Complex Systems - How Do They Work?

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Complete the following tasks in individual work. You can use the "Physik für das Klima und andere komplexe Systeme“ digital poster and the Lindau Online Matinee 2022 video for this:

https://www.mediatheque.lindau-nobel.org/GetFile?id=39532

https://www.mediatheque.lindau-nobel.org/videos/39519/lindauer-matinee-2022

Tasks

Systems, both simple and complex, describe our real world. They consist of clearly defined individual components that form a functional unit when working together. An aeroplane, for example, is a system.

Simple systems consist of a few components. Their behaviour can be completely understood and predicted, for example the free fall of a ball in the air, which is attracted by gravity and slowed down by air resistance.

It becomes more difficult when several balls are falling together: the air vortices behind each ball influence the falling motion of the following balls. The balls can hit and repel each other and so on. Complex systems contain a multitude of components that interact with each other, but also interact with their external environment. Chaotic and random phenomena occur, so that the result of these internal and external interactions is very difficult to predict. As a rule, the properties of the individual components do not allow conclusions to be drawn about the global behaviour of the entire system. Therefore, an aircraft manufacturer cannot ultimately predict with certainty how an aircraft will actually fly. A train manufacturer cannot map all eventualities in the development either, so that in extreme weather conditions such as intense heat, it is not possible to predict with absolute certainty how the individual components in the train will expand.

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1. Name and describe six things that can cause a traffic jam on the motorway even though the traffic density is not high.

2. The Nobel Prize winner Giorgio Parisi has observed flocks of starlings, other scientists have studied schools of fish to find an explanation of how the animals manage to fly or swim in a regular formation and not collide or get lost.
   Using the internet, research how fish and birds manage to move in a shoal without colliding or drifting apart.

3. Many scientists have come to the conclusion that the behaviour of individual people cannot be predicted, but the behaviour of masses of people can. "As a mass, people certainly behave in a similar way to particles of liquids or gases," says Professor Massimo Fornasier, holder of the Chair of Applied Numerical Analysis at the Technical University of Munich.
   Describe and justify how you think people will behave in the event of a real fire alarm at your school.

4. Of course, not all people react in the same way. Within crowds there are therefore certain regularities, such as how movement or opinion-forming processes take place. Just as herding dogs guide a flock of sheep by persuading the most stubborn sheep to change direction, the most radical representatives within the group are often decisive in the formation of opinions in groups of people. If they can be persuaded to change their opinion, the opinion of the entire group will change, as the mathematician, Masimo Fornasier, was able to prove.
   Explain how, according to the behavioural conclusions of Massimo Fornasier, hate on the internet could be most effectively combated.

5. The Nobel Prize winner Giorgio Parisi also found out that the smallest changes within complex systems can cause large, lasting changes. The best-known image is that the flap of a butterfly's wings can cause a hurricane at the other end of the earth.
   Describe an example of how a small thing could stop all traffic on the motorway for hours.

6. Research the life of Giorgio Parisi on the internet and present your results in a clear form (e.g. video or poster).
   The results will then be presented and discussed in plenary.

Additional task for quick learners: Looking at the diagram at the top right of the digital poster, explain to your classmates, using the example of an electricity grid, why the supply of electricity to the population is a highly complex and extremely fragile matter.

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