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Stress response and evolution

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All organisms share a common molecular stress response that includes a dramatic change in the pattern of gene expression and the elevated synthesis of a family of stress induced proteins, heat shock proteins (Hsps). Hsps, according to their molecular masses, have been grouped into five major families: hsp100, hsp90, hsp70, Hsp60 and small Hsp (sHsp). Hsps are highly conserved proteins, e.g. all the members of the sHsp family possess the "alpha-crystallin domain", a highly conserved region between members of a given species, and of different species as well. Expression of Hsps usually results in repair of damaged proteins and survival of the cell, mainly through their chaperone function. Hsps are synthesized by living organisms also under normal cellular conditions; they bind to a range of client proteins that are crucial for regulating growth and development, but their major function is related to protein folding. Cells need molecular chaperones to promote protein folding into their native conformation and to prevent aggregation. Chaperones interact with protein that are being synthesized, folded or trans-located into organelles, as well as with mature proteins that tend to unfold because of environmental insults, but do not form part of the final structure of the folded protein. Protein sequence variations that could change its folding are tolerated because, in the presence of chaperones, unstable intermediates can reach he native state. This would be a powerful evolutionary mechanism that ensure apparent genetic stability at physiological conditions and, at the same time, allows the accumulation of cryptic mutations that could rapidly become manifest under stress conditions in which chaperones are needed for assuring viability. In this way changes can be substantial and step-wise rather than incremental and progressive. Hsps are excellent candidates for the "genetic buffering" system that Waddington predicted in 1942. The range processes in which chaperones play a role might thus be broader than was previously thought, and extend from general stress tolerance, to protein folding, to signaling cascades and evolution.
This approach allows older students not only to deeply understand concepts connected with natural selection, but also to reason about some mechanisms underlying the framework of evolutionary changes.

References

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