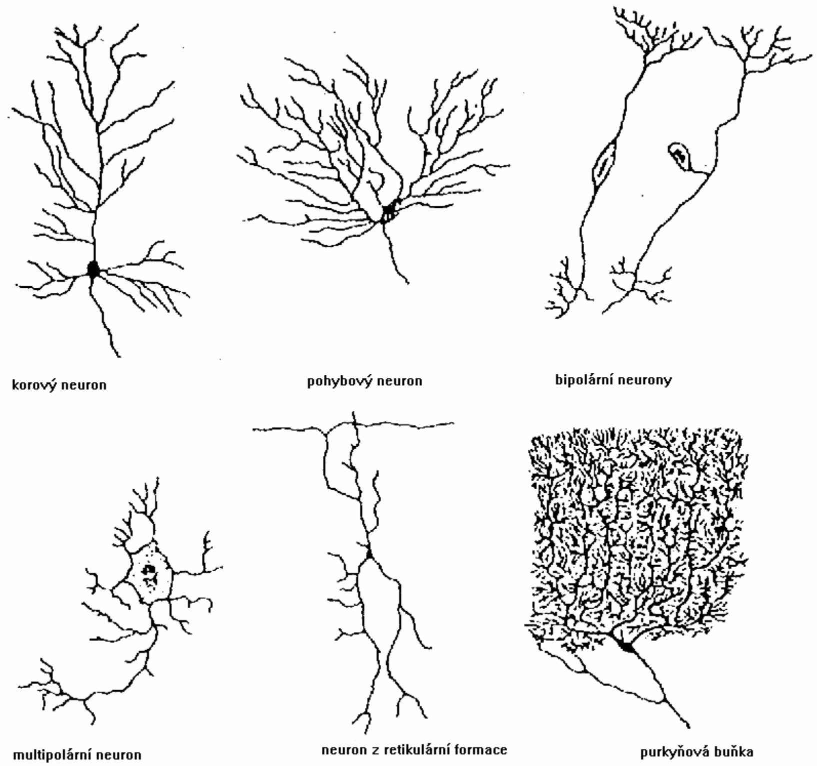
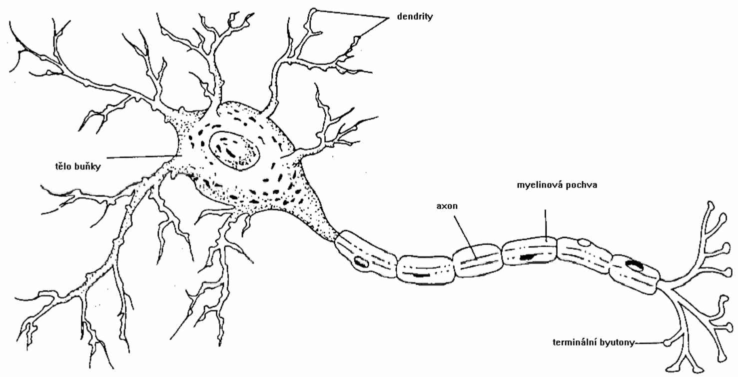
Typy neuronů



Mikrostruktura mozku



Typický neuron

New Nerve Cells for the Adult Brain

Contrary to dogma, the human brain does produce new nerve cells in adulthood. Can our newfound capacity lead to better treatments for neurological diseases?

