ments, no oxidized support was used in the STM experiments on Langmuir-Blodgett films. Furthermore, the system under consideration is not a single molecule alone but a molecule between the two electrodes, that is, the tip and support. A coupling with the electrodes can modify the electronic structure of the single molecules and thus affect their transmission (*25*). Generally, interactions with molecular vibrations (normally weakly dispersive) and molecular polarization can strongly affect the electronic wave function overlap and thus the electronic energies. The parameters that govern electron propagation in organic materials are different from those that operate in inorganic compounds. Time-dependent energy states, polarization terms, and electron-electron interactions must be considered in order to explain electron transfer in organic solids.

Finally, let us consider the possibility of electrical breakdown. In STM experiments the voltage between tip and sample is in the range of a few hundred millivolts, which corresponds to an electrical field strength of the order of 0.2 mV cm^{-1} if we assume that the voltage drops linearly across the entire Langmuir-Blodgett monolayer. This field strength corresponds to the typical breakdown strength of an 80-μm-thick multilayer (*26*), but for mono- and bilayers larger electric fields are required. In addition, for electrical breakdown large electronic energies are required in processes for carrier multiplication (*27*). In contrast, the energies involved in STM experiments are very small; Zener tunneling can thus be excluded. Energy-loss processes of tunneling electrons are negligible for breakdown.

A microscopic description of the imaging of a recA-DNA complex, an extremely complicated system, requires detailed knowledge of the physical properties of its single components and their interactions. The considerations about the pendant-group polymers might also be valid for polypeptide chains, which can be regarded as biological polymers with residues acting as pendant groups. Proteins are highly structured macromolecules: their specific structure will also influence the quantum paths, controlling whether long-range electron transfer occurs (*28*).

STM imaging of recA-DNA complexes required treating the Pt-C supporting film with $MgCl_2$ or $MgAc_2$ solution and keeping the samples wet. The recA-DNA filaments are therefore embedded in a strongly polar medium, which can also act as an electrolyte. The exact role of the salt solution is not yet clear. The fluctuations of the surrounding medium and its polarization changes can locally and temporally shift the electronic terms of the macromolecule and its hydration shell. Long-range electron transfer can thus be induced by polarization energy effects in the macromolecule, and in the hydration shell itself through nonequilibrium states of molecular subunits and solvated ions. Electrochemical processes probably contribute to imaging and also influence the contact resistance between object and support. Ionic conductivity can be excluded owing to the small mobility of ions in water (10^{-4} cm^2 V^{-1} s^{-1}). Also, Mg^{2+}, Cl^-, and Ac^- could act as dopants of the macromolecule, thus providing the charge transfer necessary for electron transfer.

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Upper Jurassic Dinosaur Egg from Utah

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The Upper Jurassic egg described here is the first known egg from the 100-million-year gap in the fossil record between Lower Jurassic (South Africa) and upper Lower Cretaceous (Utah). The discovery of the egg, which was found mixed in with thousands of dinosaur bones rather than in a nest, the pathological multilayering of the eggshell as found in modern and fossil reptilians, and the pliable condition of the eggshell at the time of burial indicate an oviducal retention of the egg at the time of burial.

A NEARLY COMPLETE EGG WAS found in September 1987 in the Cleveland-Lloyd Dinosaur Quarry at a site located in the lower fossiliferous beds of the Brushy Basin Member of the Upper Jurassic Morrison Formation in Emery County, east central Utah (*1*). This quarry has yielded more than 12,000 disarticulated bones representing 70 or more individuals of at least 12 dinosaur genera (*1–4*). In the Late Jurassic, this area may have been a shallow lake or marsh where the animals became trapped in mud (*4*).

The egg was found embedded in a calcareous blocky shale 0.4 m above the bottom of the fossiliferous stratum in the quarry. The fossil was not immediately associated with skeletal parts of the dinosaurs, although disarticulated remains of the sauropods *Barosaurus* and *Camarasaurus* and *Stegosaurus* were nearby. There was a concentration of a single theropod, *Allosaurus*, including sacral and appendicular elements, in the vicinity of the egg. *Allosaurus* is by far the most abundant taxon in the Cleveland-Lloyd dinosaur fauna. It cannot be demonstrated that the egg represents any of the above genera. No additional eggshell material was found.

