Hooks and Eyes of Sperm and Eggs

Sperm of diverse animal groups, from sea urchins to hamsters, bind rapidly and tightly to an egg's surface during fertilization. Sperm, however, are particular in their attachments; they cling best to eggs of their own species. Specific molecules from both the sperm and the eggs dictate this selectivity, Victor D. Vacquier told a symposium audience at the meeting of the American Society for Cell Biology in San Diego. He and colleagues at the University of California at Davis have isolated both components of the bond. The researchers suggest that the interaction of sperm and eggs is a good model for recognition between other cells, as in liver, muscle and retina development.

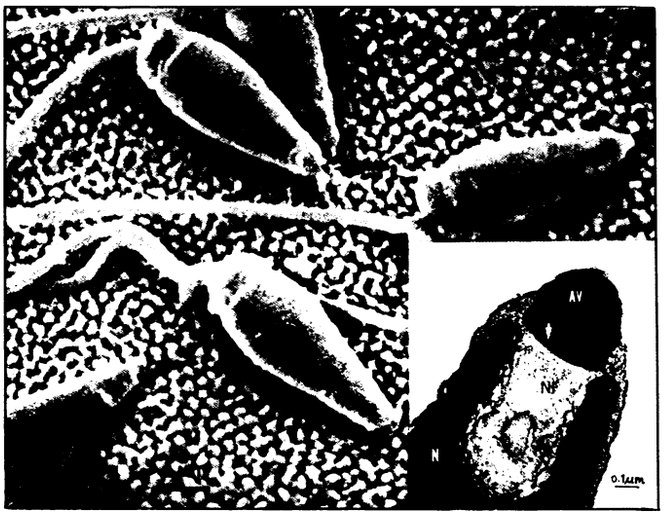
A packet of one sticking substance rides foremost in the head of the sea urchin sperm. Vacquier recounts that he discovered the trick to purifying those packets last winter while gazing at a Christmas tree. He pours disrupted sperm through a long tube filled with glass fibers, as from the angel hair decorating the tree. The compact granules slide through the fibers, while contaminating flagella catch in the tangle of glass threads.

Vacquier, working with Gary W. Moy and Charles G. Glabe discovered that the packets contain a single, medium-sized protein. When the researchers add the protein, which they named bindin, to unfertilized eggs, the eggs clump together. But the gluing ability is specific within species. Bindin from one type of sea urchin does not agglutinate eggs from another species.

Although the researchers describe bindin as a "glue," a collection of differently shaped hooks and eyes makes a better fastening model. The exact characteristics of both components determine the strength of the bond.

At the egg end of the interaction, Vacquier and colleagues have found another specific substance. This component of the egg's outer coat acts as a sperm receptor. It is a very large molecule containing both sugars and protein. The investigators suggest that bindin attaches to the sugar part of the membrane molecule. Like bindin, the receptor appears to be specific for the species. Isolated bindin attaches to isolated receptor from the same species more effectively than to that of a different species.

Discovering the exact differences between the bindins and between the receptors are the next steps in Vacquier's investigation. The researchers are in the midst of determining the amino acid sequence of the proteins. Only 2 of the 18 amino acids so far measured in bindin have differed significantly between sea urchin species. This winter the researchers hope to establish chemical differences between the receptors.



Packets of "glue" (labeled AV in inset) ride at the tip of the sperm. These processes (black arrows) bind sperm to specific receptors on an isolated fragment of an egg's outer coat.

In the sequence of events that make up fertilization, bindin may do more than glue sperm to eggs. It may also signal the sperm and egg membranes to merge so that genetic material can pass from the sperm into the egg. "Bindin is at the proper place at the proper time," Vacquier reports of recent microscopic studies in which bindin was labeled with antibodies and the electron-dense material, horseradish peroxidase. The researchers plan soon to examine whether bindin in artificial membranes will stimulate membrane fusion.

Vacquier believes that bindin is used by all animal sperm that attach to eggs. His co-worker Brigitte Brandriff has already isolated a binding protein from oyster sperm.

