Psyche and Life: Allostasis between the Predictive brain-mind system and Traditional Chinese Medicine

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***Abstract**: The paradigm of allostasis and Traditional Chinese Medicine (TCM) share foundational conceptual and pathophysiological principles, as well as a holistic perspective on the relationships between psychological and biological dimensions. TCM emphasizes the profound connection between the body and Qi, while the allostatic model places the representation and regulation of bodily states at the core of all mental processes. According to predictive processing theories, the brain-mind system employs internal models to anticipate neurosensory states, continuously comparing predictions with incoming data from external and internal environments. By minimizing predictive errors, the brain-mind system constructs perceptions, plans actions, and regulates allostasis. Disruptions in the balance between predictions and prediction errors can impair allostatic efficiency, leading to clinical consequences. Similarly, imbalances in Qi – stagnation, deficiency, excess – disrupt psychophysical equilibrium and contribute to the development of chronic diseases, notably under prolonged stress conditions. Integrating Western and Eastern paradigms holds promise for developing more effective, patient- centered therapeutic approaches.*

Key words: *Neuroscience, Eastern philosophy, Qi, Chronic stress, Integrated medicine, Chronic diseases.*

This work seeks to identify potential intersections between life sciences, particularly neuroscience as it relates to allostasis, and key principles of Eastern philosophy and Traditional Chinese Medicine (TCM). The aim is to contribute to the development of a shared perspective on the relationships between the psychic and biological dimensions of the human organism.

In Western thought, the dualistic conception of the human being, first articulated in Christian philosophy and theology by Augustine (4th century), was formalized in the 17th century by René Descartes. This perspective, foundational to modern scientific inquiry, separates soul and body, envisaging a res cogitans, an immaterial, eternal substance capable of thought and feeling, and a res extensa, the corruptible material substance that constitutes the individual body (Meditationes de Prima Philosophia, 1641). A few decades later, Spinoza criticized Cartesian dualism and proposed a monistic view in which mind and body, rather than being ontologically separate substances, are considered as two expressions of the same reality and natural order (Ethics, 1677). The dualistic perspective, in its various forms, has prevailed in the evolution of scientific thought, inspiring hypotheses and theories, lines of research, and academic training. It has also permeated popular culture, where the mind is often portrayed as a repository of rational, moral, and spiritual thought. Building on Spinoza's ideas and on contemporary philosophy of complexity (Morin, 2022), we adopt the view that the psychic dimension is an emergent property of living organisms. Evolutionary psychologists and advocates of the embodied mind framework argue that the psyche finds its roots, expressions, and fundamental purposes within biological life (Varela *et al.*, 1991; Barsalou, 2008; Ziemke, 2016). The term "psyche" derives from the Greek word for "breath", "spirit", or "soul" as the vital force. Here, we propose that the foundational essence of the psyche is deeply intertwined with "breath", understood in its literal and physiological meanings, serving as a synecdoche for the continuous flow of the living organism's complex functions. This assertion may seem less audacious if interpreted in light of the principles of Eastern philosophy. A fundamental concept of TCM and Taoist philosophy is *Qi*, the vital force that flows through the universe and all living beings, which ancient texts (such as the Huangdi Neijing, a medical and philosophical treatise written between the 4th and 2nd centuries BC) describe both as a substance and as the driving force of life, closely linked to Yin and Yang, the complementary and opposing forces that govern natural harmony.

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The Qi, the principle that unifies the universe and man

The ancient ideogram for the term *Qi* (pronounced "chi") consists of two parts (or "radicals"): one depicts rising vapor, and the other a grain of rice (Fig. 1). The ideogram symbolizes the fundamental nature of *Qi*: it represents both a dense, material reality (the grain) and a more energetic, ethereal reality (the vapor); in essence, the earth and the heavens.

Fig. 1. The *Qi* Ideogram
The radical at the top right represents swirls of vapor, while the one at the bottom left symbolizes a grain of rice

With the advancement of medicine, *Qi* came to be understood as the fundamental vital principle of human existence: it is what constitutes the human body and, at the same time, unifies it. As such, the *Qi* must be preserved and nourished in alignment with the *Qi* of the heavens, symbolized by the seasons. Otherwise, the flow of *Qi* can become pathological due to its excess, deficiency, stagnation, or improper circulation. Thus, *Qi* is seen as both the foundation of health and a potential source of illness.

