Abstract

Sexual reproduction is an energetically costly process for organisms to accomplish in contrast to asexual reproduction. It requires organisms to compete for mates, exhibit pre-copulatory behaviors, and engage in the act of copulation, all of which are arduous behaviors that are not required in asexual reproduction. Nonetheless, sexual reproduction is evolutionarily conserved. The high prevalence of sexual reproduction among organisms remains unknown. Current literature supports the conservation of sexual reproduction due to its creation of genetic variation between organisms, which is particularly favored in unpredictable environments. One model which supports this is the Red Queen Hypothesis (RQH). The RQH states that organisms and their co-evolving parasites continually undergo genetic recombination in a positive-frequency dependent selection manner, to counter-adapt one another. Whereas, the parasite acts to evade the immune system of the host, the host's immune system acts to evade the entry and virulence of the parasite. As a result of the necessity for genetic variation in this evasion process, this parasite-host relationship reinforces p^¢ˇa| r^pr å˘`ci ~. I~ c@ip r^çi^¸, I ¸rpc i~cr å˘`^ c@^ c@^ r^ ˘ c@^ R^å Queen and the type of selection that it models. I then tested the validity of the RQH against various models including computer-simulated bacterium p˘˘`@ ap Pp^˘å m ~ap '˘ r^p`^~p SB Y 25 a~å c@^ir parapici` @ pcp, a~å ancestral genomes of Denisovans and Homo sapiens. Lastly, I will conclude whether there are limitations to the Red Queen. While this review will ~ c b^*i~ c ˘ ` ç^r c@^ br^aåc@ ˘ p ppib|^ b^~^,cp c ` p^¢ˇa| r^pr å˘`ci ~, ic ¸i|| ˇ~` ç^r r^a|-¸ r|å app|i`aci ~p ˘ r @ ¸ *^~^ci` çariaci ~ ip b^~^,`ia| in combating pathogens.

Introduction

Living organisms reproduce via two mechanisms, including asexual a~å p^¢ˇa| r^pr å˘`ci ~. B c@ m å^p a`@i^ç^ c@^ pam^ r^p˘`|c, c@^ papp-i~* å ¸~ ˘ *^~^ci` mac^ria| c ˘ ppri~* a~å i~`r^api~* ,c~^pp ¸ic@i~ a~ i~åiçiå˘a|. H ¸^ç^r, c@^˘ åi ^r i~ c@^ p^r`^~ca*^ ˘ *^~^ci` mac^ria| c@ac ip passed along per parental genome, and the conditions necessary for each type of reproduction to occur. Asexual reproduction describes a parent cell å˘p|i`aci~* icp DNA c˘ pr å˘`^ a *^~^ci`a||^ iå^~`ci`a| ˘ ppri~*. Ap^¢ˇa||^ reproducing organisms will not yield genetic variation within a population's gene pool, unless in the case of random mutation. Modes of asexual reproduction typically include the duplication of the parental genome and cytoplasm within the cell, followed by a breaking away of the duplicate `^||. Sˇ˘`@ m å^p i~`|ˇå^ bi~ar^ ,ppi ~, p~appi~* åiçipi ~, a~å bˇååi~* (Baˇma~, 2016).

Alternatively, sexual reproduction is the generation of progeny via the gametic combination of two individuals, thereby creating genetically åiç^rp^ ˘ ppri~*. V@ip cˆpi`a||^ r^qˇir^p c¸ @ap| iå *am^c^p ˘ˇpi~* a~å fertilizing one another to create a diploid cell that is genetically diverse from the parental genomes. Recombination and crossing over of the parental chromosomes during fertilization allow for the zygote to remain genetically åipci~`c r m icp par^~cpt *^~ m^p (Baˇma~, 2016). Hˇ^ç^r, b^`aˇp^ c@^ zygote's DNA was yielded from the parent's DNA, parent and daughter cells are genetically similar. Overall, asexual reproduction only requires one parent cell for the formation of progeny and guarantees the full genome of the parent cell will be duplicated and passed down for generations. Whereas sexual reproduction requires two separate parent cells and assures only half of each parental genome will be passed down to progeny. Sexual reproduction is viewed as an energetically costly process compared to that of asexual reproduction. Organisms that engage in sexual reproduction must outwardly exert energy seeking a mate, engaging in both pre- and post-copulatory behaviors, and engaging in the actual act of copulation. Furthermore, these acts themselves do not ensure the organism will b^ pˇ˘˘`^pp- a~å B^~å^r, 1981). A| ~* c@ip |i~^ ˘ c@ ˇ*@c ^¢ipcp c@^ R^å Qˇ^^~ Hˆ

pothesis (RQH). The RQH states that species within predator-prey, or parasite-host associations are in a coevolutionary arms race with another, `˘ ^ç |çi~* c ˘ ` ˘ ~c^r-aåapc c@^ c@^r r*a~ipm. B^`aˇp^ p^¢ˇa| r^pr -å˘`ci ~ ^iˆ|åp @i*@ *^~^ci` çariaci ~ ¸ic@i~ ppri~*, ic maˆ pr^ç^~c b c@ species from fully optimizing the weaknesses of their competitor, acting as ‰m çi~* car*^cp,+ a~å c@^r^bˆ i~`r^api~* ,c~^pp / Z

r ¸c@ ˘ @ pcp (Ap@bˆ a~å Ki~, 2015). V@^p^ `a|`ˇ|aci~p r^qˇir^ c@^ probability of an epidemic to be inversely correlated with genetic diversity of a host population. If these calculations are true, as genetic host diversity increases, the likelihood of contracting a parasite decreases (Ashby and Ki~*, 2015). O~^ ` ˇ|å ar*˘^ c@ac ˘ ~ a p@ rc-c^rm p`a|^, i~ @ pc *^~^ci`

m å^|p, ap c@^ˆ i~` rp raᴄ^å å^~piᴄˆ-å^p^~å^~ᴄ m rᴄa|iᴄˆ, 'ˇiåiᴄˆ ˷ r^-
`  mbi~aᴄi  ˷ raᴄ^p, a~å parapiᴄ^  immi*raᴄi  ˷, a|| -a`ᴄ rp ¸@i`@ maˆ r^'^`ᴄ
p pˇ|aᴄi ˷ åˆ~ami`p ¸iᴄ@i~ ᴄ@^ r^a|- ¸ r|å (Ap@bˆ a~å Ki~*, 2015). V@^ˆ
also properly addressed the idea that genetic variation of sexual individu-

Aåça~`i~* Oˇr W~å^rpca~åi~* ˛c@^ RQH i~ N ~-Pr^åaˎ r-Pr^ˆ r Parasite-Host Relationships

While the RQH surely acts on parasite-host and predator-prey models, evolutionary biologists questioned whether it can be observed between genetically similar parasite-host models. For example, cancer cells which ~^^å |içi~* @ pˎp ~ r ~ˇcrici ~ (Aˇbi^r ^ˎ a|., 2020). V@ip ip a ˇ~iqˇ^ ˛ aˆ of viewing the RQH because cancer cells are derived from host cells but mˇcacˎ a~å r^p|i`acˎ aˎ ~apˎ^r racˆp (Aˇbi^r ^ˎ a|., 2020). I~ ˎc@^r ˛ ràp, cancer and host cells are one in the same. This is unlike a parasite-host r^|aci ~p@ip, ap parapiˎ^p a~å @ pˎp arˆ ˎ ˛ åi ^rˆ~ˎ å mai~p ˎ@aˎ i~ˎ^r-