Novel methods of contraception, not involving hormones, could result from these discoveries, Vacquier points out. If a human protein similar to sea urchin bindin could be isolated, it might become possible to immunize women against that sperm component. Antibodies would then attach to bindin, preventing the sperm from attaching to eggs. Such an approach would avoid a risk that arises in other immunological approaches to contraception. The antibodies would not be stimulated to attack any protein produced by the woman's own body. Alternatively, test tube studies made possible by these methods of isolating the binding components may suggest chemical or enzymatic ways to block attachment and fertilization. □

Schwann cells: Mixing and matching

A faulty electrical system may result from either a break in the conducting wire or from defective insulation. Similarly, some diseases of the human nervous system arise from problems with the biological insulation that allows rapid conduction of signals along the nerve cell's output branch, the axon. A technique that can wrap the insulation from humans around the nerve processes of a mouse was described by Albert J. Aguayo at the annual meeting of the Society for Neuroscience in Anaheim, Calif. (SN: 11/19/77, p. 344). Aguayo suggests this technique may lead the way to eventually replacing abnormal insulating tissue, repairing damaged nerves and reproducing human diseases for experimentation in animals.

Schwann cells are the agents of biological insulation studied by Aguayo and his colleagues at McGill University. These specialized cells wrap tight bands of membranes, called myelin, around individual axons of many nerve cells. However, Schwann cells loosely encircle axons of other nerve fibers.

Aguayo and colleagues transplant Schwann cells by grafting a section of a nerve, with its associated Schwann cells, between the segments of another cut nerve. The transplanted axon pieces deteriorate, and the cut axons grow into the tracts left in the graft. With this procedure, researchers can mix and match axons and Schwann cells.

This technique has already answered one question about which cell is calling the plays. The axon determines whether or not myelin will form. Schwann cells from an unmyelinated nerve will wrap myelin around a previously myelinated axon. This result eliminates the possibility of two different populations of Schwann cells—one for myelin and the other for the looser sheath. "Schwann

cells are multipotential and influenced by an axon," Aguayo says.

Because the axon and Schwann cells are interdependent—each subtly influencing the metabolism of the other—it is possible that disorders of the myelin sheath may actually be due to some abnormality of the nerve axon. Aguayo and colleagues have examined this possibility in mice with inherited diseases. The "trembler" mouse, for example, has so little insulation that its nerve signals travel much more slowly than normal. The animal has abnormal posture and an obvious tremble.

Aguayo transplanted a section of trembler Schwann cells into a segment of normal mouse myelinated nerve. He also grafted normal Schwann cells into a trembler nerve. Only the axon segments associated with normal Schwann cells were myelinated. Thus the abnormality in this case must be in the Schwann cells. The circumference of the axons, which is about half the normal in trembler mice, increased where trembler Schwann cells were replaced by normal ones. "We cured a trembler mouse a little bit," Aguayo told a symposium audience.

Aguayo has looked at two other mouse diseases. "Quaking" mice appear, like trembler mice, to have defective Schwann cells. However, in dystrophic mice, axonal factors seem responsible for the adnormality.

The most exciting result is that Schwann cells can be grafted between different species. Because of interest in human disease, Aguayo created mouse axons ensheathed by human Schwann cells, obtained from limb amputations and nerve biopsies. Aguayo suppressed the mouse immune system so that it would not reject the graft. The human Schwann cells persisted. Those from normal people produced normal myelin in the mouse, while those from a patient with the disease metachromatic leukodystrophy made myelin containing granules and other abnormalities. The human Schwann cells produced myelin around the mouse axons more slowly than did the mouse Schwann cells. Aguayo has not yet determined whether that difference lies in the cells themselves, or whether it is a consequence of the transplant.

A potential use of this technique in repair of nerve injury was revealed during experiments to check whether the new myelin really from human Schwann cells, rather than from mouse cells that had migrated into the graft area. The researchers stopped suppressing the mouse immune system, and macrophage cells immediately attacked the foreign Schwann cells. After the human cells were destroyed, however, mouse Schwann cells moved in and formed myelin around the naked axons. This result suggests that a temporary graft of foreign cells may provide guiding tracts for axon regrowth, and then later may be replaced by intrinsic Schwann cells. □

Thirty-year follow up: Counseling fails

Unlike the results of treatment for most physical ailments, the effects of psychological counseling and psychotherapy are frequently hard to determine. Improvements in behavior cannot be measured as objectively as can changes in heart rate, blood count or blood pressure.

