60% of TV programs contain violence, so the number of TV hours correlates closely with the number of violent TV hours (*8*). Thus, the use of TV viewing hours in this study probably underestimates the effects of TV violence.

Recent theory about human aggression suggests at least two approaches to reducing media-related aggression (*9*). One involves reducing exposure to violent media. Robinson and colleagues reported one such intervention that significantly reduced aggression among third and fourth graders over a 6-month period (*10*). The other approach involves changing children's attitudes toward media violence. Huesmann successfully used this approach to reduce aggression in first and third graders over a 2-year period (*11*). The study by Johnson and colleagues suggests that media violence affects a larger group of people than previously believed, and that interventions for adolescents might also be beneficial. Such approaches are needed because a heavy diet of media violence contributes to a societal violence rate that is unnecessarily obese.

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Links to other video game violence articles:

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2. Written version of testimony given by C. A. Anderson on 21 March 2000 at a hearing of the U.S. Senate Commerce Committee; www.psychology.iastate.edu/faculty/caa/abstracts/2000-2004/00Senate.html.

Additional Web sites related to violence:

1. www.mediafamily.org/index.shtml2
2. www.colorado.edu/cspv/
3. www.lionlamb.org/
4. http://curry.edschool.Virginia.EDU/curry/centers/youthvio/
5. www.youngmedia.org.au/
6. www.childrennow.org/
7. www.actagainstviolence.com/medviolence.html
8. www.killology.com/
9. www.cme.org/

PERSPECTIVES: EARTH SCIENCES

The Study of Superfloods

Victor R. Baker

Large, high-energy floods are both rare and dangerous. Evidence of their impacts in the geologic record is often subtle, but the greatest obstacles to advancing the knowledge of superfloods have come from misapplied scientific logic. Particularly troublesome are flawed notions of hypothesis testing, verification, and the principle of simplicity. Contrary to conventional views of scientific methodology, there has never been a general theory of superfloods that could be tested, confirmed, or falsified by observation and experiment. Instead, as in much of geology, observation has preceded theory, and understanding has emerged as previously unrecognized phenomena were discovered.

Methodological problems with the study of superfloods began early, at the inception of geology as a science. The influential 19th-century geologist Sir Charles Lyell passionately advocated a regulative principle for validating the inferences that geologists make about the past. Presuming that geologists reason by induction, Lyell thought that such a principle was necessary if geological inferences about past causative processes were to achieve the same kind of certainty as those made in experimental sciences like chemistry and physics. It was Lyell's most capable critic, the Cambridge polymath William Whewell, who in 1832 named this principle "uniformitarianism." Epistemological uniformitarianism holds that scientifically reliable inferences about the past must be confined to invoking only the slow-acting, low-magnitude processes currently in evidence to human observers.

Deposits of the cataclysmic Missoula floods. The largest boulder has a long axis of 18 m. It was eroded from scabland basalt outcrops and was transported about 10 km to the proximal portion of the immense Ephrata Fan, which covers about 1000 km^2 of the Quincy Basin in east-central Washington state.

This principle was applied blindly by Lyell's intellectual descendents well into the 20th century. In the 1920s, Bretz's documentation (*1*) of the spectacular effects of late-glacial flooding in the Channeled Scabland region in Washington state met with immense criticism from the scientific community. Not until the 1960s was it generally accepted that this flooding was caused by catastrophic failure of the immense ice-dammed Glacial Lake Missoula along the southern margin of the Cordilleran Ice Sheet, which covered the northwestern mountains of North America about 20,000 years ago.

Over the past 40 years, evidence has accumulated for catastrophic failures of ice-dammed lakes, overflows of lakes that had formed along ice margins, and subglacial outburst flooding in the many river systems associated with the immense continental ice sheets of the last ice age. The southern margin of the Laurentide Ice Sheet that covered northeastern and north-central North America was episodically drained by outburst floods (*2*). These freshwater discharges greatly influenced ocean circulation and climate at the end of the last ice age (*3*).

Even more extensive evidence of superflooding has been documented in Asia, recorded best in the Altai Mountains of the upper Ob river basin (*5*). Spectacular superflood features are also found in the upper Yenesei river basin in Tuva. A system of huge spillways connected the late glacial lakes that inundated large parts of the Ob and Yenesei basins. The huge meltwater influxes greatly extended the areas and volumes of paleolakes in basins now occupied by the much smaller Caspian and Aral Seas and drained into the Black and Mediterranean Seas (*4*). The mountains forming the border regions of modern Russia, China, Mongolia, and the central Asian republics also contain extensive evidence of ice-

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dammed lakes, many of which spilled catastrophically.

