*Special Issue: The Oosawa Lectures on DIY Statistical Mechanics***Part I. Experiencing the basics of statistical mechanics using your hands**

Editorial team for the Special Issue on Oosawa's Lectures*

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Edited by Haruki Nakamura

One of my aims in part 1 of this book is to have the reader roll dice with their own hands, so as to intuitively develop an understanding of the basics of statistical mechanics.

In Chapters 1 and 2, first, we play a game in which we roll a dice^{1,1} and exchange gaming chips randomly. Since the probabilities of giving and receiving the gaming chips are the same, under normal circumstances, we would expect everyone to have an equal number of gaming chips. However, the results can often be surprising. Actually, this game mimics how molecules move randomly, colliding with each other, and exchanging energy. If you are surprised by the results of this game, I will ask you to write down the simplest case of “three people exchanging three gaming chips” on paper. However, you can also observe the results of computer simulations in which there is a large number of participants. Based on these two examples, I would like the reader to contemplate the basic principles that surprised you in the game.

In Chapters 3 and 4, I introduce several variations of the game that the reader explored in Chapter 2. For example, “the bankruptcy elimination” rule, which indicates that you are out of the game if all your gaming chips are gone, and “the income tax” rule, which states that the probability of giving out gaming chips will increase according to the number of gaming chips you possess. I will also discuss the somewhat paradoxical realization that during the game each player is much more likely to lose their chips than gain them and so “always now is the peak moment” is nearly always the best advice. Although questions such as “How many of these molecules have energy and how much energy do they have?” lay squarely within the domain of statistical mechanics, they are remarkably similar to other more familiar questions of the type, “How many rich people are there, and how rich are they?” Even if you are not familiar with physics, you can still enjoy the journey associated with developing an answer to these types of questions.

In Chapter 5, we will summarize our arguments in order to prepare ourselves for the second part of this book.

When first using this book, please forget all the difficult mathematics, roll the dice many times with your own hands, exchange gaming chips, write a diagram on paper, and investigate the behavior of molecules.

*Editorial team for the Special Issue on Oosawa's Lectures: Masayo Inoue, Meiji University; Noritaka Masaki, National Institute of Genetics; Kiyoshi Ohnuma, Nagaoka University of Technology; Masako Ohtaki; and Taro Toyota, The University of Tokyo; Author names are listed in alphabetical order (with all authors having contributed equally)

Chapter 1: Starting Rules

Gather five friends and make a team of six people. If you can't get five people you can play all the six roles by yourself. You will need dice and gaming chips. If possible, prepare 50 dice for each team and use them one by one to generate a fair approximation of randomness (you may frequently roll a particular number due to imperfect dice). However, if preparing 50 dice is not easy, you can use as many dice as you can prepare. Given that you will need quite a few gaming chips, either cut-out colored pieces of paper or use real coins (however if using real coins please return them to the owner after the experiment).

Have the six people gather around the table and provide five^{1,2} gaming chips to each person (therefore, for a table of six people, there will be 30 gaming chips). First, assign a number from 1 to 6 for each person. Roll the dice and if you get a 1, the first person places a gaming chip in front of them. If a 2 is rolled, the second person places a gaming chip and so on. Play 30 times to distribute the gaming chips. Note how many gaming chips each of the six people obtain. This is the first stage. We have reached the starting line. Possibly at this stage, the gaming chips may be almost uniformly distributed (Fig. 1.1 Top).

Now, get ready, roll the dice and the person corresponding to the number on the dice puts one of their own gaming chips into the center of the table. Next, roll the dice again and the person corresponding to the number on the dice now takes the gaming chip from the table center. Therefore, a gaming chip is exchanged. Please record the number of chips at the start and the end of the game (but you do not have to record the number at each stage). Actually, it is better to have two dice on the table. If we go by the rule that the number on the dice rolled by one person corresponds to the person who gives a gaming chip, and the number on the other dice rolled by another person corresponds to the person who takes the gaming chip, so the time required between rolls, can be reduced. Thus, when two individuals roll the dice

Figure 1.1 Dice and chips game: 30 gaming chips (energy) are randomly distributed to 6 people (molecules) by rolling the dice. After distributing all, random exchange (interaction) of the gaming chips is performed by rolling the dice twice. When the exchange is continued, how will the histogram of the number of gaming chips held by each person change?

