Cover letter

Article title: Passive sleep mechanisms: dissipative steadiness and route distortion of multi-channel cells

The author: Qu Wenjing

The affiliation: Key Laboratory of Bionic Engineering, Jilin University, Changchun, China

Email: uu002200@163.com or 764011911@qq.com

Telephone: 86 13756171398

Statement of significance

Here the essence of sleep metabolism is deduced by a new analytical method, which is based on energy composition and the relationship between power and the selectivity of energy transfer. The fundamental function of sleep is to restore the unstable fluid structures — dissipative structures of cells, which play an important role on cell health. The steadiness and strength of the dissipative structures requires the corresponding metabolic rate keeping high enough. Different from plant and microorganism cells, animal cells without cell walls easily abate their fluid structures while could get higher metabolic rate through behaviors and the consumption of proteins by behaviors; this infers that the rationality and diversity of animal behaviors have a decisive impact on sleep quality.

Passive sleep mechanisms: dissipative steadiness and route distortion of multi-channel cells

A dissipative structure is a steady energy from particular energy transfer, such as metabolic order in cells. However, not every metabolism is always the particular energy transfer, as some cells alter metabolism into other modes to cope with uncertain environmental changes. Here, analyzing from energy composition, the importance of steady dissipative structures for cell metabolism and the inevitability of multiple metabolic patterns existing in consciousness-connected cells are expounded. Any cell with unsteady metabolism either dies quickly or restores the steady energy periodically, and this recovery phenomenon presented by whole organisms is sleep.

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Introduction

The importance of sleep may never be overemphasized, but what sleep makes animals actualize is still not very clear. However, the essential reason of sleep phenomenon may not be an abstruse physiological problem but rather a fundamental physical issue, while as for why the reason can't be found out until now may be about the construction of physics.

Human knowledge is always based on achievements of predecessors, and intentionally or unintentionally avoids the objects lacking specific subject areas. Just as AlphaGo Zero was able to teach itself to play Go without human knowledge, and did better¹, one-sidedness exists in the development of human skills and cognition. If our research is only based on the concrete foundation of predecessors, some of the undiscovered underlying principles will lag behind farther and farther until no one dares and has the ability to turn back and explore the unknown discovery paths.

It is generally believed that relationship of energy and space is based on their independent existence, but when analyzed objects are micro enough, the relationship is always obscure, and the substances belie different characteristics from perceptible scope things. However, the problem may not be in energy, but in space. If space is absolute but not matter, how to distinguish a millimeter and a light year from an

empty space?

Though physics has already been a giant fundamental discipline for a long time, it may be still a one-sidedness subject, since most of the achievements of modern physics are in the field of engineering, which relies on accurate spatial analysis with force as the physics is just brilliant in this side. However, in the research of living creatures, accurate spatial analysis with force is extremely difficult. Therefore, some fundamental physics from non-spatial or power perspectives should be developing.

Elementary composition of low-speed energy

To clarify the amount of internal energy of an object or system, the first step is to quantize the particles inside it.

In a change, the particles that there is no effective energy exchange between inside and outside and do not reflect structural attributes such as size and shape could be seen as quantized particles, hereinafter referred to as quanta, which form the basic units of change.

The integral of force and distance between two quanta from the equilibrium position of all forces is named as positional energy.

As the maximum internal energy that a system could reflect, the total positional energy between every two quanta in the system plus the total relative kinetic energy of all the quanta to the system is named as the internal absolute energy of the system, short as the absolute energy of the system.

If there are n quanta in a system, the number of the units of quantum positional energy should be C_n^2 while the number of quantum kinetic energy should be n . In a simple substance system, most of the units of quantum positional energy could hardly change or equivalent, but in a complex system like a cell, it's hard to say in general which quantum energy changes are negligible or equivalent.

Positional energy is a different view from potential energy, which determines the equilibrium position of quanta in space. No matter whether the space really exists, every position of a quantum is determined by the energy between the quantum and other quanta, which could be a surface, a line, a point or discrete points. Energy between two quanta can only determine a distance and the energies of a quantum may be mainly concentrated between a single or several quanta, and these localizations cannot establish a point while any energy transfer will change some positional energy more or less, such as detecting an electron in an atom, in which the position of the electron may not be determinable as a point, because there are too few quantum constraints.