As many scholars have observed, this concept serves as a bridge between East and West, appearing in Greek philosophy as *pneuma* and in Indian tradition as *prana*. In humans, it is intimately connected to "breath", therefore to life in its root and most evident expression (Maciocia, 2007; Bottaccioli F., Bottaccioli A.G., 2024a). Without delving too deeply into technicalities, it is essential to understand that *Qi* originates from a dual process: one innate and the other derived from food and breath. The innate component, inherited from one's parents, is known as *jing*, i.e. the vital essence stored in the Kidneys. This essence generates *yuan Qi*, the driving force of *Qi*, which enables its extraction and transformation from food and breath. An essential feature of *Qi*, recognized as early as the Mawangdui manuscripts (2nd century BC), is its close relationship with blood. Blood is moved by *Qi*, and disturbances in *Qi* are the root cause of blood-related disorders.

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Psyche and body: an integral unity in ancient Chinese wisdom

In this perspective, the human organism is a system of interconnected functions rooted in the organs. These functions extend beyond physiology to encompass mental activities, including emotions and consciousness. Each organ (*zang*) is associated with a specific emotion and mental function; in turn, emotions and mental states influence their corresponding organs. The *Ling Shu* explains: «If the blood of the Liver is deficient, there is fear; if it is in excess, there is anger […]. If the Qi of the Heart is deficient, there is sadness; if it is in excess, there is manic behavior». Conversely: «Fear, anxiety, and ruminative thought harm the *Shen* of the Heart […]; rumination linked to the Spleen damage the *Yi*» (cited in Maciocia, 2007).

This interplay between organs and emotions operates in two directions. The first movement goes from organs to emotions: an excess of *Yang* of the Liver can result in anger, a deficient *Qi* of the Lung can lead to sadness, a deficient *Qi* of the Kidney can cause fear, an excess of *Yang* of the Heart may produce manic euphoria, a deficient *Qi* of the Spleen can lead to ruminative or obsessive thoughts. The second movement, in reverse, goes from emotions to organs. Mental imbalances can damage their associated organs, as each organ serves as the seat of specific mental functions: the Heart houses the *Shen* (consciousness, mental vitality, emotional stability, and spiritual connection), the Liver is associated with the *Hun* (the ethereal soul linked to the heavens, to which it returns after death; on a psychological level, it reflects the ability to act outwardly, linked to creativity and action), the Lungs house the *Po* (the corporeal soul, tied to the earth, which decays with the body after death; on a psychological level, it is tied to introspection), the Kidneys are linked to *Zhi* (willpower that knows how to act, determination as desire to act and ability to do so; it is the foundation of a stable personality), the Spleen governs the *Yi* (intellect and cognitive processing). In this unified framework, mental disorders are always interpreted in relation to the energetic imbalances of the organs, while organ dysfunctions are understood to have a psychological component in their origin or clinical manifestations. This perspective avoids the mind-body dualism, rejecting both biological and spiritual reductionism (Bottaccioli, 2020).

Life gives rise to mind: an evolutionary perspective

As surprising as it may seem, the discussion around the definition of life remains still open. In their seminal work, *Autopoiesis and Cognition* (1980), Chilean neuroscientists Humberto Maturana and Francisco Varela argue that living organisms are *autopoietic systems*: self-contained entities, distinct from their environment

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yet in constant exchange with it, describable as networks of heterogeneous components functionally interconnected by organizational patterns largely dictated by genetic programming. These entities transform energy, matter, and information to continuously regenerate the very components that make up their networks, thereby actively maintaining their internal organization. Living beings, from the earliest unicellular organisms, "create" their environment by assigning meaning and significance to external elements based on the repertoire of possible interactions they can have with them, given their internal structure and organization. For instance, a glucose molecule is not a nutrient without a bacterium capable of transforming it into metabolic energy, thus "attributing meaning" to it in relation to its own internal organizational structure. The interaction between a living organism and its environment is, therefore, a process of meaning-making (thus a cognitive process, even in the absence of a mind).

As the complexity of organisms increases, evolving from single cells to multicellular systems, the exchange operations with the environment are managed by a variety of organs and systems, which require efficient coordination to ensure an optimal, integrated regulation of vital functions. The emergence of motor effectors enabling flexible and diversified actions aimed at selected objectives necessitates the development of specialized sensory systems for increasingly refined and informative representations of the environment. This is precisely the role of the nervous system. In the earliest metazoans, even a few neurons sufficed to form rudimentary nervous systems that governed the activity of simple structures responsible for motility, resource acquisition, and waste elimination. Over the course of phylogeny, the nervous system underwent progressive development, culminating in the human brain, the most complex organ in nature. Yet, despite its increasing sophistication, the brain's fundamental task remains the same: to ensure the acquisition and distribution of energy resources, preserving the organism's integrity and supporting adaptive behavior.

