Chapter 8
Amazing Scientific Discoveries: Aspirin, Cattle, Business Communication and Others

Besides the philosophical arguments, one could think of a series of possibilities where all these observations about paths could be used. Have you ever wondered, for example, what happens in your body after you swallow an Aspirin? As incredible as it sounds, this question was answered only 74 years after the development of the medicine. It was 1897 when the young German chemist Dr. Felix Hoffmann managed to stabilize the agent of Aspirin. After patenting in Germany in 1899 and in the US in 1900, Aspirin started its great triumph and became the most popular painkiller worldwide. Even Neil Armstrong took an Aspirin pill in his medical-kit when going to the Moon on the Apollo 11. In the early 1970s, more and more researchers asked the question: How and where does Aspirin work in the body? Pharmacologist Sir John Vane was the first to demonstrate the classical effect profile of Aspirin, for which he received the Nobel Prize in 1982.

What is this foggy mystery about the effect of drugs? Well, the effects and side-effects of drugs are mainly characterized by the path of molecules which the drug interacts until it has its targeted effect. Usually, the drugs are first converted into so-called metabolites which then interact with the metabolic network of the cells.[1] The metabolic network is comprised of the maze of chemical reactions in our cells over which various materials are converted into each other. A specific path or set of paths in this network can basically correspond to a chain of chemical reactions happening after somebody swallows a pill. For example, after taking an Aspirin, it is readily hydrolyzed to salicylic acid, which in turn undergoes conjugation reactions generating the major metabolites salicyluric acid and glucuronides. And this is just the major path of Aspirin's metabolism, there are other minor paths governing the whole metabolic process and thus the effects and side effects of Aspirin. Interestingly, simple shortest paths in the metabolic network do not always reflect the biochemical facts. Such paths may introduce biologically infeasible

[1] See, Fig. 8.1.