As long as being dissected to a particular unit level, the energy in any specific object is absolute and unconditional. Hereinafter, the systems are dissected to electrons and nuclei. The units composed by electrons and nuclei are atoms or ions. Since in low-speed chemical reactions the total positional energy and kinetic energy of electrons in equilibrium position in atoms could be seen as unchanged, according to conservation of energy, the total energy change of electrons and nuclei in some atoms can be seen as the change of inter-atomic energy of these atoms.

Basal positional energy

As a quantum may not be surrounded by one quantum, when the quantum is in the equilibrium position, the energy between the quantum and the surrounding quanta may not all be zero. Under same external conditions, the lowest positional energy inside a group of quanta is named as basal positional energy, which is decided by composition of chemical elements but not bonding states.

Heat

Atoms or molecules are continually vibrating in solid, liquid or gas, and the vibration energy is heat. In solid, the vibration is around specific equilibrium position, but in liquid or gas it is not.

Heat vibration is composed by positional energy and kinetic energy. Heat kinetic energy determines temperature; heat positional energy is an increment of basal positional energy which is affected by temperature, state of matter and pressure.

Structural energy and dissipative structures

In the 1960s-70s, Ilya Prigogine, a Belgian scientist and his colleagues noticed and researched on a phenomenon that some systems may form orderly structures when transmitting energy or substances, and called the orderly structures or regular motion as dissipative structures.

It is defined that the structural energy (SE) of a system is equal to the inside absolute energy (E) minus the basal positional energy (BPE) and the heat (H). As:

$$E = \text{BPE} + H + \text{SE}$$

SE could be divided into two categories: one is stable solid structural energy (SSE) mainly in solid or molecules; the other is unstable transmitting-induced SE named as dissipative structural energy (DSE) such as relative motion, uneven or regular distribution, non-thermal vibration and reversible deformation. As:

$$E = \text{BPE} + H + \text{SSE} + \text{DSE}$$

Sometimes, it is difficult to distinguish SSE and DSE, as stability needs under some conditions like some continuous deformation and some macromolecules in stable in particular conditions. At these times, to distinguish which category SE belongs to depends on judging whether the conditions changed in research range or actual situations. Though chemical energy normally lies within BPE and SSE, this paragraph infers that, in some cases, DSE could also contain chemical energy.

Hereinafter, dissipative structures represent transmitting-induced orderly phenomena with DSE.

The process of energy transfer and instantaneous power

In a system, an energy change of a quantum is denoted as Q, which is distinguished by the result of the increase and decrease of the absolute energy of the quantum as is denoted as Q^+ and Q^- . E_r represents the energy released from the system to the environment; E_a represents the energy absorbed from the environment to the system. E_{ir} represents the energy transferred in the period of time. As:

$$E_{ir} = \sum Q^+ + E_r = \sum Q^- + E_a = \frac{1}{2} \cdot (\sum |Q| + E_a + E_r)$$

If in a time every quantum belongs to Q^+ or Q^- invariably and the energy transfer rate isn't significant changed, the time is an instantaneous time (dt). The power of E_{ir} in an instantaneous time is named as instantaneous power (IP). As:

$$IP = dE_{ir}/dt = d(\sum Q^+ + E_r)/dt = d(\sum Q^- + E_a)/dt = \frac{1}{2} \cdot d(\sum |Q| + E_a + E_r)/dt$$

However, because a quantum can also absorb and release energy in a change, the macro-time power of a system could be smaller than its IP.

Routes

It is defined that a category of specific quanta that transfer energy in a sequence as a same frequency network is a route, and each energy transfer as a simultaneous quantum energy change between some quanta in the route is a link. Because in cell metabolism heat can't turn into other forms of energy, heat generation is seen as terminal links of all routes and heat transfer isn't seen as links herein.

Steadiness and route distortion

No matter in essence or in appearance, the steadiness of a motion or a dynamic distribution is because of regular changes.

It is defined that constancy or periodic changing is steadiness. In a steady route, every link is strictly limited.