As the brain's complexity grows, it acquires the ability to construct internal models of the body and the world; thus, the mind emerges. The brain identifies and encodes the statistical regularities of the organism's interactions with its environment, and it can be regarded as the neurophysiological realization of the causal structure of the world inhabited by the organism, embedded in the spatial and temporal patterns of its neural activity. The more complex and hierarchically organized the brain's structure, the greater its capacity for multimodal integration and abstraction, enabling the construction of increasingly rich and intricate internal models that capture and map the causal structure of the world. Nonetheless, as in the earliest stages of unicellular life, every organism attributes meaning to the world in relation to the repertoire of possible interactions it maintains with it,

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"constructing" reality based on the internal models and interpretative schemas that its brain-mind system projects onto the world. Here, we use the term 'brain-mind system' to underline the interconnected and inseparable nature of mental and physical processes in human functioning, thus emphasizing the ongoing interaction between psychic and bodily aspects in shaping both experience and behavior.

Allostasis and adaptation

In 1970, Conant and Ashby formulated one of the foundational concepts of cybernetics, stating that any regulator, to be effective, must contain a representation of the system it aims to control («a good regulator of a system must be a model of that system»). Using its internal models of the body and world, the brain-mind system integrates current information with its repository of prior knowledge and experiences to anticipate needs and prepare to address them. This predictive regulatory process is known as *allostasis*.

The concept of allostasis, introduced in the late 1980s by Peter Sterling and Joseph Eyer (Sterling, Eyer, 1988; Sterling, 2012), represents an evolution of the homeostatic paradigm developed decades earlier by Walter Cannon. While homeostasis emphasizes the role of reactive and corrective mechanisms aimed at maintaining internal parameters within fixed limits (such as blood oxygen concentration or pH), allostasis recognizes the need for greater flexibility in physiological regulation. Allostasis, that means "achieving stability through change", describes a model of dynamic and predictive regulation of physiological and behavioral states, which anticipate needs and demands and proactively adjust its parameters, ensuring balance and efficiency in response to fluctuating environmental conditions while preventing potential perturbations. An example: in trained individuals, before beginning physical exercise, blood glucose levels, respiratory rate, and cardiac output increase in anticipation of heightened energy demands; simultaneously, heat dissipation and sweating mechanisms are activated in preparation for an imminent rise in metabolic heat production. The allostatic model involves a broad network of brain structures, involving hierarchically advanced regions (such as cortical areas responsible for self-awareness, abstract thinking, and executive functions) and subcortical regions, including the hypothalamus and brainstem, which directly regulate autonomic and neuroendocrine functions. This framework highlights the critical role of psychological and social dimensions, often overlooked in the homeostatic model, in driving allostatic adaptive processes.

Allostatic processes are essential for both acute responses to events and long-term adaptation. However, they carry a cost (McEwen, 1998, 2016). Chronic activation of these mechanisms can lead to *allostatic load*, a term describing the detri-

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mental effects of excessive and prolonged action of allostatic mediators. This cumulative strain results in a gradual wear-and-tear on the systems regulating physiological and psycho- behavioral functions, contributing to the development of a wide range of chronic conditions, including cardiovascular, metabolic, neuropsychiatric, and oncological diseases.

Allostasis and the *Qi*

Although stemming from different cultural and scientific perspectives, allostasis and TCM appear to share a fundamental concept: *dynamic adaptation* as the foundation for maintaining balance and health of the organism. Like allostasis, the *Qi* is dynamic, and it continuously adapts to various internal (emotional states, nutrition) and external (climate, seasons, stress) changes, by balancing *Yin* and *Yang*. The predictive nature of allostatic regulation finds a parallel in the *Qi* of TCM, understood as a proactive element capable of anticipating the body's needs and physiological requirements, thus preventing imbalances in energy flow before they manifest as physical and emotional symptoms, such as fatigue and weakness (associated with *Qi* deficiency), pain and emotional tension (*Qi* stagnation), inflammation or hyperactivity (excess of *Qi*). This capacity for adaptation and regulation highlights the complex and anticipatory nature of *Qi,* in perfect analogy with the principles of allostasis.