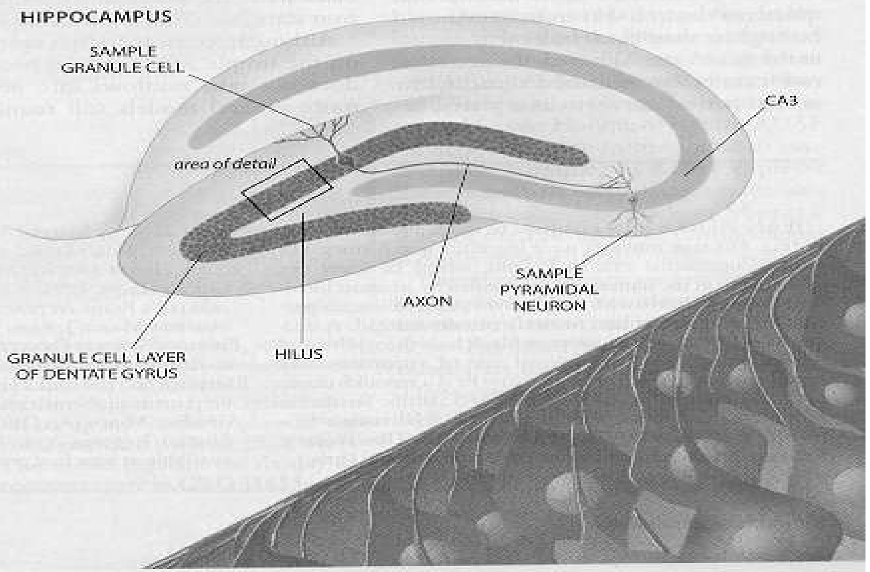
by Gerd Kempermann and Fred H. Gage

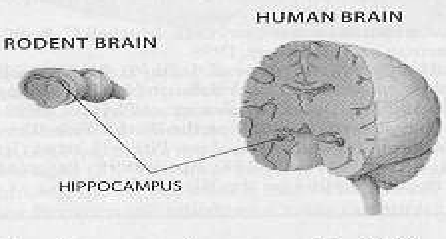
Cut your skin, and the wound closes within days. Break a leg, and the fracture will usually mend if the bone is set correctly. Indeed, almost all human tissues can repair themselves to some extent throughout life. Remarkable "stem" cells account for much of this activity. These versatile cells resemble those of a developing embryo in their ability to multiply almost endlessly and to generate not only carbon copies of themselves but also many different kinds of cells. The versions in bone marrow offer a dramatic example. They can give rise to all the cells in the blood: red ones, platelets and a panoply of white types. Other stem cells yield the various constituents of the skin, the liver or the intestinal lining.

The brain of the adult human can sometimes compensate for damage quite well, by making new connections among surviving nerve cells (neurons). But it cannot repair itself, because it lacks the stem cells that would allow for neuronal regeneration. That, anyway, is what most neurobiologists firmly believed until quite recently.

This past November, Peter S. Eriksson of the Sahlgrenska University Hospital in Göteborg, Sweden, one of us (Gage) at the Salk Institute for Biological Studies in La Jolla, Calif., and several colleagues published the startling news that the mature human brain does spawn neurons routinely in at least one site—the hippocampus, an area important to memory and learning. (The hippocampus is not where memories are stored, but it helps to form them after receiving input from other brain regions. People with hippocampal damage have difficulty acquiring knowledge yet can recall information learned before their injury.)