The period of a constant route is the time of the link that takes the longest time, which is named as global link. If the global link takes too long time or too short time, links may recombine and the route will lose original constancy, which is called route substitution. The longest or shortest time of the global link that the route isn't substituted is called substitution threshold, and the link that first substitutes are called substitutive link.

In a dissipative structure, the routes are constant or in regular route substitution, while, if some route substitution breaks the steadiness, the route substitution is named as route distortion and the substitutive routes are distortive routes.

Analysis of the properties of dissipative structures

Many dissipative structures are not incessantly steady, which alternate in between forming state and steady state.

For a system, the formation of a steady dissipative structure is the process accumulating the structural energy and forming specific steady routes, which is the forming state. If the routes are unique when nearly getting to the steady state, and could be unchanged when getting to the steady state, the structure is steady and the unique routes are forming routes; otherwise, if the routes are always random, or always distort when getting to the steady state, dissipative structural energy can't get offsetting balance and the structure is unsteady. This principle is named as routes

uniqueness of the steadiness of dissipative structure, short as routes uniqueness principle.

Dissipative energy is come from motion or motion-induced force, which is positively correlative to the speed. Therefore, for homologous dissipative structures, the larger the transmitting power is, the greater the structural energy is.

Dissipative structure is much more fragile than the solid structure, but much more easy to restore.

Temperature is a key factor to destroy the steadiness, because higher temperature could accelerate the irregular movement of molecules, so more structural energy is required to limit the position of the molecules. Nevertheless, higher temperature may increase transfer power, which could increase the structural energy. Therefore, many of dissipative structure are steady in specific temperature range.

If the structure is steady for a long time, some molecules with long-term regular and relative fixed position may bond into a solid structure.

However, there may be many dissipative structures in a system, between which there are competition. It is a decisive competitive advantage that global link is the shortest.

Multi-channel cells

It is a postulate that metabolism is regular routes with specific structures, as cells structures are solid structures that are solidified from series of changing dissipative structures in developmental stage and maintained by last dissipative structures. For a specific cell, the routes that could form the particular cell structure are healthy metabolism.

In animal cells, some healthy metabolism could be divided into two categories: growth routes and function routes. It is defined that growth routes are healthy anabolism mainly as the correct gene expression; function routes are different from growth routes as execution of some specific functions such as muscle contraction and nerve conduction, and the cells with function routes are functional cells. For most of functional cells, such as most of nerve cells and muscle cells, growth routes and function routes are two or more sets of routes that occur asynchronously, but the other few functional cells and nonfunctional cells, such as cardiac muscle cells and epithelial cells, growth routes and function routes could be synchronous or there isn't functional route. The cells with one set of routes are named as single-channel cells; the cells with two or more sets of routes are named as multi-channel cells.

In most of nerve cells and muscle cells, because function routes can suddenly increase the transfer power and the function routes and growth route have much same energy source like some ATPs, the sudden increase will cause distortions of growth routes. Although the function routes of cardiac muscle cells can also increase abruptly, the scope and rate of the increase is quite limited and declining smoothly, which could not cause much distortion; so the metabolism of cardiac muscle cells can be approximately seen as single set of routes, and they needn't rest as function routes stopping. In cardiac muscle cells, the growth routes and the function routes compose the forming routes together.

Maybe, in fact, as long as an animal awakes, no matter what behaviors occur, in some sensory cells and conscious cells, the function routes, which couldn't be steady and consequently can't be the forming routes, are active all the time while the growth routes, which could be steady and the forming routes, are always being inhibited; so they need a time to have a rest to restore the distorted dissipative structures and the forming routes.

Passive mechanisms of sleep

Sleep is such a metabolic phenomenon in animals that cells that work connecting with consciousness or sense turn into in a functional-inhibited metabolism in a relative steady environment with less intercellular energy exchange for stress response, in which the dissipative structures restore, and the principles without specific evolutionary characteristics in which is the passive mechanism of sleep; while some developed physiological mechanisms in these cells or some active metabolic phenomenon in other cells may also lies in sleep, which isn't studied herein.

According to routes uniqueness principle, routes distortion will make the dissipative structures turn into unsteady and changes. Well, what specific structural changes may occur in cells when routes are distorted?