In the allostatic model, certain predictive systems are designed to anticipate periodic changes in physiological demands. Many hormones, neurotransmitters, and inflammatory factors exhibit circadian profiles of secretion and activity on target tissues. In fact, the activity of the heart and blood vessels, kidneys, gastrointestinal system, as well as the functions of the liver, pancreas, and spleen, all follow an underlying circadian rhythm. This coordination ensures integrated and efficient multi-system responses to the most probable demands throughout the day. On a longer timescale, seasonal variations in daylight duration allow organisms to anticipate environmental temperature and food availability, regulating behaviors such as migration, mating, and hibernation in many animal species. Similarly, the theory of *Yin-Yang* balance reflects an anticipatory process of cyclic adaptation, in which the *Qi* proactively regulates the mind and body in anticipation of the needs associated with seasonal and circadian rhythms: during winter, the *Qi* tends to concentrate on the internal organs to conserve energy (in preparation for spring); during the day, the *Qi* flows outward to protect the body, while at night it retreats inward to regenerate the organism.

In allostasis, cognitive and emotional states generate anticipatory responses aimed at regulating the activity of bodily systems based on expected needs. Simi-

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larly, in TCM, which views emotions and thoughts as manifestations of *Qi*, the *Qi* "anticipates" how mental states may affect the body and dynamically adjusts to maintain balance in response to shifting environmental influences. The anticipatory nature of *Qi*, whose flow addresses disharmonies before they fully manifest, reflects the principle of preventive health – a fundamental pillar of TCM. A harmonious and balanced flow of *Qi*, like an efficient and flexible allostatic system, is essential for adaptation and for the maintenance of physical and mental well-being. Conversely, interruptions, stagnations, or excesses of *Qi* inevitably lead to illness.

Allostasis and the predictive brain-mind system: the deep roots of self-awareness

An emerging paradigm in neuroscience is the *predictive brain* framework (Clark, 2013; Hohwy, 2016), encompassing a group of theoretical and conceptual approaches that have generated fascinating hypotheses about how the brain constructs experience and plans actions in the service of efficient energy regulation (thus in service of allostasis; Kleckner *et al.*, 2017). Drawing inspiration from Bayesian statistics, this theory suggests that the brain operates as a probabilistic prediction machine, using its internal models to actively generate hypotheses and expectations for inferring the most likely causes of the ambiguous and noisy sensory inputs it receives from the world. This is referred to as *predictive coding*. In the brain-mind system, higher- order hierarchical units constantly send predictive signals to lower-level units that are compared with incoming sensory signals. When descending predictions match incoming input, the contents of the internal models, i.e. the top-down simulations, become perceptions of the external world and action plans for interacting with it. When predictions do not align with sensory inputs, then prediction errors arise, which the brain-mind system must minimize. It does so in two ways: by updating internal models so that new predictions align with incoming input (this is perception), or through action, i.e. keeping models and predictions fixed while moving the body, thus altering the incoming signals to receive the expected inputs (*active inference*; Friston, 2010).

Predictive coding also explains interoception and allostasis. Emotions and awareness of interoceptive states, as well as the visceromotor regulation of bodily parameters, emerge from the brain-mind system's probabilistic predictions which infer the most likely causes of signals originating from the internal environment (Chanes, Barrett, 2016; Seth, Friston, 2016). At the most fundamental (and phylogenetically ancient) level, interoceptive predictions manifest as *affect*, an indistinct and amorphous core of experiences that represent in a non- conceptual manner the

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body's momentary conditions, constantly monitoring the internal physiological states in terms of valence and intensity and signaling the quality and salience of the organism's ongoing interactions with the environment. Primarily, interoceptive predictions serve the function of *interoceptive active inference*, thus allowing the adaptive regulation of internal variables. Simultaneously, however, they generate the pre-cognitive and pre-representational phenomenal experience of "being an embodied living organism", thus forming what can be considered the primitive and foundational core of conscious selfhood (Seth, Tsakiris, 2018). This core, although raw and amorphous, has a profound and pervasive influence on brain activity, reaching the highest hierarchical structures of the neocortex, where the most complex and abstract representations emerge through the maximal integration of multimodal information (Kleckner *et al.*, 2017). These cortico-limbic areas (e.g. anterior insula, anterior cingulate cortex, and orbitofrontal cortex), which are densely connected to deep brain structures that directly regulate bodily functions, serve as high-centrality hubs within the cerebral connectome, facilitating the rapid, large-scale integration of neural information. Collectively, this means that the representation of core affects and bodily states, along with the visceromotor regulation of physiological parameters, is at the center of our mental life (not only emotions, but all psycho-cognitive faculties). In other words, the primary function of the brain is to sustain allostasis. As Spinoza suggested, the psychic and bodily dimensions are two expressions of the same reality. For this reason, signals originating from and regulating the inner body are integral to perception, thought, and decision-making processes. Consider, for instance, Antonio Damasio's «somatic marker hypothesis» (Damasio, 1996), or the extensive experimental evidence demonstrating how internal signals influence exteroceptive perception, spontaneous ideation, and the construction of the embodied self (Azzalini *et al.*, 2019). This also explains why bodily disorders often co-occur with mental disorders (challenging the validity of strictly compartmentalized and hyper-specialized nosography and pathophysiology), and why energy deficits and psychomotor alterations frequently emerge as the primary manifestations of psychological distress.