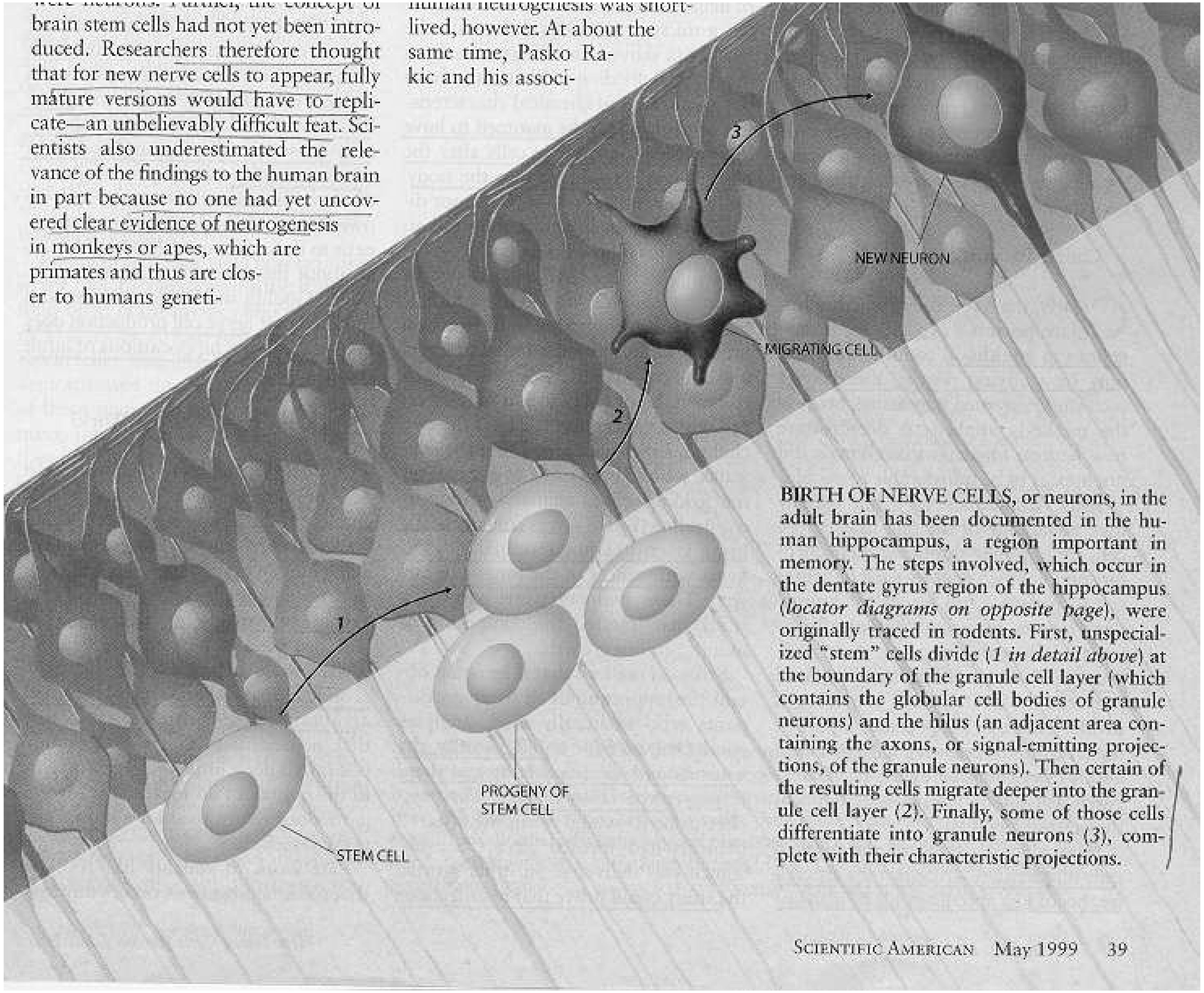
The absolute number of new cells is low relative to the total number in the brain. Nevertheless, considered with recent findings in animals, the November discovery raises some tantalizing prospects for medicine. Current data suggest that stem cells probably make new neurons in another part of the human brain and also reside, albeit dormantly, in additional locations. Hence, the adult brain, which repairs itself so poorly, might actually harbor great potential for neuronal regeneration. If investigators can learn how to induce existing stem cells to produce useful numbers of functional nerve cells in chosen parts of the brain, that advance could make it possible to ease any number of disorders involving neuronal damage and death—among them Alzheimer's disease, Parkinson's disease and disabilities that accompany stroke and trauma.





were neurons. Further, the concept of brain stem cells had not yet been introduced. Researchers therefore thought that for new nerve cells to appear, fully mature versions would have to replicate—an unbelievably difficult feat. Scientists also underestimated the relevance of the findings to the human brain in part because no one had yet uncovered clear evidence of neurogenesis in monkeys or apes, which are primates and thus are closer to humans geneti-

human neurogenesis was short-lived, however. At about the same time, Pasko Rakic and his associ-



