Report from Brainhack

The Chemical Basis of Morphogenesis

Project URL: https://github.com/r03ert0/bptest

Alan Turing

Correspondence: alan@gmail.com
University of Manchester, Manchester, United Kingdom
Full list of author information is available at the end of the article

1 Introduction

In this section a mathematical model of the growing embryo will be described. This model will be a simplification and an idealization, and consequently a falsification. It is to be hoped that the features retained for discussion are those of greatest importance in the present state of knowledge. The model takes two slightly different forms. In one of them the cell theory is recognized but the cells are idealized into geometrical points. In the other the matter of the organism is imagined as continuously distributed. The cells are not, however, completely ignored, for various physical and physico-chemical characteristics of the matter as a whole are assumed to have values appropriate to the cellular matter. With either of the models one proceeds as with a physical theory and defines an entitycalled 'the state of the system'. One then describes how that state is to be determined from the state at a moment very shortly before. With either model the description of the state consists of two parts, the mechanical and the chemical. The mechanical part of the state describes the positions, masses, velocities and elastic properties of the cells, and the forces between them. In the continuous form of the theory essentially the same information is given in the form of the stress, velocity, density and elasticity of the matter. The chemical part of the state is given (in the cell form of theory) as the chemical composition of each separate cell; the diffusibility of each substance between each two adjacent cells rnust also be given. In the continuous form of the theory the concentrations and diffusibilities of each substance have to be given at each point. In determining the changes of state one should take into account

1. The changes of position and velocity as given by Newton's laws of motion.
2. The stresses as given by the elasticities and motions, also taking into account the osmotic pressures as given from the chemical data.
3. The chemical reactions.
4. The diffusion of the chemical substances. The region in which this diffusion is possible is given from the mechanical data.

This account of the problem omits many features, e.g. electrical properties and the internal structure of the cell. But even so it is a problem of formidable mathematical

complexity. One cannot at present hope to make any progress with the understanding of such systems except in very simplified cases. The interdependence of the chemical and mechanical data adds enormously to the difficulty, and attention will therefore be confined, so far as is possible, to cases where these can be separated. The mathematics of elastic solids is a welldeveloped subject, and has often been applied to biological systems. In this paper it is proposed to give attention rather to cases where the mechanical aspect can be ignored and the chemical aspect is the most significant. These cases promise greater interest, for the characteristic action of the genes themselves is presumably chemical. The systems actually to be considered consist therefore of masses of tissues which are not growing, but within which certain substances are reacting chemically, and through which they are diffusing.

These substances will be called morphogens, the word being intended to convey the idea of a form producer. It is not intended to have any very exact meaning, but is simply the kind of substance concerned in this theory. The evocators of Waddington provide a good example of morphogens (Waddington 1940).These evocators diffusing into a tissue somehow persuade it to develop along different lines from those which would have been followed in its absence. The genes themselves may also be considered to be morphogens. But they certainly form rather a special class. They are quite indiffusible. Moreover, it is only by courtesy that genes can be regarded as separate molecules. It would be more accurate (at any rate at mitosis) to regard them as radicals of the giant molecules known as chromosomes. But presumably these radicals act almost independently, so that it is unlikely that serious errors will arise through regarding the genes as molecules. Hormones may also be regarded as quite typical morphogens. Skin pigments may be regarded as morphogens if desired. But those whose action is to be considered here do not come squarely within any of these categories.

The bibliography `report.bib` must respect BibTeX format. You can cite entries in your bibliography using their tags:

- Cite an article: [1]
- Cite a GitHub repository: [2]

You can use `inline code highlight`. This paragraph shows how to add blank lines and how to start a paragraph without indentation.

Remember that this is a LaTex flavored markdown. Therefore, some characters must be used with an escape character within the text:

`& % $ # _ { } \`

2 Section

You can create additional sections as you prefer. Section title levels are determined by the number of hastags as in a traditional markdown file.

2.1 Subsection

Subsection content goes here. You can create numerated lists:

1. The labels consists of sequential numbers.
2. The numbers starts at 1 with every call to the enumerate environment.

2.1.1 Equations & formulas

You can add mathematical formulas. Single dollars ($) are required for inline mathematics e.g. $f(x) = e^{\pi/x}$.

You can also use plain LaTeX for equations. These equations are rendered by MathJax, you can right click on them and explore the rendering options available at your browser!

$$\hat{f}(\omega) = \int_{-\infty}^{\infty} f(x) e^{i\omega x} dx \tag{1}$$

and refer to 1 from text.

2.1.2 Hypothes.is

We enabled hypothes.is for the brainhack proceeding reports. This way, you can annotate, highlight and tag the content collaboratively! You may choose to share your insights with everyone, or keep them private.

3 Results

Figure files must be placed at the `figures` folder. You can include figures using the following block:

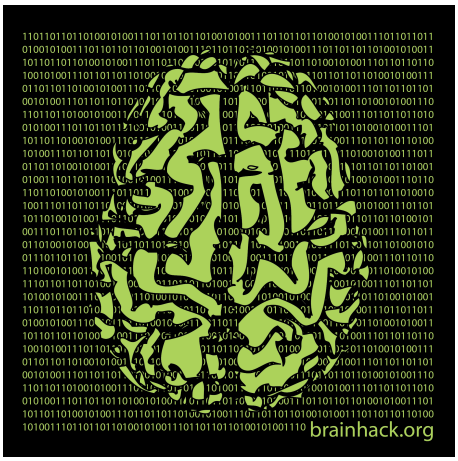

Figure 1 Your caption goes here.

Note that `width=.47 \textwidth` above sets scales the figure size in the PDF. To change attributes of the figures on the webpage, please see `/figures/figures.css`.

To refer a figure in the text, you need to use the respective label defined in its caption: Fig. 1

Availability of Supporting Data

Supplemental material has not been provided. More information about this project can be found at: https://github.com/r03ert0/bptest. This report is generated at: https://github.com/r03ert0/bptest.

Competing interests

None

Author's contributions
Author's contributions statement is missing.

Acknowledgements
Acknowedgements section is missing.

Reviewers
No reviewers has been added yet.

References
1. Doe, J., Doe, J.: Lorem ipsum. Neuroimage **50**(4), 1000–1001 (2010)
2. Cox, R.W.: An example GitHub repo citation. https://github.com/owner/repo (2020)