Abnormal predictive processing and *Qi* imbalances in stress and chronic illness

In the predictive brain, as we have seen, prediction errors are resolved either by updating internal models or by adapting behavior. However, when prediction errors persist or are inadequately resolved, they can foster maladaptive patterns associated with chronic illnesses. There are numerous examples of this. In conditions of chronic pain, such as fibromyalgia, the brain may erroneously predict pain sig-

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nals even in the absence of actual nociceptive input; the persistence of these "false alarms" creates a vicious cycle of sensitization and disability (Apkarian *et al.*, 2009; Tabor, Burr, 2019). In depression, predictive models may overweigh negative information, leading to distorted and catastrophic anticipations of failure and harm (Huys *et al.*, 2016; Shaffer *et al.*, 2022). Similarly, anxiety disorders involve models that generate excessive and abnormal predictions of danger, triggering stress responses which are disproportionate to actual threats (Paulus, Stein, 2006, 2010). Beyond neuropsychiatric conditions, metabolic disorders may also arise. Insulin resistance in type 2 diabetes, for instance, can be conceptualized as a discrepancy between predicted and actual energy needs, resulting in disruptions to glucose metabolism (Burdakov, 2019).

We believe that the negative consequences of altered predictive processing bear similarities to the adverse effects associated with *Qi* imbalances. In predictive coding, disruptions in the delicate balance between predictive signals and prediction errors can perpetuate maladaptive internal models, disturb allostasis, and have clinical implications. Similarly, in TCM, *Qi* imbalances – when the harmonious and dynamic flow of energy is stagnant, insufficient, or excessive – disrupt psychophysical balance and adaptation, thereby promoting the development of chronic diseases (Li *et al.*, 2019). This connection is particularly evident in the case of stress, which is understood as the allostatic response to physical or psychological events perceived – whether real or imagined – as threats to the organism's integrity and well-being, being especially impactful in situations marked by uncertainty and lack of control, where reallocating energy resources to update models and predictions becomes essential. Under chronic stress conditions, dysfunctions in the allostatic mediators and the production of allostatic load create a self-reinforcing cycle; similarly, *Qi* imbalances are viewed both as causes and consequences of systemic dysfunctions that lead to chronic illnesses. In the predictive brain, chronic stress can amplify prediction errors by heightening sensitivity to negative feedback and/or by reinforcing rigid, maladaptive predictive models. Likewise, stress is a critical factor in *Qi* imbalances. Emotional tension, irritability, and chronic pain conditions, such as migraines or musculoskeletal disorders, are commonly associated with *Qi* stagnation (Huys *et al.*, 2016). Conditions such as anemia or chronic fatigue syndrome are described in TCM as consequences of *Qi* deficiency (Kaptchuk, 2000). Disorders such as hypertension and inflammatory diseases may arise from an excess of *Qi*, resulting in hyperactivation of bodily systems (Li *et al.*, 2019; Wang *et al.*, 2022). Prediction errors are central to psycho-affective disorders such as depression and anxiety (Shaffer *et al.*, 2022); similarly, *Qi* stagnation is often linked to emotional disturbances, including frustration and sadness (Huys *et al.*, 2016; Kaptchuk, 2000).