The preservation and condition of the egg make it unlikely that it was transported. The

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egg is broken open, with the two halves connected along a hingelike, folded area (Fig. 1, a and b). The broken edges were uppermost in situ with the two parts resting inverted on a horizontal plane. Each part is filled with fine sediment, which is very similar to the enclosing, blocky, shale matrix. Computerized axial tomography (CAT) scans and photographs show that the eggshell fractured in the hingelike area where stress was maximal; in other places the shell was distorted and its curvature was inverted, indicating that the shell was semipliable during breakage and deformation (Fig. 1b). A rigid eggshell is pliable only in the oviduct and for minutes after oviposition as, for example, in geckos (*5, 6*).

Restored, the elliptical egg would have measured approximately 110 mm by 55 mm. With an estimated volume of 175 cm^3, this egg is comparable to identified eggs from the Upper Cretaceous nesting sites in Montana (*Troodon*, 140 cm^3; *Orodromeus makelai*, 300 cm^3) and *Protoceratops* (290 cm^3) from Mongolia. *Hypselosaurus* from France has a much larger egg (2000 cm^3).

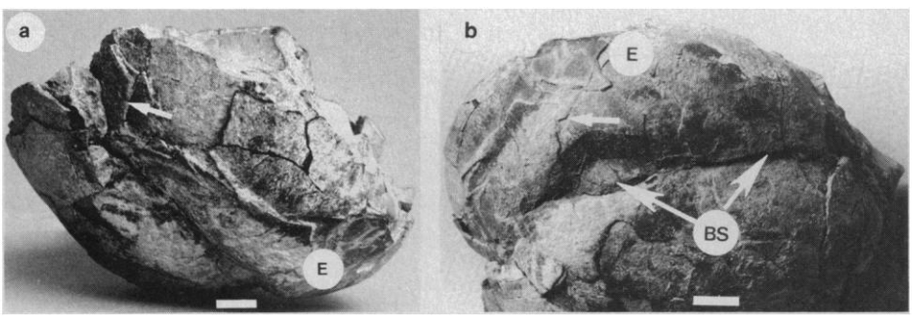

Fig. 1. (**a**) Specimen UUVP 11584 in the orientation in which it was found but with the front tilted slightly upward to allow a better view of the two halves. (**b**) Bottom view of the specimen showing the hingelike connection between the two halves. Note the location of inferred embryo as determined by the CAT scan (E); pathological eggshell (arrow); bent eggshell (BS). Scale bar, 1 cm.

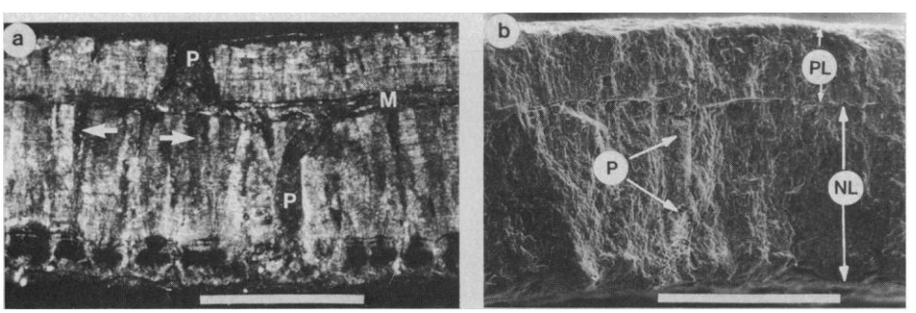

Fig. 2. View of the edge of normal (NL) and thin pathological (PL) eggshell layers. The outside of the eggshell is up. (**a**) Radial thin section (45 μm thick) viewed under polarized light (petrographic microscope). Columnar extinction pattern (arrows) is of ornithoid morphotype. Note the slight reversed curvature of both shell layers. (**b**) Edge of the eggshell viewed under a scanning electron microscope. Pores (P) of the two eggshell layers do not line up or do not continue through the second layer; peculiar tubelike pore structures (P); the thin layer between the two eggshells may represent the mineralized membrane (M) of the pathological eggshell. Scale bar, 1 mm.

