

Chromatin structure and McDonalds franchises are assembled from repeating fundamental units that allow flexibility of structure.

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Living Architecture Research Project Report
Bio219 / Cell Biology
Wheaton College, Norton, Massachusetts, USA
December 7, 2010

Rule to Build By:

The first rule presented on the living architecture website states that in order to maximize flexibility, complex human built and cellular structures are composed of simple repeating units.

What:

The complex and highly dynamic structure of chromatin in eukaryotic chromosomes made up of repeated nucleosome core particle complexes of DNA and histone octamers is an example of an aspect of cellular architecture that follows this principle. A modern day human built structure that follows this design is the carefully designed stores created composed of repeating fundamental units owned by the McDonalds fast food company.

How:

During mitosis and when a region of the DNA is not expressed the cell relies on specific modulations of chromatin. The structure of chromatin consists of histones as well as some other nonhistone proteins. Its highly compact structure is made up of repeated units called the nucleosome core particle that consists of DNA wound around a histone octamer. Each octamer contains two copies of the same four histone proteins H2A, H2B, H3, and H4. All four of these proteins are composed of many positively charged lysines and arginines, which allow the histone octamer to bind virtually any sequence of the DNA. At its lowest degree of packing in a living cell, the chromatin adopts a 30-nm chromatin fiber arrangement. In order to obtain this structure the nucleosomes are positioned into a regular repeating array to allow a compact structure. During interphase the 30 nm fiber is folded into loops and series of these loops are folded on another to obtain the most compact chromatin structure that is the one formed at the beginning of mitosis. Most importantly, this repeated pattern of nucleosomes and linker H1 allow for extremely efficient use of space in the nucleus or cytoplasm of a dividing cell (Alberts et al. , 2010).

Numerous transcription regulators affect the transcription of genes in particular areas of the chromatin structure by modifying the DNA or histones. Patterns of modification of histones that contact promoters, insulators, and transcribed regions of DNA either increase or repress the expression of these genes. Methylation of lysine or arginines on histones can either activate or repress transcription depending on which lysine or arginine is methylated and how many methyl groups are attached (Nimura, Ura, Kaneda, 2010). Histone acetylases and deacetylases attach or remove acetyl groups to histones, which also affects the folded chromatin structure in a specific region. Chromatin structure is also affected by methylation to the DNA. All types of modifications to the histones and directly to the DNA are reversible processes that affect the stability of DNA histone interactions and their accessibility to the basal transcription factors.

In one type of human Tcell, Th17 cells H3 acetylation in addition to H3K4me3 methylation marks the interleukin 17 gene so its transcription can be enhanced. Bcell differentiation depends on the sequential expression of three essential transcription factors, and their expression depends on demethylation of at the CD79a promoter that is hypermethylated during the progenitor phase. Expression of one of these genes, Pax5, leads to the recruitment of acetyl transferases which alter chromatin structure in other regions of the DNA (Fernandez-Morera, 2010). The simple

repeating nucleosome units facilitate these dynamic interactions between regulatory proteins, because each of them can be modified easily and in diverse ways through reversible processes.

In a similar way human built food chains like McDonalds pattern not only Americas landscape, but the landscape of the world. Each McDonalds store contains the same familiar double golden arch, a drive trough window, a large menu board with numbered meals, a selection of sodas from a dispenser off to the side, and other basic repeating fundamental units that make up nearly all of the fast food shops. These repeating units though do not always have to be combined in the same way. Indeed to maximize the accessibility to their client base, Mcdonalds corporate strategically places the restaurants at locations where they think demand for their food will be the highest. Depending on the real estate availability, owners of these restaurants must flexibly combine these basic fundamental units of a prototypical Mcdonalds. In many cases, Mcdonalds shares the same building as other retail stores or restaurants or both. In these cases, the shop may be very small, but still contains the same core familiar aspects of a McDonalds for customers to recognize and maintain interest in the store. In other cases, with extra room to spare in the store, Mcdonalds in a highly residential area might include a fun place to attract families with very young children.

Why:

To a multicellular organism such as humans modifications of histones and chromatin remodeling allow for the expression of different set of genes across various cell types. Epigenetics is a large area of study in biology that explore how modifications to the chromatin affect the transcription of genes in different cells through out development and through out the life of the organism. Highly dynamic gene expression profiles during development allows for the differentiation of different types of cells, and it allows the cell to constantly adapt and respond to signals in its environment. The immune system for example coordinates its response to certain pathogens by causing multipotent CD4 +T lymphocytes to differentiate into different types of Tcells, and epigenetic mechanisms are largely responsible for these cell fates (Fernandez-Morera et al., 2010). Epigenetic mechanisms have also been implicated in the development of the brain, cognition, and learning. In mice, acetylation of H3 in neurons in the CA1 area of the hippocampus has been positively associated with long term potentiation and fear conditioning. Activation of the NMDA receptor and signaling pathways that result in activation of ERK both result from high frequency firing of neurons, and both are required for an increase acetylation of H3. The ERK signaling cascade integrates activity of NMDRs, as well as PKA and PKC signaling pathways to influence chromatin structure and transcription of genes necessary for memory consolidation. change transcription of genes that Like immune responses long term memory depends on the coordinated action of multiple signaling pathways that neutralize the charge of histones by acetylation and result in enduring changes in gene expression (Levenson et al. , 2004). So clearly, in order for the cell to adapt and change according to signals it receives the chromatin structure must be unpacked quickly in the right places at the right times. However, in order for a cell to maintain its identity after repeated rounds of cell division it is important that the daughter cell express the same genes of the stem cells that gave rise to them. Daughter cells inherit the same condensed chromatin structure from stem cells as well as DnA methylation patterns of their cytosines (Alberts et al. , 2010). Thus, the many different modifications are possible to the repeating DNA and histone units of chromatin allow for infinite possible combinations of transcription patterns in diverse cell types in response to many different signals. Still it allows for ways to provide order to the chromatin structure so that different cell types can maintain their identity.

Mcdonalds food chains consist of basic repeating units, because store owners know that the experience of Mcdonalds at one location creates the expectations they have for the next location. It helps the business if every store maintains this familiar knowledge and experience, and ensures business at a new location even if the store just opened. In other words, the ubiquity of Mcdonalds franchises serve as one of McDonalds greatest advertisements. Because the opening of a new store is facilitated simply by the inclusion of the big yellow double arch and a drive through window, the actual physical layout of McDonalds stores across regions and nations is a very flexible structure that can fluctuate depending on regions with the highest demand for McDonalds or highest availability of real estate. By strategic placing and designing of stores in areas where there is a lot of food business competition, it helps the Mcdonalds empire if the Mcdonalds in this area are spacious, gaudy, and maybe even juxtaposed with huge billboard signs next to highways. These motives may be extremely costly for the company initially, but over all, by squandering the competition in these areas and luring hungry drivers off I-95 these modifications serve a benefit for McDonalds. In other small towns, strategies to attract customers may be a lot more subtle and less of an investment, but the presence of the basic fundamental units ensures that good business at one location spreads to others.

Figures:

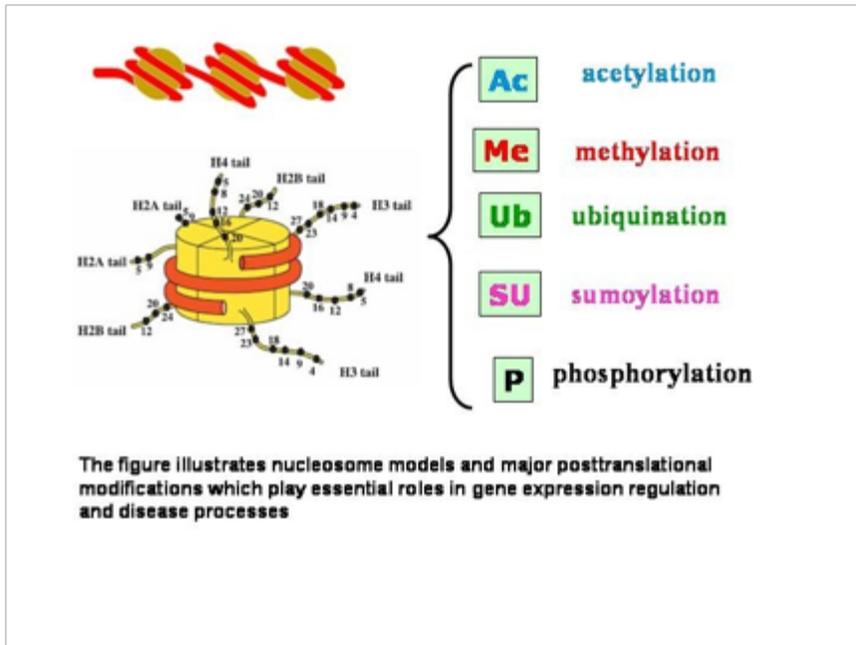


Figure 1. Depicts a fundamental unit of the chromatin structure that is the DNA wrapped around a histone octamer. The various histone tails projecting from the histone proteins can be chemically modified through any of the 5 chemical processes shown. These modifications can occur at any of the charged amino acid positions indicated by the numbered dots in reversible processes and different combinations of these modifications affect the association between the histone and DNA (Zheng, Y., 2010).



Figure 2 Depicts three very basic fundamental units of a familiar McDonald's franchise: the red and yellow coloring, the double yellow arches, and the drive through window complete with illuminated screens. These three features do not necessarily have to be arranged in the same way at every store as indicated by the unique red and white stripes and the peculiar lighted arch structure supporting the drive through window. Every store might be organized and piece these units together in a unique way that managers feel will help their own profit. (CNN Money.com, 2010)

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