-rization of actin, resulting in the formation of a filament which is necessary to attach the sperm to the egg. This actin polymerization, as in the egg, may be pH-mediated.

Summary. The initiation of development thus involves complex changes in both sperm and egg. The changes in the sperm are initiated as the sperm comes near the egg, probably triggered by substances released by the egg. The changes in the egg are triggered by sperm-egg contact. The nature of these important changes is unclear, but it is apparent that the initial changes involve ions; release of calcium appears to be universal, and in the sea urchin egg an increase in intracellular pH, mediated by a sodium-hydrogen exchange, is also critical. One target of calcium is calmodulin. Important problems to be answered in the coming years will concern how these ion changes are mediated by sperm-egg contact and how these are transduced into the initiation of new metabolic pathways necessary for development.

For background information *see* FERTILIZATION in the McGraw-Hill Encyclopedia of Science and Technology.

[DAVID EPEL]

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Flash floods

In the United States more people are dying each year from flash floods than ever before. But there are important opportunities for science and technology to reverse this trend.

Causes. Flash floods most often result from heavy rainfall. Some result from damming of a stream by mud slides, avalanches, or ice jams; release of water from a glacier-dammed lake (Icelandic, *jokulhlaup*): rainfall combined with snowmelt: or failure of a dam (either natural or erected structures). Dam failures often are the result of intense rainfall producing reservoir inflow that exceeds the damming and spilling capabilities. Flooding resulting from the sudden release of impounded water by dam failure has been responsible for a major portion of the loss of lives and property in many flash floods. Major dam failures occured at Buffalo Creek, WV, in February 1972; Teton Dam, ID, in June 1976; Johnstown, PA, in July 1977; and Toccoa, GA, in November 1977 (see table). In these four cases alone there were 251 killed and nearly $139 million in damages.

Forecasting. In the United States, success in decreasing the tragic loss of life (averaging nearly 200 deaths per year) and property (over $1 billion in damages each year) depends on the ability to understand and forecast the physical processes which produce flash floods, and on the ability to satisfactorily cope with the human aspects associated with protective or preventive measures when flood warnings are issued.

Dam failure. Satisfactory techniques have recently been developed for predicting the flood flows resulting from dam failures, based on assumptions as to the type of failure, reservoir contents, and streamflow into the reservoir. Under actual conditions, specific information on these three factors can be used to improve the predictive accuracy and timing of the downstream rapid flooding.

Technical limitations. There are substantial gaps in knowledge of how extremely heavy rainfalls of short duration are produced. In many cases, storms that produce flash floods are neither forecast nor even detected by the present river and rainfall reporting networks.

New approaches to observing the occurrence and magnitude of intense precipitation are providing forecasters with increased information for issuance of flash flood warnings. Automation of many rain and stream gages in drainages subject to flash flooding have helped to provide information more rapidly, but less than 10% of the reporting networks are automated. Many means of communication are presently in use, including AM and FM radio, radio via meteor bursts, satellites, and microwave links, as well as the telephone. Many gages are programmed to report periodically (as at hourly intervals). An event-reporting rain gage is now being used to report directly to computers each time a specified amount of rainfall occurs. In many areas of the United States large numbers of people have rain gages and serve as spotters to provide telephone or citizen-band radio reports on heavy storms, as is done for reporting of tornadoes.

However, rainfall gages can measure only those intense storm cells that occur immediately over the gage. Radar scopes monitored by meteorologists of the National Weather Service (NWS)—a component of the National Oceanic and Atmospheric Administration (NOAA)—provide surveillance of precipitation events. The intensity of the reflected microwave energy, from heavy precipitation, does provide a measure of the water flux in the cloud and thus an index to the precipitation rate. Some radars are equipped with automatic digitizers that allow the data to be processed by minicomputers for quickly providing maps of the areal distribution and amount of rainfall to the forecaster. Photographs and infrared data from NOAA meteorological satellites are used to derive estimates of the amount of rainfall. The satellite infrared data provide a measure of the temperatures of the cloud tops. For very large storm centers the cloud tops are generally very high and thus have colder temperatures than warmer and lower clouds that generally produce only moderate or average precipitation. Papers describing the equipment and techniques for observing and measuring heavy rainfall were presented at the 1st National Conference on Flash Floods held in Los Angeles on May 2–3, 1978.

Watch-warning forecasts. The NWS has a watch-warning forecast service to alert people to the possible occurrences of a flash flood. The issuance of a flash flood watch for a particular area indicates that heavy rains may result in flash flooding and people in the area should be prepared for the possibility of a flash flood warning signifying an emergency which will require immediate action. A warning is issued when flash flooding is occurring or is imminent in the area. Persons in the area should move immediately to safe ground.