However, a preventive treatment program begun in 1939 for youths in Cambridge, Mass., and neighboring Somerville, is providing today's researchers with a rare chance to assess the impact of therapy more than 30 years later. The Cambridge-Somerville Youth Study originally consisted of more than 500 "difficult" and "average" youngsters, aged 5 to 13. At random, half the youngsters in each category received one-to-one therapy with a personal counselor for about five years, and the other half received no therapy. One of the study's goals was to see if such counseling would divert the children from later involvement in crime.

Nearly 80 percent of the original youngsters have been located. An extensive follow-up of their behavior as adolescents and adults has yielded some rather astounding findings: Almost without exception, therapy appeared to have had a negative, or at least a non-positive, effect on the youngsters in later life.

A comprehensive study of the subjects' criminal records reveals solid negative correlation between therapy and the onset of criminal behavior. "The study provides a basis for doubting some of the more basic assumptions—assumptions which I shared—about therapy," says Joan McCord of Drexel University, who conducted the study.

In the overall comparison between therapy and non-therapy groups, McCord reports that slightly more of the men in treatment were convicted of at least one non-traffic crime, for a serious crime and for more than one crime. She presented her results last week in Washington at a meeting of the American Association of Psychiatric Services for Children.

In addition, the results show that in the therapy group, the incidence of antisocial and criminal behavior increased (or was not decreased) among boys who received therapy over the longest period of time; had the most frequent contact with counselors; began therapy at an earlier than average age; had male, rather than female, counselors; had therapy directed at personal problems, rather than at academic or family difficulties; and had close ties with counselors. All these findings run contrary to expectations, McCord says.

Why did therapy produce such uniformly negative effects? "I've got some hunches," McCord told SCIENCE NEWS. "It's possible that people become too dependent on counselors, and therefore they do not acquire the skills of those who do not have therapy," she said. "They come to see themselves as 'needing help.'" She also notes that while one of the groups was classified as difficult, the children were not "sick" by emotional standards. In such a case, treatment could make them worse, she suggests. The results indicate, she says, "that the most widely held beliefs about therapy may be untenable." □

Making nuclear bombs the quick, dirty way

A simple, inexpensive, "quick and dirty" nuclear fuel reprocessing plant described by Oak Ridge National Laboratory indicates that a "bandit nation" with access to commercial spent (used) nuclear fuel could separate enough plutonium to make a nuclear weapon within only seven days. An "intralaboratory" memo outlining the procedure estimates that it would take up to six months to build such a plant, with the first 10 kilograms of plutonium metal ready for machining into bomb parts only one week later. After that, it could produce up to 100 kg—enough for about 10 atomic bombs—per month.

According to the Oct. 27 NUCLEONICS WEEK, a newsletter of the nuclear industry, the design was examined by Argonne National Laboratory and three industrial laboratories "and upheld as reasonable." A later issue (Nov. 3) quoted an Energy Department source as saying the report is "an imprudent elaboration on existing literature [the report references sources obtainable in most technical libraries]. It could help potential proliferators by simplifying their planning."

The study contained a number of crucial assumptions, such as: would-be reprocessors would have access to existing small industries (such as wineries, dairies or oil refineries) that could be pirated for instruments, tanks and fittings; the surrounding community is sympathetic to the bandit cause; and adequate funds, machine-shop equipment (such as lathes, power saws and welders) and construction equipment and materials are available. The entire plant would cover less than 1.5 acres and could be made from easily obtainable supplies. Technicians of average capability could assemble and operate it; stainless-steel welding is the most difficult skill it requires.

The study assumes that spent-fuel rods from commercial power reactors are stolen from cooling ponds and processed at the rate of one rod per day. Each rod must be cut and dissolved in an extraction-stripping operation. Resulting plutonium "buttons" are 99.8 percent