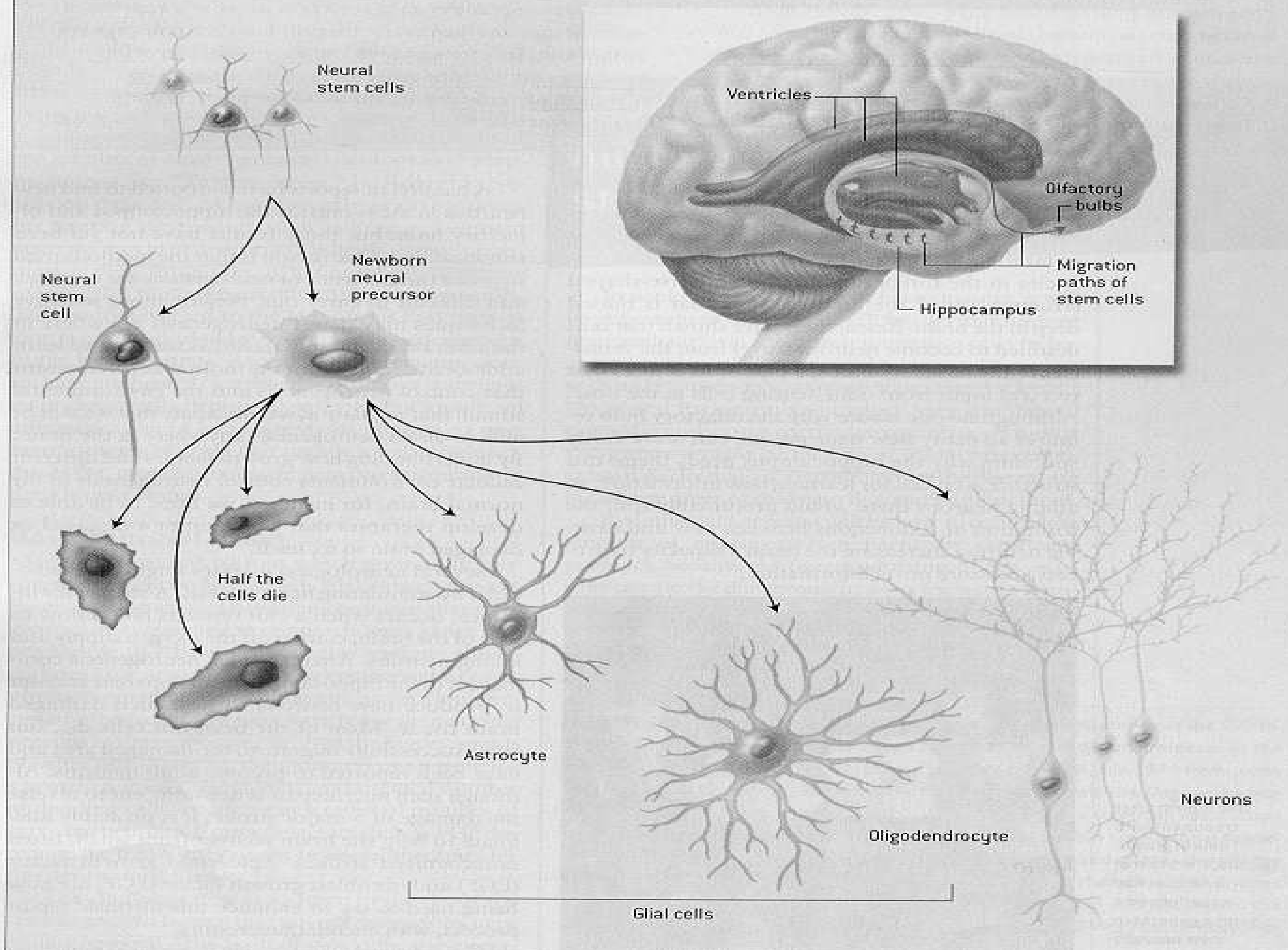
BIRTH OF NERVE CELLS, or neurons, in the adult brain has been documented in the human hippocampus, a region important in memory. The steps involved, which occur in the dentate gyrus region of the hippocampus (*locator diagrams on opposite page*), were originally traced in rodents. First, unspecialized "stem" cells divide (*1 in detail above*) at the boundary of the granule cell layer (which contains the globular cell bodies of granule neurons) and the hilus (an adjacent area containing the axons, or signal-emitting projections, of the granule neurons). Then certain of the resulting cells migrate deeper into the granule cell layer (*2*). Finally, some of those cells differentiate into granule neurons (*3*), complete with their characteristic projections.

HOW THE BRAIN MAKES NEW NEURONS

NEURAL STEM CELLS are the fount of new cells in the brain. They divide periodically in two main areas: the ventricles (*purple, inset*), which contain cerebrospinal fluid to nourish the central nervous system, and the hippocampus (*light blue, inset*), a structure crucial for learning and memory. As the neural stem cells proliferate (*cell pathways below*), they give rise to other neural stem cells and to neural precursors that can grow up to be either neurons or support cells, which are collectively termed glial cells (astrocytes or oligodendrocytes).

But these newborn neural stem cells need to move (*red arrows, inset*) away from their progenitors before they can differentiate. Only 50 percent, on average, migrate successfully (the others perish). In the adult brain, newborn neurons have been found in the hippocampus and in the olfactory bulbs, which process smells. Researchers hope to be able to induce the adult brain to repair itself by coaxing neural stem cells or neural precursors to divide and develop when and where they are needed.

