TOWARDS A GENERAL EQUATION FOR THE
SURVIVAL OF MICROBES TRANSFERRED BETWEEN
SOLAR SYSTEM BODIES.
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Introduction: It should be possible to construct a general
equation describing the survival of microbes transferred between
Solar System bodies. Such an equation will be useful for
constraining the likelihood of transfer of viable organisms
between bodies throughout the lifetime of the Solar System, and
for refining Planetary Protection constraints placed on future
missions. We will discuss the construction of such an equation,
present a plan for definition of pertinent factors, and will describe
what research will be necessary to quantify those factors.

Description: We will examine the case of microbes
transferred between Solar System bodies as residents in meteorite
material ejected from one body (the “initial body”) and deposited
on another (the “target body”). Any microbes transferred in this
fashion will experience four distinct phases between their initial
state on the initial body, up to the point where they colonize the
target body. Each of these phases features phenomena capable
of reducing or exterminating the initial microbial population. They
are:
1) Ejection: Material is ejected from the initial body,
imparting shock followed by rapid desiccation and cooling.
2) Transport: Material travels through interplanetary space to
the target body, exposing a hypothetical microbial population to
extended desiccation, irradiation, and temperature extremes.
3) Infall: Material is deposited on the target body,
diminishing the microbial population through shock, mass loss,
and heating.
4) Adaptation: Any microbes which survive the previous
three phases must then adapt to new chemophysical conditions of
the target body. Differences in habitability between the initial and
target bodies dominate this phase.

A suitable general-form equation can be assembled from the
above factors by defining the initial number of microbes in an
ejected mass and applying multiplicative factors based on the
physical phenomena inherent to each phase. It should be possible
to present the resulting equation in terms of initial ejection mass,
ejection shock magnitude, transfer time, initial microbial load
and/or other terms and generate graphs defining the number of
surviving microbes. The general form of the equation is:

\[ x_f = x_i \cdot f_1 \cdot f_2 \cdot f_3 \cdot f_4 \]

Where \( x_f \) is the final number of microbes to survive transfer, \( x_i \)
is the initial population prior to ejection, and \( f_1, f_4 \) are mortality
factors for the four phases described above. Among other
considerations, \( f_1 \) will vary with respect to impact shock
magnitude and \( f_2 \) will be time-dependent.

Considerable research has been performed to date to quantify
the survival rates of various microbes in response to portions of
these four phases, both as vegetative cells and/or spores [e.g. 1-4]. Results indicate that many species tend to respond differently
to the pertinent mortality factors, especially in the case of
extremophiles. Therefore, a complete equation will include
species-specific responses to the mortality factors.