Table 1.1 Outline of exchange of gaming chips

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- First, the gaming chips are distributed randomly from a source (the number of chips per person becomes almost uniform).
 - After that, when an exchange is initiated, the state of distribution changes completely
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at a time, one exchange will be completed. Play this game for 10 or 15 minutes, and make a note of how many gaming chips each of the six people finally possess.

In considering how this game is connected to statistical mechanics, note that each person corresponds to a molecule, and the number of gaming chips corresponds to the amount of energy that each molecule has. In other words, through this exchange, we can understand how the energy possessed by a molecule is distributed. First, when the gaming chips were randomly distributed from a source, the numbers of the chips per person were almost equal. This is important. This corresponds to the energy (gaming chips) that flows from somewhere. The energy that flows suddenly is received randomly. Thereafter, the molecules that received the energy randomly collide with each other (interact), and exchange energy^{1,3}, which is what I would like you to do from now on (Table 1.1).

Although some people may know the answer, please begin without stating that you knew it. Although I have had these experiments performed during various lectures, I often intentionally chose individuals who did not know the expected results to perform it. For several years, I lectured at Aichi University of the Arts and had this experiment performed. When I asked what would happen if they exchanged energy in this manner, all of the approximately 120 students stated that they expected that the gaming chips would be further evenly distributed when they exchange energy with each other. At that stage, I recommended to them to actually perform the exchange. When they start carrying out the exchange, the state of distribution changes completely. As far as art school students are concerned, most of them were greatly surprised (and I thank everyone for being surprised!).

Here I point out the supplementary aspects to the rules of this game. After exchanging the chips a few times, some people may have zero gaming chips. Although the person who has zero gaming chips cannot give gaming chips even if their number is rolled by the dice, they also cannot have a debt. Therefore, if the dice roll for “giving out gaming chips” corresponds to a person who has zero gaming chips, the dice is rolled again. In this game there is no debt, and therefore no negative number of gaming chips can accrue. Even if they have zero chips at one time, the game doesn’t end there, and if they hit the dice roll for getting a gaming chip, they still receive a chip. If we divide 30 gaming chips by 6 people, the average is five, and 5 squared is 25. If we do this approximately 100 times, someone will likely have zero chips. Even if you do not perform this activity 100 times, the number of gaming chips that some people have can become zero, or near to it. Now, let us do it.

Exercise 1: Dice and gaming chips

1. If there are many people, make a group of six. If the number of people is less than six, one person can perform the roles of a few people. Number each person in the group from 1 to 6.
2. Prepare two dice and 30 gaming chips and place them in the middle of the table (field).
3. Roll the dice, and if you obtain a “1”, the first person takes a gaming chip from the field. Similarly, if you get a “2”, the second person takes a gaming chip, and if you get a “3” the third person takes a gaming chip, and so on. Do this 30 times to hand out all the 30 gaming chips that were on the field.
4. Record the number of gaming chips each individual possesses.
5. Predict how the number of gaming chips each person has will change after the exchange.
6. Start the exchange. For each set, roll the dice twice. The person whose number appears on the first dice roll places a gaming chip on the field. The person whose number appears on the second dice roll will take the gaming chip from the field. For example, if 3 appears on the first dice roll and 5 appears on the second dice roll, person number 3 places their gaming chip onto the center of the table and the person number 5 picks up the gaming chip from the center. One such exchange of gaming chip makes one set.
7. Repeat at least 25 sets of exchanges (mean squared), or if possible, 150 sets (mean squared $\times$ number of people).
8. Continue even if some people have 0 gaming chips during the game. If the person with 0 gaming chips gets his number on the dice roll for giving out the gaming chip, they don’t have to give out a gaming chip, but if the second

dice roll indicates so, they can receive a gaming chip (they will not have a debt). However, even when the person having 0 gaming chips gets their number on the dice roll, it is counted as a one-time exchange.

9. After completing all the sets of exchanges, count the number of gaming chips each person has.
 10. Compare the number of gaming chips of each person before and after the exchange
 - When performing it strictly, it is recommended that 50 dice are prepared for one group and to use two dice in sequence because common dice can not generate accurate random numbers.
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Notes

- 1.1 Translator's note: Although "dice" is plural and "die" is singular, "dice" is used for both the singular and the plural in this manuscript.
- 1.2 Translator's note: The original text includes "An average of four gaming chips would be few."
- 1.3 Original note: Note that the total number of gaming chips is constant during the exchange.

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