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What's happening in the mathematical sciences. Vol. 8.

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The book is the eighth volume of the series of this title. Five first volumes were written by Barry Cipra [Zbl 0858.00003, Zbl 0858.00004, Zbl 0858.00005, Zbl 1028.00002, Zbl 1028.00002], the sixth volume by Barry Cipra and Dana Mackenzie [Zbl 1244.00007], and the seventh volume by Dana Mackenzie [Zbl 1244.00007]. The aim of the series is to show the remarkable recent progress in pure and applied mathematics. Those achievements are described in a popular way (nevertheless, it seems that this very interesting and well written book will be read mainly by mathematicians). This volume consists of 9 chapters devoted to different mathematical achievements. A short description of these chapters is presented below. A movie rental company Netflix offered a million-dollar prize for the development of a computer algorithm that could predict customers' taste of movies 10 percent better than Netflix's own proprietary program. After 3 years of competition the award was given to a team called BellKor's Pragmatic Chaos. The competition upset some conventional wisdom in the field of machine learning. The competition led to new scientific ideas and can be regarded as a successor of the famous Longitude Prize (given to John Harrison for his chronometers in 1773). This is described in the first chapter "Accounting for taste". The chapter "A brave new symplectic world" is devoted to the solution of the Weinstein conjecture. In the late 1970s Alan Weinstein conjectured that certain kinds of dynamical systems with two degrees of freedom, such as a pendulum that is free to stretch as well as swing, always have periodic solutions. This conjecture stimulated research in symplectic topology. In 2008 Cliff Taubes proved the conjecture and showed that for a certain kind of systems with two degrees of freedom periodic orbits exist, even if the system is far from equilibrium. The third chapter "Mathematics and the financial crisis" concerns financial mathematics. In the first decade of the 2000s, the financial crisis came and mathematical models were blamed to be one of the reasons of this crisis. However, such an accusation is at least controversial. Mathematical models (including the Black-Scholes formula), their role and several recent events concerning finances are described here. In the chapter "The ultimate billiard shot" mathematics concerned with the game of outer billiards is presented. The game was invented in 1959 by Bernhard Neumann. The game is played at the infinitely large table with a hole in the centre. Some problems concerned this game were investigated for a long time. In 2007 Rich Schwartz proved that for certain shapes of the hole it is possible to play the trick shot that cannot be contained in any bounded region. Some ideas and patterns were suggested by the computer (however, the proof was not a computer proof). The following chapter "SimPatient" concerns another application of mathematics. In 2009 some medical experts in the USA recommended that women between the ages of 40 and 49 should no longer be counseled to undergo routine mammograms. This led to a great interest of politicians. The story and mathematical models are described here. The chapter "Instant randomness" concerns the ultimate changes of states of the system from "unmixed" to "mixed" (like during mixing milk in a coffee cup, neutrons in an atomic reactor, or atoms in a gas). This phenomena was first observed in 1980s, it is called "cutoff phenomena", and the time when mixing occurs is called "mixing time". Recently the team of mathematicians at Microsoft Research observed that cutoff phenomena occurs in many important models of statistical physics, like the Ising model of magnetism. A cutoff time was calculated for some phenomena. The same behaviour is expected for other systems described by the theory of Markov chains. The chapter "In search of quantum chaos" is also connected with billiard, but this time with a classical one. A billiard ball on a table with curved sides travels on a chaotic trajectory that essentially randomizes the ball's position over the long term. However, at low energies, quantum billiard balls are not chaotic. With the use of methods of pure number theory and physics it was proved that quantum chaos does emerge at high energies. This is a next beautiful example of the interplay between physics and mathematics. The eighth chapter "3-D surprises" shows that some new phenomena in ordinary three-dimensional space can be even contemporarily discovered. In 2008 and 2009 new ways to pack tetrahedra extremely densely were discovered. A little earlier, but also in the XXIth century, two Hungarian engineers: Gábor Domokos and Péter Várkonyi discovered a new three-dimensional object, which is the first homogeneous, self-righting, and self-wronging (i.e. it automatically rights and wrongs itself). Finally, in the chapter "As one heroic age ends, a new one begins" we read about recent discoveries connected with famous "exotic spheres". The story began from John Milnor's constructions on 7-dimensional exotic spheres on the 1950s. This led to new tools and development of important theories. However, one important problem, so-called Kervaire Invariant One Problem remained unsolved. It concerned the complete census of all exotic spheres. The question was answered in 2009 by Mike Hill, Michael Hopkins and Doug Ravanel. The book printing is of high quality full colour. Many pictures, diagrams illustrating the phenomena and some photos of scientists mentioned in the book are included.

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