A. Gulyás et al., *Paths*, https://doi.org/10.1007/978-3-030-47545-1_8

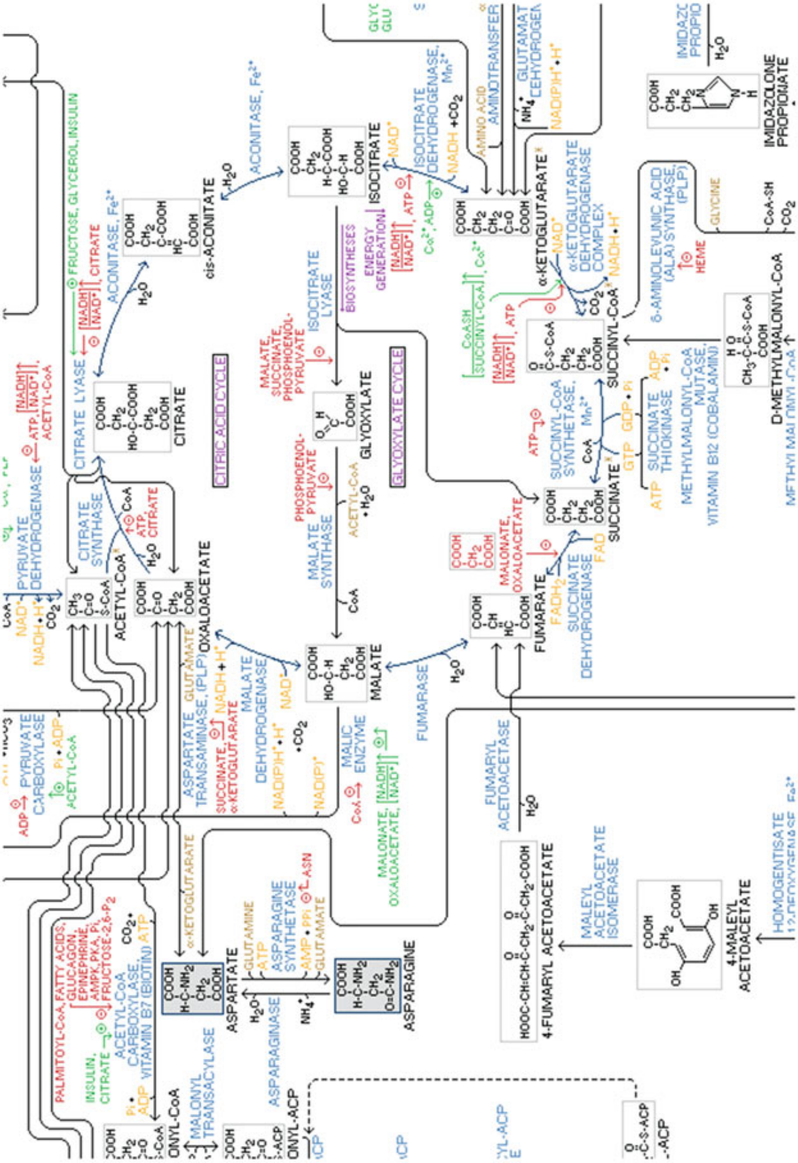

Fig. 8.1 A small part of human metabolism by Evans Love. [With the permission of Evans Love]

shortcuts [18]. Thus, a deeper understanding of the structure of paths can be used to estimate the side effects of drugs more carefully even before anyone takes them.

The sum of everyday paths taken by people in larger cities to reach their workplaces or homes constitutes the load which public transportation and road systems have to carry day-by-day. The appropriate knowledge about these paths can support the design and operation of such systems and approximate their behavior in unforeseen situations, such as scheduled network changes, roadworks, natural disasters or walkouts. In the era of in-pocket GPS powered route planners, the assumption that people use the shortest paths for traveling between their sources and destinations seems more than reasonable, it seems somewhat obvious. Recently, Shanjiang Zhu and David Levinson at the University of Minnesota decided to check the validity of this assumption [27]. They evaluated the paths followed by residents of the Minneapolis-St. Paul metropolitan area and they had an interesting observation. For some reason, people don't always use the shortest possible path for their journeys. They found that, if the destination is near (around 1.5 km), 80% of people follow the shortest paths, the remaining 20% prefer a longer ride. Interestingly, if the destination lies farther, the larger portion of people tend to take a longer ride compared to the shortest possible path. For example, if the destination is around 16 km away, then only around 17–18% of people follow the shortest path and the majority of them will choose a longer path. Thus, the authors' claim is that the available path selection methods based on the shortest path assumption cannot reveal the majority of paths that individuals take and they promote future efforts for building better path selection models and improving transportation services based on them.

It seems that it is not just humans who like detours. Temple Grandin, the famous autistic scientist, discovered that cattle like to go on curved routes and they are reluctant to cross straight passages[11] for some reason. Grandin's ability of thinking in pictures enabled her to discover the main motives and fears of cattle when put into a pen system. Her designs of pen systems have revolutionized the industry and today her patterns are widely adopted in cattle-handling facilities across the US. In such facilities, an important procedure is dipping the cattle in a vat filled with water to free them from ticks. The common way of doing this was to order the cattle to the vat through a straight corridor made of cattle-pens. Despite their good swimming skills, many cattle drowned in the course of dipping, so Grandin redesigned the whole pen system to make it more comfortable for the cattle (see Fig. 8.2). She observed that cattle like to move along curved paths, similarly to Chi. So instead of directing the cattle to the dip vat through a straight path, she used slightly longer and curved races. These curved segments have calmed down the cattle, significantly decreased their level of stress, thus decreasing the possibility of drowning. As of today, it is estimated that half of the cattle in the United States and Canada are handled with equipment Grandin has designed.

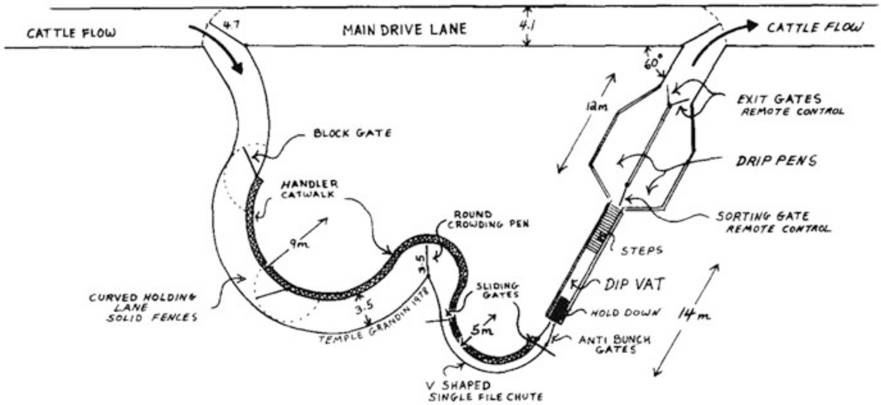

Fig. 8.2 Handling system for dipping cattle with curved races. As appeared in the publication [11]. [With the permission of Temple Grandin]