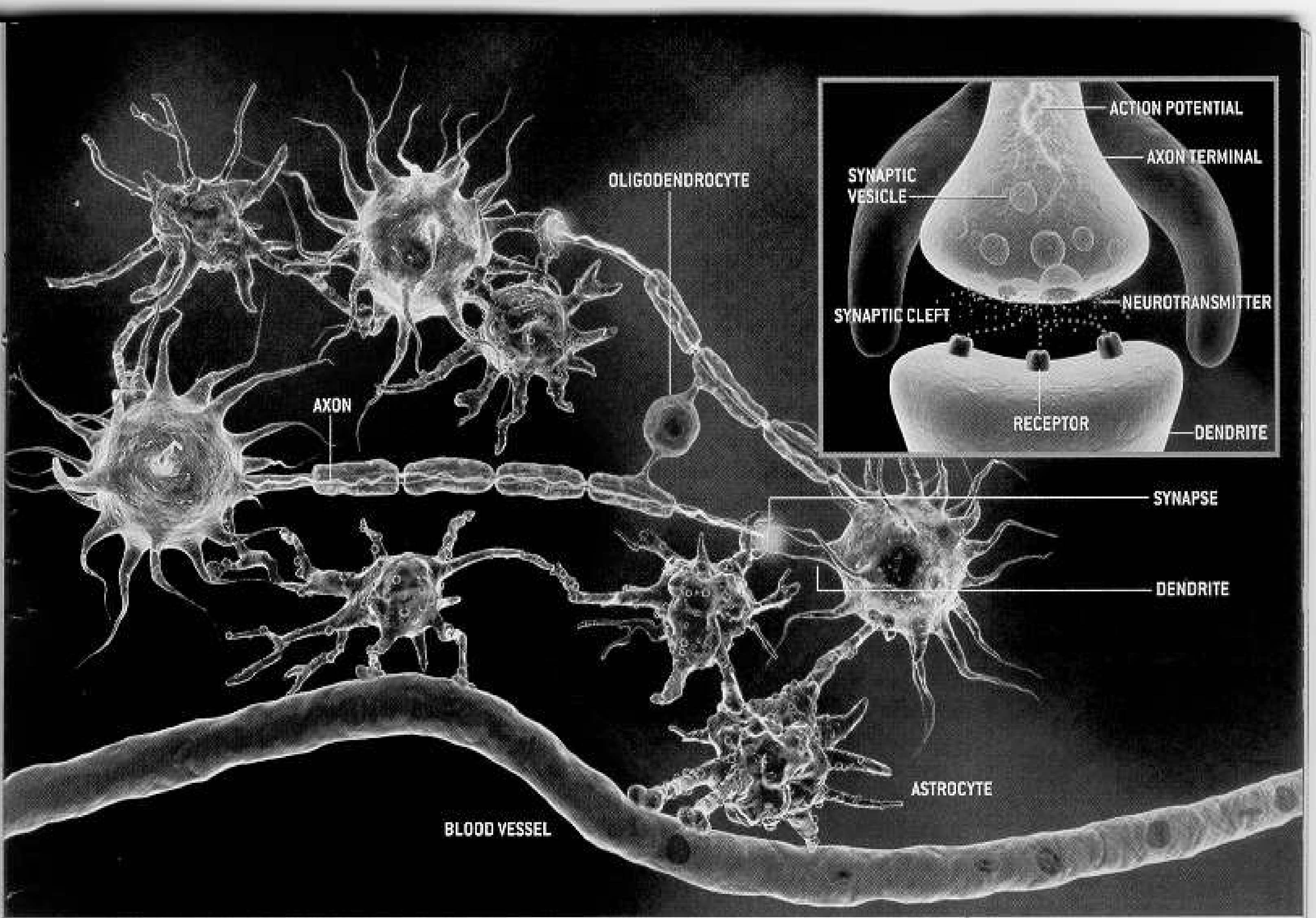
—F.H.G.