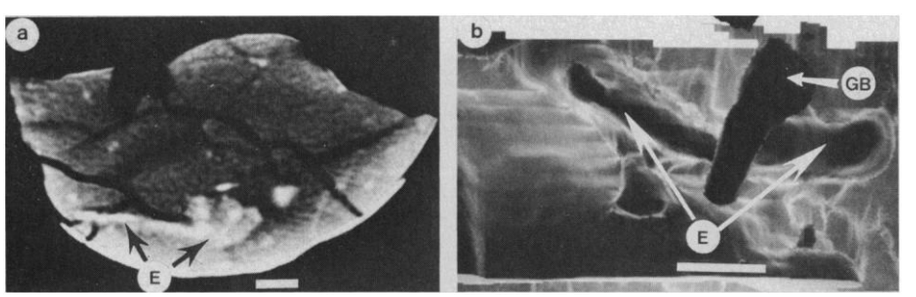

Fig. 3. (**a**) Conventional CAT x-ray image shows embryo-like object (E). Specimen was scanned in 68 overlapping sections (slices) of 1.5-mm thickness with a setting of 120 kV per 480 mA · s. A General Electric scanner was used. (**b**) Computed and enlarged three-dimensional reconstruction of the embryonic image based on a stored data set of 42 axial slices. Note the probable gas bubble (GB). Scale bar, 1 cm.

The eggshell ranges in thickness from 0.8 to 1.0 mm and is composed of calcite ($CaCO_3$). The normal shell layer is well preserved and is covered by a secondary, thin, pathological shell layer with an average thickness of 0.5 mm (Fig. 1, a and b).

The nonflexible, rigid eggshell is composed of interlocking shell units with straight columns. This structure, and a distinct columnar extinction pattern under polarized light (Fig. 2), is similar to the ornithoid (avian-like) type described by Sochava (*7*). The aeration canals (pores), however, are not of the angusticanaliculate types (straight and narrow) but have a peculiar tubelike form and a larger diameter. A specimen with a similar pore type and eggshell structure has been found in a newly discovered Jurassic egg site in the Morrison Formation of Colorado (*8*). Some modern gecko eggshell also has tube or funnel-like pores (*9*), but they are not, as yet, known from other dinosaurian eggs. Thus, we should establish a new structural morphotype for the Jurassic eggshell. The much thinner secondary eggshell is similar to the primary shell in microstructure, although the mammillae are not quite as developed. Most pores of the primary layer do not continue through the secondary layer, which would restrict the gas exchange seriously.

The retention of eggs and the formation of pathological eggshell have not been studied systematically and are still topics about which opinions differ (*10, 11*). However, it is known that oviducal retention of a normally shelled egg beyond the time of normal oviposition (egg-laying) due to stress, illness, or environmental conditions may lead to a pathological condition, which differs between birds and reptiles. In birds the formation of a single egg takes place in specialized regions of the oviduct (*12*)—albumen in the magnum, egg membrane in the isthmus, and calcareous layer in the uterus. Retention of the egg may trigger reverse peristalsis, transporting the egg back into the albumen-forming region and producing an "ovum in ovo," an egg that includes extra yolks and layers of albumen positioned between inner and outer eggshell (*13, 14*). In reptiles a simultaneous shelling takes place in one long section of the oviduct, which is homologous to the isthmus in birds (*15*). Without reverse peristalsis, the egg merely receives another egg membrane and another calcareous layer (*11*). Thus the multiple shell in the Jurassic egg, typical of modern pathological reptilian eggs, will allow us with further study to draw inferences about the oviduct, based on the shelling process in some of the dinosaurs.

CAT scans reveal a 38-mm-long and 6.4-mm-thick object (Fig. 3, a and b) near the

bottom of the smaller half of the specimen (Fig. 1, a and b). This object differs in appearance and density from that of the enclosing matrix and surrounding eggshells and resembles an embryo in an early stage of development (*16, 17*). It is rare, but not unusual, for soft organic matter to be preserved through diagenesis (for example, jellyfish, worms, tendons) (*18*). Moreover, the inferred early-stage embryo in the fossil egg is comparable in size to what would be found in modern reptile eggs before oviposition. Most reptiles, except turtles (*19*), lay eggs containing embryos whose development is about equivalent to a 48-hour chick embryo.