Firstly, dissipative structures in cells are mainly uneven or regular distribution and regular motion or vibration, including various macromolecules like enzymes in their particular position, the orderly movement of macromolecules and inhomogeneous distribution of ions. The order of these phenomena preserves the normal growth and function of cells, so when the dissipative structures are damaged from consciousness and actions, the growth and function of the cells will be affected directly.

Secondly, function execution accelerates proteins degradation in function routes, thus promoting growth routes — gene expression. Most of proteins are fragile with precise structural energy; when some proteins are involved in the energy transfer in functional routes, the proteins have more chance to be damaged and collapse by collision or conjugation. In addition, there are many other fast degradation reasons from function execution like providing energy, deformation and secreting the decomposition products etc. If functional proteins accumulate in the low growth rate cells, which are very common in animal organisms, the last link of expressing routes will be inhibited and accordingly the global time of all the routes may be increased; therefore, protein degradation at a high enough rate can increase the power of expressing routes and consequently increase the stability of the gene expression in sleep. This principle illustrates that sleep is not an independent process, which needs alternating with the action in awake.

Thirdly, keeping the power of specific gene expression high enough from adequate sleep and actions may be necessary for chromosome structures or DNA macromolecules being stable. This may not be a common phenomenon, but may exist in higher animal cells, as the genes of these cells may be too large and complicated to be stable unconditionally.

Lastly, energy retention from inadequate sleep and actions will increase the risk

of pathological expression, which makes cells more susceptible to infection and carcinogenesis. There are many harmful genes like virus genes and once-genes in cells, which may conduct unhealthy possible dissipative structures. Though healthy routes have many advantages, if the global link takes too much time, unhealthy routes may have a chance to present.

In conclusion, the recoverable damage of dissipative structures, which mainly comes from consciousness and actions, is named as cell fatigue, but is various degrees in different cells while if cell fatigue is inappreciable, the state that cells are in is named as standard state, as the main purpose of sleep is to restore the fatigued cells towards their standard state.

Preliminary discussion on the balance of metabolism

Every behavior action itself is a particular metabolism by specific cells and makes these cells more fatigue. The balance of metabolism is studied on the homogeneity of fatigue degrees between different cells.

Cells with low fatigue levels tend to be excited and are easy to execute function, which may generate action potentials or stimulate nerve cells to generate action potentials to the area of consciousness in brain and cause insomnia or some sleep disorders while other cells may be very fatigued; therefore, metabolic imbalance of fatigue degrees could be behavior-induced diseases usually with changes of habitual behavior and reductions of actions.

Varied and pleasant activities usually bring good sleep. A higher animal could have thousand billions of cells, and every cell has its habitual mode of metabolism. Animals can also acquire habits and skills through practice, which are enhancements of metabolism in specific cells. Therefore, the metabolic balance mainly depends on the suitable actions in awake while the habitual mode of metabolism is constantly adapting to specific behaviors.

However, in spite of un-routine actions, sleep may be well, as sleep could also balance metabolism. Many phenomena and behaviors in sleep may consume energy for the cells with saturated or falsely accumulated structural energy to accelerate the metabolic rate or restore the structures of these cells.

Verification of the theory

As it spans many subjects, and is limited by the author's knowledge and scientific research ability, there may be some loopholes and inaccuracies in this theory; and theoretical verification requires experiments or evidential facts. There are may be some verification methods and possible difficulties as the following.

According to the theory, orderly dissipative structures should have higher energy. Different cellular fatigue degree determines different movement and distribution. However, observation processes are likely to destroy the dissipative structures.

A growing cell may be more easy to achieve metabolic balance, but low growth rate cells need special intercellular energy exchange mechanisms to maintain metabolic balance and high enough metabolic rate for metabolic competitiveness. There may be some known mechanisms or phenomena related to the balance of

metabolism in animal cells, such as cell adhesion in monolayer culture.

1. David Silver, Julian Schrittwieser, Karen Simonyan, Ioannis Antonoglou, Aja Huang, Arthur Guez, Thomas Hubert, Lucas Baker, Matthew Lai, Adrian Bolton, Yutian Chen, Timothy Lillicrap, Fan Hui, Laurent Sifre, George van den Driessche, Thore Graepel & Demis Hassabis. Mastering the game of Go without human knowledge. *Nature* **volume550**, pages354–359 (19 October 2017)