The flash flood watches and warnings are based on the prediction or observance of heavy rainfall. In addition to the use of various observing and measurement methods, the NWS offices predict the occurrence of heavy rains or other causative factors. Basic weather guidance is prepared by the National Meteorological Center of the NWS, located in Camp Springs, MD. These forecasts are based on observations and numerical, diagnostic, and predictive models of the atmosphere, and include quantitative precipitation forecasts. The large-scale numerical models do not provide adequate forecasts for the extreme amounts of rainfall generally associated with flash floods.

Research. Studies by C. F. Maddox and R. A. Chappell of the Environmental Research Laboratories, NOAA, and others are beginning to develop a knowledge of the characteristics of flash flood storms. A cooperative experiment is being funded by NOAA, the National Science Foundation, and other government agencies, to improve the scientific understanding of mesoscale storms and rainfall processes. SESAME (Severe Environmental Storms and Mesoscale Experiment) was conducted in the spring and summer of 1979 to provide a massive measurement of mesoscale storms in "tornado alley" centered near Norman, OK. The SESAME data will be of great value for testing and development of mesoscale weather models needed to predict the convective activity that often results in flash floods. Of 20 significant flash floods in the United States between 1972 and 1977, striking similarities have been observed. For example, in 75% of the cases studied, the floods began during the night hours of 6 P.M. to 6 A.M.

Many flash flood-producing storms are associated with extratropical storms that degenerate from hurricanes or tropical storms. The movement of these storms, such as occurred from hurricanes Camille in 1969 and Agnes in 1972, can be predicted with some degree of success. However, it has been almost impossible to predict accurately the timing, intensity, and location of flash flood-magnitude rainfalls that occur with severe local storms.

A review of the major flash floods during the past decade (see table) shows that four were associated with storms derived from tropical storms, and five were associated with one or more dam failures that contributed to the severity of the flooding. The table indicates whether telemetered rainfall reports, radar, and satellite data were used for issuing flash flood forecasts prior to the flooding.

Human factors. If there is inadequate public response to warnings, even a perfect forecast of impending disaster may be of little value. Case studies have shown that people do not always recognize the direct relationship between heavy precipitation and flash flooding. Therefore, they are often unwilling to evacuate or take other protective measures even when warned by national, state, or community officials. In many situations, the potential victims have not been trained as to protective or preventive measures. An example is the false

Major flash floods in the United States, 1969–1978

	James River Basin, VA, August 1969	Arizona, September 1970	Buffalo Creek, WV, February 1972	Rapid City, SD, June 1972	Hurricane Agnes, northeast U.S., June 1972	Teton Dam, ID, June 1976	Big Thompson, CO, July 31–Aug. 1, 1976	Appalachia, April 1977	Johnstown, PA, July 1977	Kansas City, MO, September 1977	Toccoa, GA, November 1977	Southern California, February 1978	Texas, August 1978
Observations (used for issuing forecasts prior to flooding)													
Precipitation, telemetered	No	No	No	No	Yes	*	No	Yes	No	No (?)	No	No	No
Radar (from area of heavy precipitation)	No	No	No	No	Yes	*	No (?)	No	Yes	Yes	Yes	No	Yes
Satellite (from area of heavy precipitation)	No	No	No	No	Yes	*	No	Yes	No	Yes	No	Yes	No
Forecast issued (for principal flood area prior to flooding)													
Flash flood watch	No	—	Yes	—	Yes	*	No	Yes	No	Yes	Yes	Yes	Yes
Flash flood warning	No	Yes	No	Yes	Yes	*	No	Yes	No	Yes	No	No	Yes
Highest amount of precipitation, mm	810+	290	142	381	478	*	304	394	305	406	178	120	1067
Previous tropical storm	Yes	Yes	No	No	Yes	No	No	No	No	No	No	No	Yes
Dam failure involved	No	No	Yes	Yes	No	Yes	No	No	Yes	No	No	No	Yes
Report available (NOAA or USGS-NOAA)	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes
Lives lost†	153	23	125	237	105	11	139	22	76	25	39	20	33
Damages, millions of dollars†	116	5	10	165	4020	500	30	424	330	90	2.5	83	100+

*Dam failure – not weather related. †For some cases, statistics are for all flooding.

...urity that people often place in their cars; a ...jor percentage of deaths is related to automo-...es. An increased and continuous education pro-...am is essential for success in reducing the annu-...loss of life and damages from flash floods.

