**Modelling plasticity tutorial** (Cian O’Donnell, ISRC Autumn School 2021)

In this tutorial you will create and run your own Hopfield network 😎.

Begin by loading the partial *Fashion MNIST* dataset (originally taken from <https://github.com/zalandoresearch/fashion-mnist>) stored in the files trainimages.csv and testimages.csv. The total dataset consists of three training patterns and two test patterns. Each individual image is actually a 784-element array of +1s and -1s, corresponding to pixels in a 28×28 image. You can visualise the images using a python command like plt.imshow(np.reshape(x,(28,28))).

The values of the weights in a Hopfield network are given by

when . labels patterns, so is the activation of the th node in the th pattern, and is the total number of training patterns. Set all self-connections to zero, .

Now you should:

* Create a weight matrix of s, initially just filled with zeros.
* Fix the weight matrix to store the three training patterns 💪.
* Write a function to evolve the network according to the McCulloch-Pitts formula:  
  This update should be done asynchronously, so one random node is updated each timestep.
* For each of the two test patterns, evolve the patterns until they stop changing (it will probably take a few thousand iterations 🥵). **Make plots of the network state at timesteps 0, 1000, and 3000.**

Bonus totally optional stuff to try 🤓:

* Write a function to calculate the ‘energy’ of a configuration:  
  Re-run the two test pattern simulations, recording the energy value at each timestep. Plot the energy as a function of timestep. What does it show?
* Now we will examine the network’s ‘basins of attraction’. Write a function that when given a pair of images *A* and *B*, can generate a mixed image which has *x*% of the pixels from image *A* and the remaining (100−*x*)% pixels from image *B*. For each of three pairs of images in the training set, compute such mixed images, varying *x* in increments between 0 and 100%, and compute the energy of the mixed image at each increment. Plot the energy as a function of the mixing fraction *x*, overlaid for each of the three pairs of images. Have a look at the curves and try to reason about what they show.