The presence of a pathological eggshell and the inverted eggshell curvature in the hingelike area on the Jurassic egg indicate that the egg was retained beyond normal oviposition, possibly as a result of traumatic events leading to the death of the mother. It is not known how long it takes for pathological shell to form; however, the mother must be alive for this process. In such double-layered eggs the embryo may still develop for a short time but will ultimately suffocate for lack of oxygen caused by misalignment of the pore canals (*20*). Because no other egg has been found, it is possible that the mother was disturbed during oviposition and had no chance to lay this last egg. The oviducal position of the egg and burial with the gravid female would also explain the fine preservation of the egg and the enclosing eggshell. The egg may have been fractured and opened during the death of the mother, and the oviduct may have held the two halves together until preservation by sediments.

Whole dinosaur eggs, pathological eggshell, and embryonic remains are extremely rare, especially before the Cretaceous (*21, 22*). However, with an eggshell structure that has a new type of pore canal and unidentifiable embryonic remains, we are as yet unable to link the specimen to any of the dinosaurs of the Cleveland-Lloyd fauna. We may, however, exclude the sauropods as they have a totally different eggshell structure (*23*). Reliable taxonomic referral, at this time, can only be based on the presence of hatchlings or embryos of known identity or an established fossil record of a structural type that has been clearly identified with a taxon.

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Mutations in a Protein Kinase C Homolog Confer Phorbol Ester Resistance on *Caenorhabditis elegans*

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The *tpa-1* gene mediates the action of tumor-promoting phorbol esters in the nematode *Caenorhabditis elegans*. A genomic fragment that constitutes a portion of the *tpa-1* gene was cloned by Tc*1* transposon tagging and was used as a probe to screen a nematode complementary DNA library. One of the isolated complementary DNA clones had a nucleotide sequence that predicts a polypeptide of 526 amino acids. The predicted amino acid sequence revealed that the predicted *tpa-1* protein sequence is highly similar to protein kinase C molecules from various animals, including man.

PHORBOL ESTERS SUCH AS 12-O-TETRADECANOYL PHORBOL-13-ACETATE (TPA) and phorbol-12,13-didecanoate (PDD) are potent tumor promoters and cause characteristic responses in many in vivo and in vitro biological systems (*1*). These compounds induce severe disturbances in the behavior and growth of the soil nematode *Caenorhabditis elegans* (*2*). The effects are specific, since phorbol esters that are not tumor-promoting do not appear to cause any disturbances in *C. elegans*. This relation between tumor promotion and effects on the nematode has led to the suggestion that *C. elegans* has a cellular component similar to that which mediates tumor promotion (*3*). To identify this cellular component and clarify the mechanism of action of phorbol esters, we have isolated and analyzed TPA-resistant mutants that show little TPA-induced phenotypic change. We have also investigated the gene *tpa-1*IV, defined by the mutants, which is involved in the action of TPA (*4*). Here, we report the molecular cloning of the *tpa-1* gene by Tc*1* transposon tagging (*5*) and its sequence analysis.

To tag *tpa-1* with transposon Tc*1*, we isolated spontaneous TPA-resistant mutants of the strains NJ82 and RW7097 (*6*) that could grow in TPA (1 μg/ml). The phenotypes of spontaneous mutants exemplified by MJ566 (*k532*), isolated from RW7097 (Fig. 1), were similar to those obtained with ethylmethane sulfonate (EMS)–induced *tpa-1* mutants (*4*).

Both the complementation test (Fig. 1, D and I) of MJ566 (*k532*) against the EMS-induced *tpa-1* standard reference mutant MJ500 [*tpa-1(k501)*IV] and three-factor crosses (7) indicated that MJ566 harbors the *k532* mutation in *tpa-1*. The *tpa-1* mutants MJ562 (*k529*), MJ564 (*k531*), and MJ566 (*k532*) were used for our analysis; the first two were independently isolated from the mutator strain NJ82, and had a phenotype similar to that of RW7097-derived MJ566 (*k532*).

For molecular analysis, MJ562 (*k529*) was ten times outcrossed to the wild-type N2 and N2-derived *tpa-1*IV–linked standard genetic markers (*8*). This outcrossed mutant was designated MJ563 (*k530*). The Tc*1* polymorphic pattern in Southern analysis of the genomic DNA from MJ563, N2, and

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