Funkce gliových buněk

- Výživa neuronů
- Odklízení iontů ze synaptické štěrbiny
- Strážce pathogenů

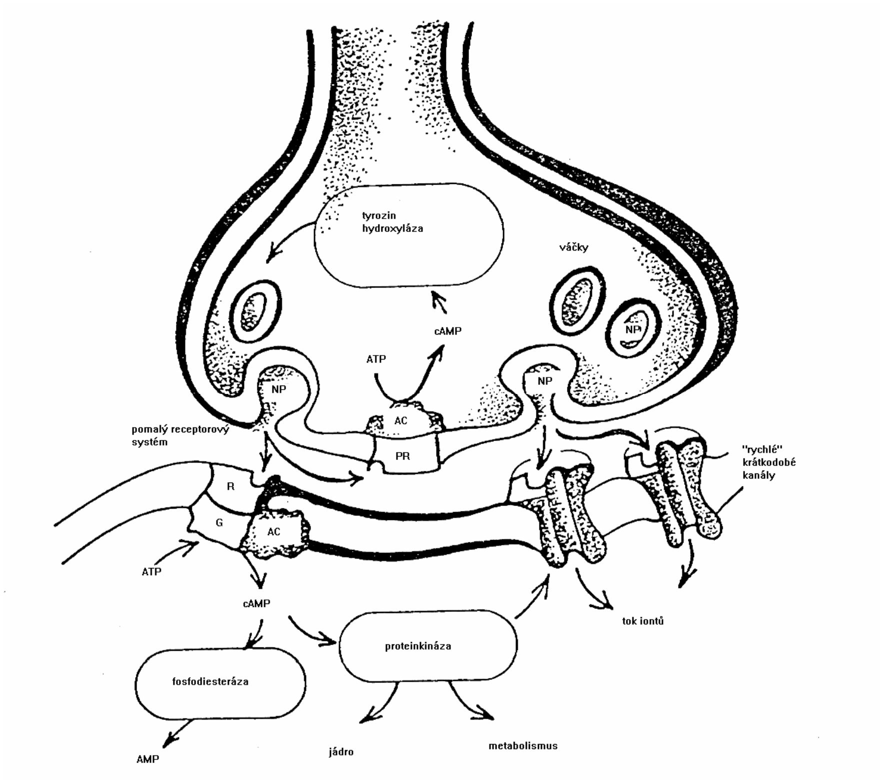
- Ovlivňování formování synapsí a tím určování, které z neuronálních spojů budou silnější, a které slabší
- Vzájemná gliová komunikace – vytváření paralelní sítě



GLIA AND NEURONS work together in

- For decades, neuroscientists thought neurons did all the communicating in the brain and nervous system, and glial cells merely nurtured them, even though glia outnumber neurons nine to one.
- Improved imaging and listening instruments now show that glia communicate with neurons and with one another about messages traveling among neurons. Glia have the power to alter those signals at the synaptic gaps between neurons and can even influence where synapses are formed.
- Given such prowess, glia may be critical to learning and to forming memories, as well as repairing nerve damage. Experiments are getting under way to find out.

Synapse


tyrozin
hydroxyláza
váčky
NP
cAMP
ATP
NP
AC
NP
pomalý receptorový
systém
PR
"rychlé"
krátkodobé
kanály
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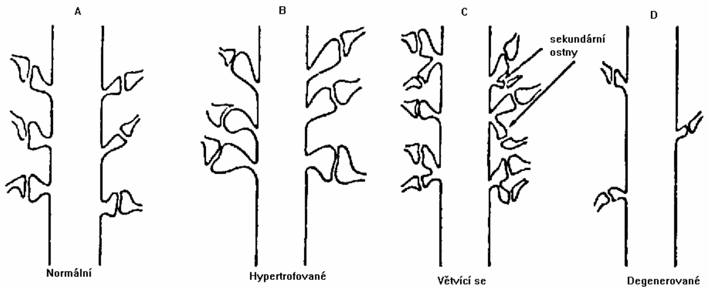
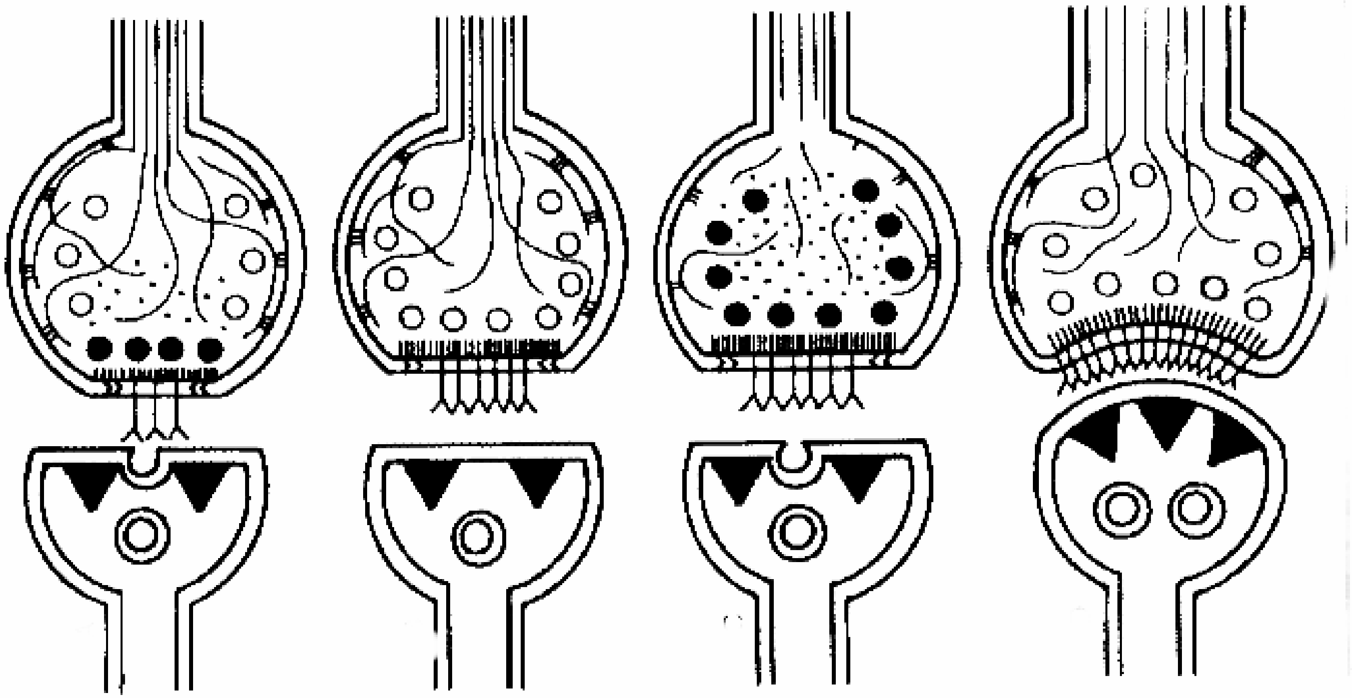
tok iontů
proteinkináza
fosfodiesteráza
AMP
jádro
metabolismus