Long geologic records from river basins bear witness of repeated superflooding. The Columbia basin was affected by superfloods numerous times over the past 1.5 to 2.5 million years (*6*). Its flood sediments were introduced into the Pacific Ocean, where they were transported as turbidity currents along a 1000-km path across the sea floor (*7*). Hydraulic reconstructions of the flood discharges show that their magnitude can be substantial: The Missoula and Altai superfloods achieved peak discharges of about 20 million m^3/s (*5*), comparable to the volume of water moved by many ocean currents.

Ocean currents rarely move faster than a few m/s, whereas superflood flows may move several tens of meters per second. High-discharge floods in narrow, deep bedrock channels also generate immense magnitudes of power per unit area and of bed shear stress (*8*). Paleohydraulic calculations have shown that high-energy floods may lead to large-scale turbulence, cavitation, boulder transport (see the figure), suspension of very coarse particles, and abrupt changes in flow dynamics (*8*). The bedrock is scoured to form longitudinal grooves, giant potholes, inner channels, and cataracts. Deposited material forms giant current ripples composed of gravel and boulders and immense bars of gravel and boulders. Slackwater sedimentation occurs at the margins of the flood discharge channels.

These well-documented features associated with superflooding have been used to infer even more spectacular flooding scenarios during the last ice age. In a recent interpretation of the central Asian evidence, Grosswald (*9*) infers that immense volumes of water were conveyed from the margins of the great ice sheets that occupied what are now the shallow continental shelves of northern Asia. The floodwater moved southwestward, not only cutting spillways between the major north-flowing river systems but also inundating hundreds of kilometers of intervening upland to produce an east-west flow pattern in the topography that is apparent on satellite images of central Asia. Another much-disputed theory ascribes subglacial landforms associated with the late-glacial ice sheets to meltwater flooding beneath the ice, leading to outburst flooding at the ice margins (*10*).

These highly controversial studies of superfloods show that flood science has not achieved the universally accepted valid scientific methodology envisioned by Lyell. Instead, it is my view that superflood studies are motivated by a notion introduced by Whewell, who proposed in 1840 that productive scientific hypotheses work toward achieving "consilience," a kind of confirmation through the unexpected connections and explanatory surprises they engender.

The most unexpected superflood connection has been the discovery of immense flood channels on Mars, which have morphologies that are best explained by direct comparison to flood-eroded landscapes on Earth (*11*). Less spectacular, but highly relevant to human adaptation to flood hazards, is paleoflood hydrology (*12*) in which the generally smaller floods of the last several thousand years are reconstructed with techniques previously applied to the study of the superfloods of the last ice age.

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PERSPECTIVES: BIOMEDICINE

Defining the "S" in SERMs

Benita S. Katzenellenbogen and John A. Katzenellenbogen

Successful treatment of hormone-responsive breast cancer with the drug tamoxifen represents a major accomplishment for cancer chemotherapy. Tamoxifen, which opposes the action of estrogen in certain tissues and mimics the action of this hormone in others, has been an important contributor to the decline in breast cancer mortality rates during the past decade. In the first significant demonstration of cancer chemoprevention, women at high risk of breast cancer who take tamoxifen or a related drug, raloxifene, halve their risk of developing the disease (*1, 2*). But despite its effectiveness in blocking estrogen action in the breast, tamoxifen has an Achilles heel—it stimulates proliferation of endometrial cells in the uterus, putting women who take it at a somewhat increased risk of developing endometrial cancer. Shang and Brown, reporting on page 2465 of this issue (*3*), bring new insight to this conundrum. They reveal that the contradictory action of tamoxifen in the breast and uterus depends on a combinatorial collaboration between its binding partner, the estrogen receptor, and a specific cellular coregulatory protein, which acts on target genes in uterine cells.

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Originally called antiestrogens, tamoxifen and raloxifene are better termed selective estrogen receptor modulators (SERMs). This term appropriately indicates that these compounds are not uniformly estrogen antagonists. Rather, they display an unusual tissue-selective pharmacology: They are agonists in some tissues (bone, liver, and the cardiovascular system), antagonists in other tissues (brain and breast), and mixed agonists/antagonists in the uterus. Tamoxifen has greater uterine-stimulatory activity than raloxifene (*4–6*). Great efforts are under way to improve the tissue selectivity of SERMs so that they are optimized for preventing and treating breast cancer and for alleviating the symptoms of menopause.

It is now appreciated that the pharmacology of estrogens is tripartite, relying not just on the ligand and estrogen receptor but also on third parties, such as gene promoter elements and coregulatory proteins (*7*). Crystal structures of the estrogen receptor bound to different ligands (estrogen, tamoxifen, or raloxifene) reveal that ligands of different sizes and shapes induce a spectrum of receptor conformational states (*8, 9*). These states are then "interpreted" by the cellular complexion of coregulators and the environment of the local promoter of the target gene.

The estrogen receptor is a versatile transcriptional regulator and can interact with target genes, either by binding directly to DNA response elements or through indirect