Similarly to directing cattle in pen systems, the flow of information among employees could be directed within a business firm. Why not? A prerequisite of good problem-solving in a business organization is good communication between the employees. We have seen in Chap. 7.6 that an unnoticed dispute wheel (which is nothing more than a bunch of employees/decision-making entities using each other as strawmen, communicating in a circle and passing the information infinitely among each other) can lead to a communication disaster. The structure of an organization could surely be enhanced based on information about the communication paths preferred by people. For example, business firms can employ professional communication strawmen, whose task it is to lower communication boundaries between people and ensure a more fluent and less stressful communication culture within the company. Just think about public relations (PR) specialists, whose job it is to maintain positive relationships between the company and the public. As we have seen in Chap. 7.6, organizational networks usually have a strong backbone hierarchy on top of which the informal links between employees appear [3]. In such networks, the paths of communication and problem-solving coincide with our findings about paths in other networks. Although social networks seem much more complicated, there is a chance that we will find similar characteristics in the paths of retweets on Twitter[2] or in the sharing paths of posts at Facebook. Such knowledge about paths in social networks can be used to strengthen and better organize the human communities. The way the human brain processes information and learns is one of the great mysteries of life. In lack of path related data from inside the brain, neuroscientists mostly use shortest paths when reasoning on information processing paths in the brain. However, with the adoption of modern computer-aided imaging and measurement techniques (like DSI and fMRI), more realistic models of paths

[2] see Fig. 8.3.

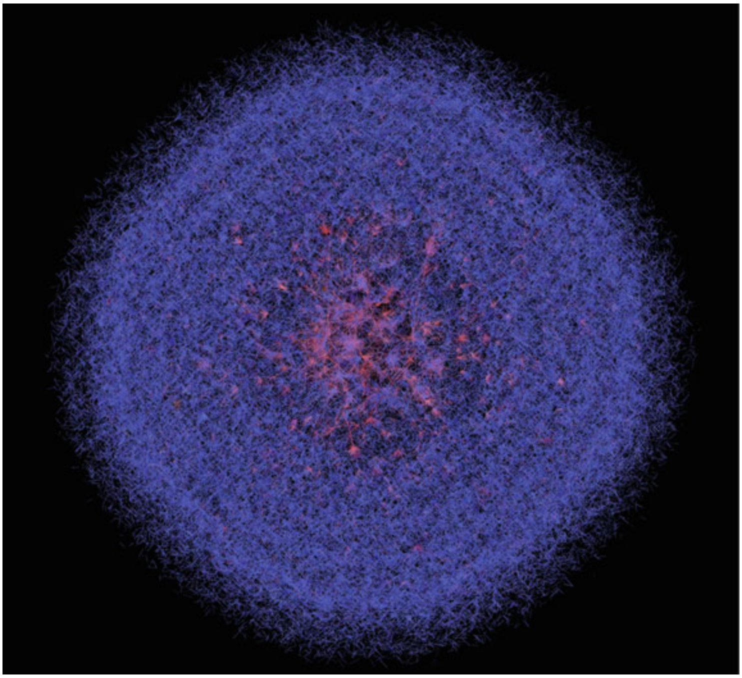

Fig. 8.3 Visualization of a part of Twitter by Elijah Meeks. [With the permission of Elijah Meeks]

selection are proposed. For example, in a very recent work, Koenigsberger and others argue that brain paths should be somewhere in between random diffusion and shortest paths [1]. This observation highly coincides with our results in other networks. Although the end of this path seems very far, the proper characterization of neural paths inside the brain can take us a step closer to solving the challenging mystery of the human brain.