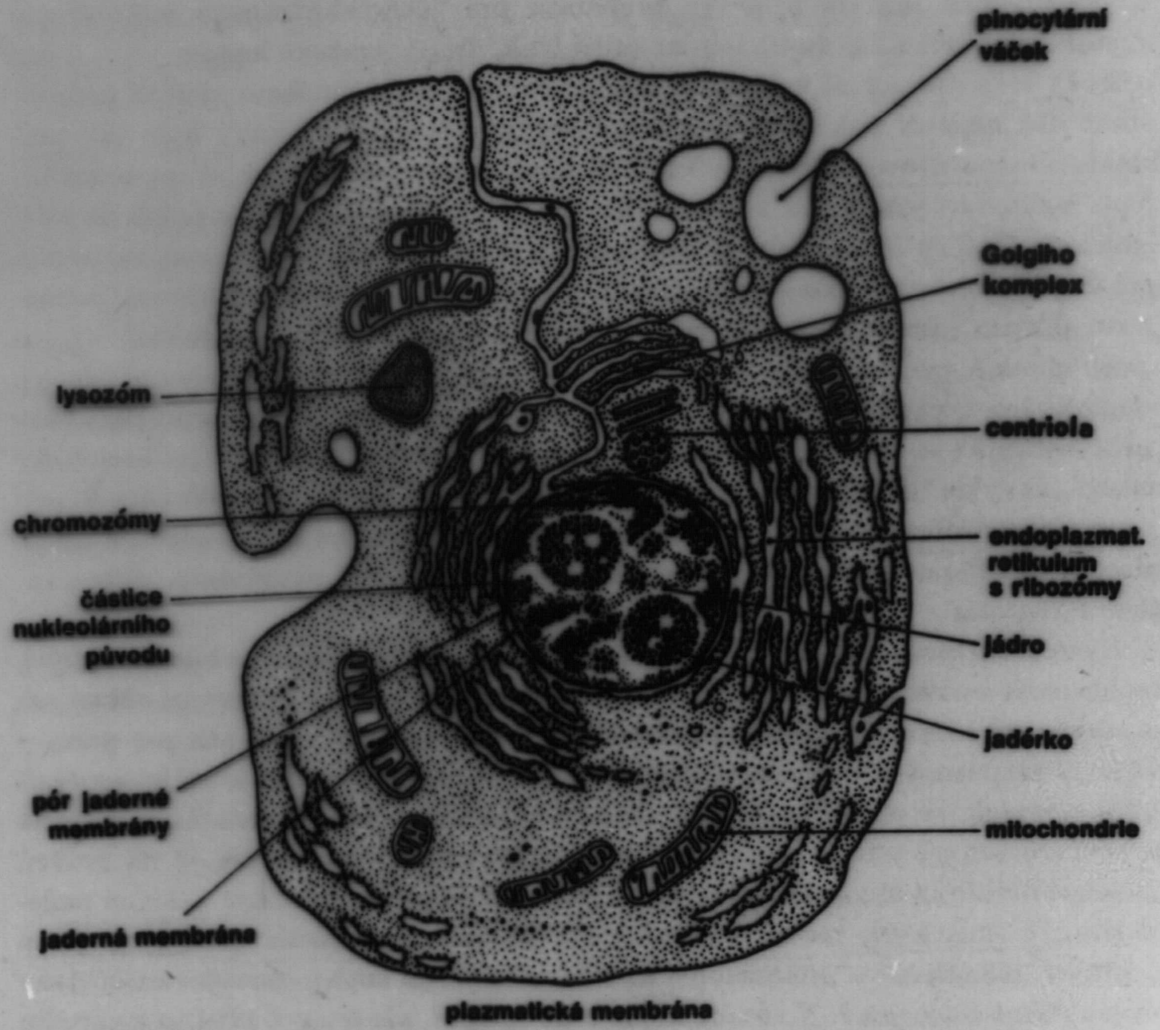
Mikrostruktura mozku



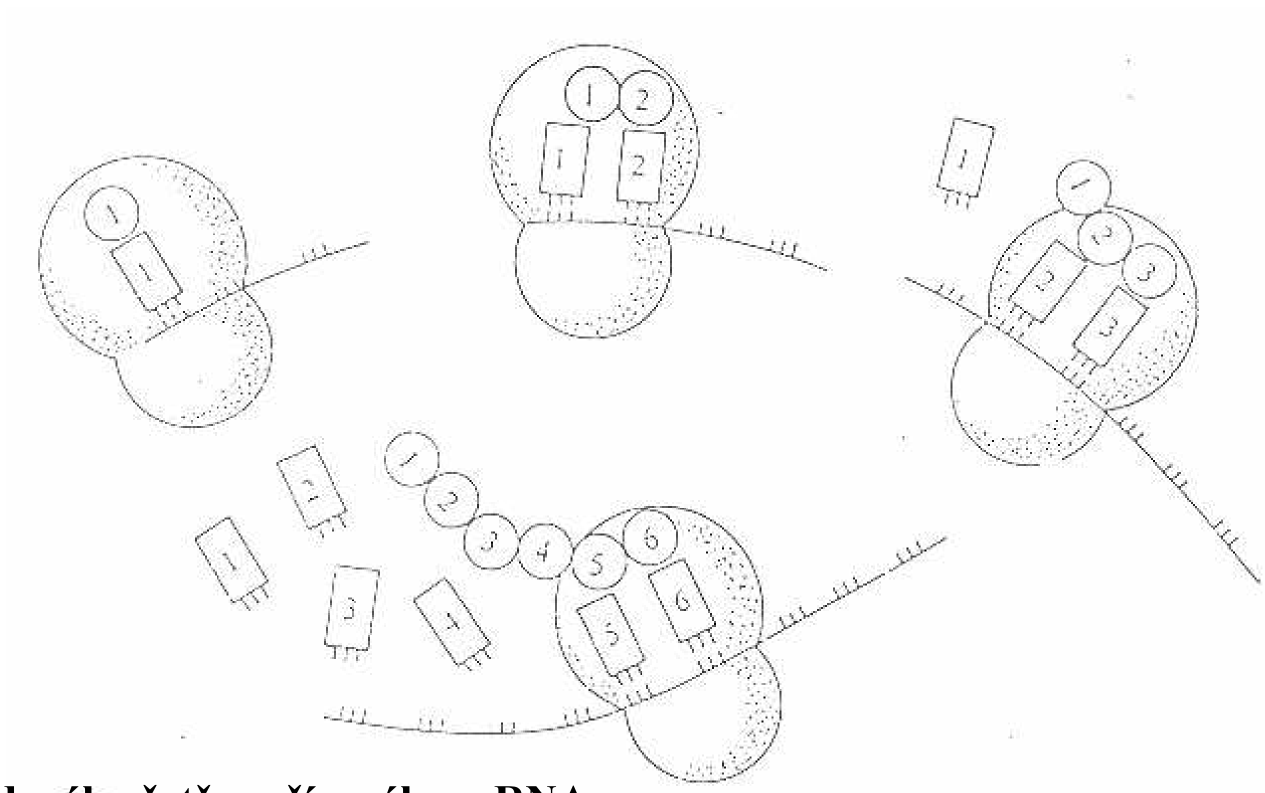
Druhy synaptického větvení

Mikrostruktura mozku





173/ **Schéma živočišné buňky. Struktury jsou znázorněny tak, jak se jeví při elektronové mikroskopii.**



Výstavba peptidového řetězce řízeného mRNA