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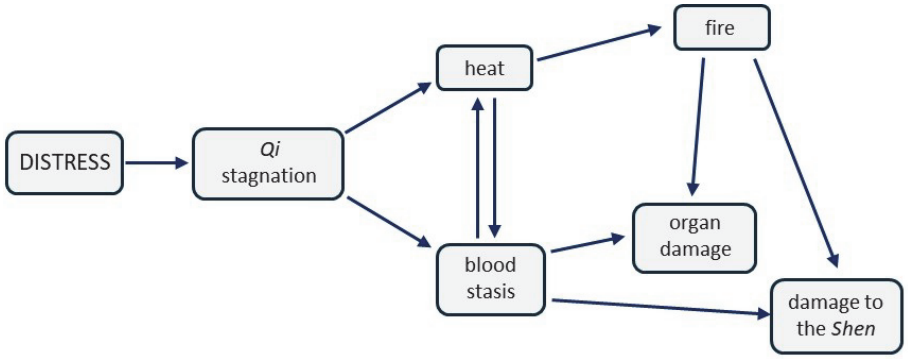

Fig. 2. Negative emotions (distress) in TCM can cause *Qi* stagnation, which in turn leads to blood stagnation (as the blood is no longer moved by *Qi*). This stagnation increases heat, which can transform into fire, causing harm to both the psyche (*shen*) and internal organs. Psychological distress can therefore also lead to biological damage, which in turn exacerbates the distress. This model strongly resonates with current scientific research, which assigns a psychopathogenic role to inflammation (referred to as *heat* or *fire* in ancient Chinese terminology).

In this context, the ancient Chinese medical model provides valuable insights into the integration of the psyche and biological systems in psychiatric disorders. Mood disorders, such as anxiety and depression, exemplify chronic predictive errors, as previously discussed. Psychotherapies like cognitive-behavioral therapy, which focus on helping patients identify and correct faulty thoughts and predictions, can achieve a certain degree of efficacy. However, this framework for understanding psychological suffering overlooks the systemic dimension and the psychopathological impact of biological systems perturbed by the distressed psyche. By contrast, the ancient Chinese model conceptualizes the psychic and biological dimensions as operating in a synergistic relationship – a pathological synergy, as illustrated in Fig. 2. This holistic perspective enables a more accurate understanding of the therapeutic tools required to address both psychological and biological aspects of these conditions.

Towards integration

Both the paradigm of allostasis as explained by predictive brain theories and the concept of *Qi* in TCM highlight the importance of balance and adaptability for human health. Combining these approaches could offer new tools and opportunities to address pathology in an integrated manner, targeting both measurable dysfunctions and subjective experiences (Bottaccioli F., Bottaccioli A.G., 2024a, 2024b). Modern

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healthcare is increasingly challenged by the growing prevalence of chronic illnesses and stress-related disorders. Combined strategies could incorporate pharmacological interventions alongside practices designed to enhance *Qi*, such as acupuncture, Tai Chi, Qi Gong, meditation, and phytotherapy – methods whose efficacy in reducing allostatic load is supported by robust empirical evidence. Moreover, advances in neuroimaging and molecular biology offer promising opportunities to investigate the neurophysiological and epigenetic correlates of these interventions (Kanherkar *et al.*, 2017). Examples of synergy are already emerging. Meditation and mindfulness, deeply rooted in TCM, are increasingly understood through the framework of predictive processing, as practices that recalibrate internal models by improving stress management and enhancing attention (Tang *et al.*, 2015). Similarly, acupuncture serves as a potential bridge between *Qi* and the predictive brain, influencing predictive mechanisms while modulating autonomic regulation and pain perception (Fang *et al.*, 2009; Kong *et al.*, 2009; Napadow *et al.*, 2009; Langevin, Wayne, 2018).

Conclusions

The entirety of our psychic life is founded on affects, thus deeply rooted in the body, and inherently oriented toward preserving vital balance. The human psyche, rising from organism, operates *with* the body, *through* the body, and *for the benefit of* the body. Perhaps it is time to reclaim the etymological meaning of the Greek word "psyche" and reconnect it to "breath", understood in the concreteness of its organic function – a function upon which the preservation of biological life and the fundamental experience of being a living, embodied organism depend. Eastern philosophy and TCM have long emphasized the profound connection between the body and *Qi*, which must remain in harmony to ensure a state of complete well-being. The *Qi* of modern neuroscience appears to reside in the processes of *interoceptive active inference*, i.e. in the interoceptive predictions that, while adaptively regulating bodily states and energy budgets, create the deep affective sense of being alive in a body – which serves as the essential psychological foundation for all other psychic phenomena. We believe that incorporating this knowledge into biomedical education could help bridge the gap between Western and Eastern paradigms, fostering a more patient-centered approach to care (Bottaccioli F., Bottaccioli A.G., 2024a, 2024b).

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