Flash floods occur in all parts of the United States. Some areas, such as the recreational areas of the Southwest, can quickly turn into death traps for the unobserving traveler. In all areas, simple precautions such as never driving into inundated areas could save hundreds of lives.

Community involvement. The key to an effec-tive preparedness program lies with local com-munities. Training of individuals in how to protect themselves and their property and how to respond when warned by local officials is best accom-plished at the local community level.

The local community should also establish an appropriate organization which can cooperate with Federal and state officials responsible for issuing warnings of impending disasters. This must be a 24-hr operation. It must also have sufficient author-ity to properly coordinate with the police, fire, and other preparedness organizations, and have the necessary communications for collection of data, receipt of information, and contact with all emer-gency personnel, as well as with the public news media.

In addition to the flash flood watch and warning service, the NWS assists communities on the de-velopment of local warning systems. Such systems include the installation of reporting precipitation and stream gages, some of which may automatical-ly sound an alarm when a specified amount of pre-cipitation occurs in a watershed or when a stream reaches a specified level. The NWS forecast of-fices in many cases can provide daily information on the amount of rainfall needed to cause flooding. Local officials can then predict the streamflow which would occur on small, fast-rising streams, using this information and the amount of precipita-tion from their gages. The U.S. Army Corps of Engineers and other government agencies provide extensive help and guidance for both structural and nonstructural alternatives for flash flood pro-tection and preventive actions.

Needed action. The American Meteorological Society has issued a statement of concern, "Flash Floods—A National Problem." The following ac-tions were recommended to help alleviate the problem: (1) increase regulation of the use of areas subject to flash flooding; (2) certify and monitor the safety of dams; (3) improve information on fre-quency of maximum precipitation and associated runoff for design and planning; (4) plan and carry out an extensive and continuous public awareness program; (5) strengthen ties among meteorologists, hydrologists, engineers, social scientists, and ac-tion agencies in communities; (6) improve the abil-ity to monitor and detect flash flood conditions, partly by increased use of automated ground mea-surements, radar, and weather satellites; (7) in-crease the capability to forecast the location and magnitude of rainfall; (8) improve the capability to forecast intense, small-scale phenomena; (9) im-prove community warning programs, with empha-sis on encouraging individual response to warn-ings.

For background information *see* DAM; STORM DETECTION; WEATHER FORECASTING AND PREDICTION in the McGraw-Hill Encyclopedia of Science and Technology. [EUGENE L. PECK]

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Flight controls

Developments in a number of technologies related to flight controls are leading to major changes in aircraft flight control systems. Examples of these recent developments are advances in digital tech-nology, fiber optics, and electric motors that use rare-earth magnetic materials. These develop-ments will make possible reduced volume, weight, power requirements, and cost and improved reli-ability of conventional flight control systems, as well as providing additional options for the aircraft designer for improving aircraft efficiency. One op-tion is to incorporate active control technology (ACT) in the design of the aircraft, with resulting greater dependence upon the flight control system and improved aircraft efficiency. The fuel efficien-cy of commercial transports is of growing impor-tance due to the rising value of liquid petroleum and its various derivatives, including jet fuel.

Primary flight controls. Flight control system design is in a state of change as a result of the im-provements in electrical and electronic component reliability. These improvements have led to flight control designs for military aircraft with electrical control paths from the pilot's controls to the sur-face actuators. In these designs, motions or forces applied to the cockpit controls are transmitted by electrical means to the aircraft control surfaces instead of by cables or push-pull rods. As flight control systems become more complex to meet requirements for improved civil aircraft perfor-mance, savings in aircraft weight and cost can re-sult from this fly-by-wire (FBW) approach.

Auxiliary flight controls such as flaps, commonly called secondary flight controls on commercial transport aircraft, have conventionally been used for improving lift capability on fixed-wing aircraft. In addition to this function, they now are being used for aircraft maneuvering and regulation of aerodynamic loads. Applications such as these are finding increased usage on short takeoff and land-ing (STOL) aircraft and highly maneuverable air-craft, such as military fighters.

Hydraulic actuators are used to power primary flight control surfaces for most high-performance military and civil aircraft. However, there is in-creased interest in the development of high-torque, low-inertia electric motors using rare-earth samarium-cobalt magnetic materials. For certain low-power applications this form of actuation may result in lower actuation weight and cost.

Automatic flight controls. Automatic flight con-trol systems, such as autopilots and autothrottles, are used to control aircraft position and speed. These systems are installed on most aircraft, from