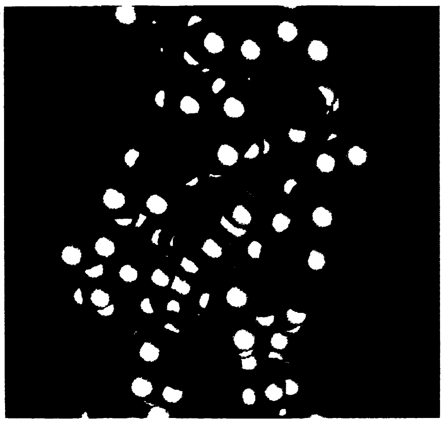
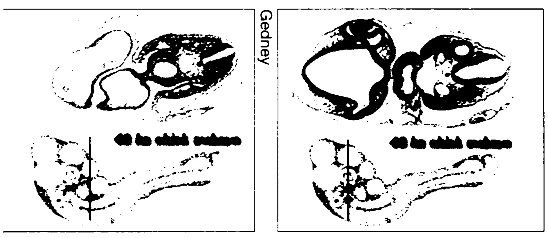


S. Broyde, B. Hingerty, Colvin/Sandia, DOE Office of Scientific Computing

F: Carcinogen (yellow) binding to DNA.

Those images help Olson and others take the next step — determining how one molecule links to another (see cover). They are also refining software that tackles the docking of one protein with another **(E)**. This second program represents the surfaces of proteins at greater and greater resolutions as it searches for and finds the regions where proteins can bind together, Olson explains. With each iteration, the program rules out connections that prove energetically or structurally untenable and fine-tunes those



Gedney

G: Two views of chick embryos; lines show locations of the cross section portrayed.

that seem likely, eventually homing in on the optimal orientations.

At Sandia, Colvin, too, investigates molecular connections. For one project, he portrayed a carcinogen attacking DNA **(F)**. "The DNA has grooves, and the carcinogen just drops down into these grooves like a key into a slot," he says.

Students, too, are reaping the benefits of these representations of the invisible world. At Purdue University in West Lafayette, Ind., Clark D. Gedney and his colleagues have developed several visualization procedures for teaching biology. One teaching tool incorporates pictures of cross sections of chick embryos taken at different stages of development **(G)**. Gedney's team added colors to highlight the various tissues and had the computer reconstruct the whole embryo. Rather than wield scalpels or fuss with mounting and viewing microscope slides, students click a computer mouse to see embryos at 13 stages of development. They can look at it whole or in cross section, notes Gedney.

Finally, another simulation enables both teachers and students to build their own cell membranes and then examine the effect of adding or removing an electron from the membrane **(H)**. The computer program makes sure the membrane works just as a real one does, Gedney says. □

Gedney

H: Visualization of a cell membrane with an incoming electron (red).

Reflections of clinical reality

It has become one of the rituals of pregnancy. A pulse of high-frequency sound (ultrasound) emanates from a device placed on a pregnant woman's bare abdomen. The sound waves travel into her body, echoing from various organs and tissues. Eventually, the waves return to the device, where they are detected. A computer quickly assembles the data — the strengths of the returning echoes — into a fuzzy black-and-white image on a video monitor.

For the mother-to-be, this first glimpse of her child can be both exhilarating and disappointing. She can see the new life that exists within her body, but the details are lost in the image's bleak haziness.

Sakas et al.

A pair of three-dimensional Images reconstructed from ultrasound data acquired in the 25th week of pregnancy (left) can be compared with a photo of the baby 24 hours after birth (right).

It generally takes an experienced clinician to make sense of the light and dark splotches — to point out the head, arms, and other fetal features — visible in the image. Even practiced physicians can have trouble interpreting ultrasound scans, whether used to check the development of a fetus or to assist in brain surgery or in the diagnosis of heart ailments.

To get more informative images out of ultrasound echoes, specialists in the visualization of data have been investigating the possibility of generating realistic, three-dimensional images from sequences of ultrasound scans. Such reconstructions are difficult, given the numerous factors — the noise — that can distort or obscure the data. The need for speed in the clinical setting adds to the challenge.

In one recent effort, Georgios Sakas and his coworkers at the Fraunhofer Institute for Computer Graphics in Darmstadt, Germany, used a workstation computer to generate high-quality three-dimensional images of a fetus in only a few seconds.

To do these reconstructions, the researchers wrote a computer program to clean up and visualize the fetal ultrasound data. The software digitally filtered out various types of noise, helped isolate relevant features and removed artifacts and extraneous material, and added shadows and shading.

Computer scientists Andrei State, Henry Fuchs, and their colleagues at the University of North Carolina at Chapel Hill have a more ambitious goal in mind. They want a clinician to see a three-dimensional image of a fetus — reconstructed on the fly from ultrasound data — not on a nearby screen but superimposed on the patient's abdomen.

Wearing special headgear that tracks head movements and displays the fetal image, a physician could examine a fetus as if he or she were looking directly at it in the patient's abdomen (see illustration). In this "augmented reality" system, any movement of the head would produce a corresponding change in the fetal image.

At present, a number of technological obstacles stand in the way of implementing such a scheme. Tracking equipment is still too imprecise, and computers can't generate the three-dimensional images fast enough.

UNC

View (bottom) of a reconstructed, three-dimensional fetal image (top left) superimposed on a pregnant woman's abdomen (top right).

Ultimately, the real test of any system for three-dimensional ultrasound imaging will occur in the clinic. Physicians will use the equipment only if it operates quickly, conveniently, and accurately — and only if they feel confident they can trust the results.

Sakas and State described their projects at the Visualization '94 conference held last month in Fairfax, Va.

— *I. Peterson*