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Quorum sensing as the microbial expression of a bioethics for mars colonisation

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Quorum sensing (QS) may be understood and applied as a chemical grammar for eco-community interaction on Mars. Such interaction radiates a disruptive technology, anchored in the phylogenetic and ontogenetic instinct of diversity-based self-preservation. More than a novel astrobiological insight, our aim is to introduce a bioethical cosmivision that, inspired by the strong microbial social bonds, is able to introject into the 'moral DNA' of future Mars settlers the gene (dogma) of reciprocal care, which brings us back to the key issue of habitability as a continuous property of nature (Cockell et al., 2019; Heller, 2020).

QS—one type of social interaction among mixed-species microbial groups (biodiversity) — is critical to their gene expression and adjust to changing environmental conditions (Prescott and Decho, 2020). Indeed, different species of microbes have learned to interact with each other in all stages over the evolution geological periods, through chemical and not random communication/signalling (Wellington and Greenberg, 2019). Such an ability (creative entropy) has been important for architecting adaptive and flexible QS systems, where microbes use the genomic properties of nearby cells, expanding their capabilities to cope with many eco challenges (Smalley et al., 2022).

It is feasible the idea of transferring some properties of (microbial) interactions in the microcosm to the different types/clusters of people (another microcosm when it comes to interplanetary migration and the Mars colonisation), since there are general regularities or patterns in biosystems at various levels. It is also possible to determine such regularities, delimiting their zone of applicability. In fact, QS occurs as a result of overpopulation density (Postat and Bousoo, 2019) in the microbial communities—similar to the confinement of 'QS settlers' in tiny (cocoons) habitats on Mars —, when the concentration of signaling/autoinductors 'molecules' (a metaphor for existential challenges) exceeds a certain threshold so that they begin to influence the behavior of 'cells' (a metaphor for individuals). Microorganisms in this state can trigger a coordinated sporulation, bioluminescence, biofilm formation, etc. (Ng and Bassler, 2009; Whiteley et al., 2017; Eickhoff and Bassler, 2018; Antonioli et al., 2019). For instance, biofilm dynamics performs in the human dimension the role of casing produced by a strong bioethical cohesion/cooperation, aimed at structuring the experimental collectivity of 'QS settlers' against potential or eventual aggression.

The QS must therefore be considered an instinctive *noûs* (Ancient Greek, *νοῦς*; intellect), i.e., a paradigm anchoring in 'community survival' as the supreme value, which presupposes an extraordinary and complex biopsychosocial compatibility of the isolated explorers (for a long time, perhaps definitely) in blocks of Martian colonies. Behavioural evidences about

this complexity have been reported by literature (Kanas et al., 2009; Goel and Dinges, 2012; Stuster, 2021). But the incompleteness of lab-simulations (and their risk prediction controlled models) consists in setting the premise that it is possible, from experiments on Earth, to deduce practicable intercultural patterns on Mars (Kanas, 1990; Boyd et al., 2007; Basner et al., 2014). An alternative forward is proposed here: such tests should induce transcultural interactions (Lapierrea et al., 2009) (performance training) where each ‘cell’ (individual) has internalized the primacy of collectivity principle, whose inductive ‘molecules’ (existential challenges) stimulate a QS-inspired autopoiesis/homeostasis as a dogmatic phenomenon, in order to weave a resilient network/tissue—able to metabolise external and internal threats—into the human collective on Mars.

There are at least four empirical findings for this socio-immunological engineering approach (briefly outlined some of its parameters below, introducing perspectives for development in further investigations).

- a) specific bioethical microclimate: the colonisation of Mars will amount to the deployment of remotely traceable research protocols, with the moral safeguards of studies involving humans (Ushakov et al., 2014; Araújo et al., 2022) — one of the preferred objects of bioethics;
- b) founders overview: the human ecosystem on Mars will initially be an island of ‘QS settlers’ (surrounded by challenges) within a planetary island (sailing the astrophysical ocean), forming two perimeters of existence;
- c) Earth lab: follow-up per cohort study aimed at simulation of human coexistence on Mars (of the first generation of ‘QS settlers’) designing and providing support for an integrated vivariums circuit—to improve skills inside conflict fields, desert areas with a large temperature range, (MDRS project, 2001), abyssal submarine expeditions, polar environments, (Palinkas and Suedfeld, 2008), orbital research stations, (Kanas et al., 2001), tornado or hurricane corridors, regions with major seismic activity —, as voluntary incubation of QS-based communal experiments (enterprises) adaptable to extreme and threatening situations;
- d) semantic resizing: Mars exploration mission needs to be re-signified, i.e., interplanetary voyage to Mars camp also involves an inner journey into the instinct of self-preservation guided by caring for the other: behold the crux of that QS code applied

to the organising the human life under adverse and harsh conditions.

Perhaps a paradox occurs nowadays. The same humanity driven by the idea of colonising another planet (Witze, 2022) is only beginning to awaken globally, but still in a timid way, to the symbiotic benefits—since forever—of an ethic of cooperative association between individuals, nations and in relation to the Earth itself. Microbial life has much to teach us in this respect; may we therefore have the humility to learn from it.

The QS-based hypothesis to coordinate the survival of people in extreme conditions seems to contain a significant and current worldview not only for astrobiology and cross-cultural bioethics, but also to the pacification of human bonds on our planet, avoiding the re-edition of deep antagonisms/conflicts on Mars. Thus, it is reasonable to encourage the transposition (by analogy) of QS logic to human coexistence, achieving outcomes similar to those of microbial communities. However, we should consider other ancillary regulatory factors such as a legal regime of rewards and punishments.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

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