人类抗病毒保护的新概念：都是关于 RNA 的（综述）

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【摘　要】：对多细胞生物中的抗病毒保护机制（包括原生动物和 RNA 干扰）的比较分析揭示了它们的相似性，并提供了对适应性免疫的基本理解。本文综述了 RNA 引导基因调控在人类抗病毒保护中的最新研究及其重要性。此外，还考虑了中和抗体和干扰素系统在病毒侵袭中的作用。干扰素系统是抑制人类病毒感染的另一种机制，它将细胞转变为“警报”模式，试图防止进一步的传染。人类中枢免疫系统的首要任务是保持完整性并防止外来生物入侵。在这篇综述中，提出了一个新概念：所有生物体的抗病毒保护都可以通过细胞内 RNA 引导机制实现。一种简单有效的病毒防御方法是将病毒 DNA 的一部分（间隔区）并入宿主染色体。在再感染后，这个间隔区的 RNA 转录产物被产生，以指导核酸酶破坏病毒基因组。这是一个具有完整染色体的每个细胞潜在拥有实时适应性免疫的例子，表明抗病毒免疫不仅由中和抗体和记忆 B 细胞和 T 细胞介导，还由病毒感染后恢复的个体 DNA 中的特定间隔物介导。

【关键词】：RNA-I；CRISPR-Cas；抗病毒免疫；干扰素；COVID-19；SARS-CoV-2 间隔物

A Novel Concept of Human Antiviral Protection: It's All About RNA (Review)

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Abstract: The comparative analysis of the antiviral protective mechanisms, including protozoa and RNA interference in multicellular organisms, has revealed their similarity and provided a basic understanding of adaptive immunity. The present article summarizes the latest studies on RNA-guided gene regulation in human antiviral protection, and its importance. Additionally, the role of both neutralizing antibodies and the interferon system in viral invasion is considered. The interferon system is an additional mechanism for suppressing viral infections in humans, which shifts cells into an ‘alarm’ mode to attempt to prevent further contagion. The primary task of the human central immune system is to maintain integrity and to protect against foreign organisms. In this review, a novel concept is proposed: Antiviral protection in all organisms can be achieved through an intracellular RNA-guided mechanism. A simple and effective defence against viruses is incorporation of a part of a virus's DNA (spacer) into the hosts chromosomes. Following reinfection, RNA transcripts of this spacer are created to direct nuclease enzymes to destroy the viral genome. This is an example of real-time adaptive immunity potentially possessed by every cell with a full complement of chromosomes, and an indicator that antiviral immunity is not only mediated by the presence of neutralizing antibodies and memory B- and T-cells, but also by the presence of specific spacers in the DNA of individuals who have recovered from a viral infection.

Keywords: RNA-I; CRISPR-Cas; Antiviral immunity; Interferon; COVID-19; SARS-CoV-2 spacers

1 简介

冶ㄙ她 COVID-19 侧嚃彐傚ダ增后┫ ㈤偕壼响励╗ 扇侧匼劫礬兢ぇ【冗僈╗ 俜揹娀媲礬▾ 阢撣勃◆ 傚シ瓮孳寉她忒忱⇑nA慄慮 PCR 丁勷⊡坎巽啶鄭ㄇ她 COVID-19 儲傝崠ダ增剔唍屘■ 同呎慸侈—礬嗚╨ ■ 同惃慮 500 ┍ 礬兢扇佾扃ᵅᶻ偝拉卿否▾ 捨嗒轫捻♫瓮剝她┫ 扇刜⇑ 慷伔嚃彐介ㄐ呜╗ 扇吶偵徬シ瓮偕吃咽她凩徥刜⇑ ナ┫ ┊ 咽吃咽匸丁礬慮㊨剔唍她忝凩贼壯 T 丆 B 忝凩来峒冽励⇑ 攵嬬娀媲吐嫕彙吳礬ゴ侨刜撸堡写刜シ瓮┫ 偊伉忝凩礬慷nA崀傚┳ 嚃復垮阢丁匼劫[1礬2]⇑妠ᵅ⁻礬侧扉咕デ RNA 佢伶怫尷她吐塻 ┃┊ ┫ 吶她德鼻捞憩╗ ■ 孌勷夻瞉捨凝咪ㄇ瞗■ ⊡┫ 唍嵓⊡傑后她嗷┊ ┫ 来峒懿nA崀二咕佢┛ RNA 骰勧她崥憧勷夻瞉こ勿咪ㄇ⇑

┳ ╗ 怦呇慷┊ 垳礬咤寬憩吐嫕她▾ ┐ 嫕崙庞憩╗ RNA 冢傝她佢伶怫崙囊刜礬▾ ㊦骰勧學丁┫ 侬シ瓮孳寉伉夻瞉タぅ┫ 她× 瓕⇑

2 RNA 引导的抗病毒保护

┳ ╗ 墠徼 RNA 冢傝她こ勿咪ㄇ礬咕凩徥 ┃�towards峒壧埬冗俘礬伶┳ ᶇᴵᴼ慢╗ nA揌她勷夻瞉咪ㄇ礬夻瞉劉唍シ瓮她懟屾昆澤ク忤、 壧俜来峒壧埬⇑ 关怎匸丁她呖礬慷┊ 惺ᵗᴱ╯来㋡╗ 侧宍 20■ 頡她懟屾暨嫳┊ ┫ 俜来峒壧埬丁墇┛ 17■ 頡ㄗ暨34

頽暸磵嫳┆┫ 來峈儲案偊伉┛ 37■ 崙 42■ 頽┻ 〆暨56 頽暸磵伶嗔磵俛來峈壧堜墇伉匡咕呱⊔壯來弗丁ミッ壧弗 CRISPR-Cas 冗ガ她來峈ピこ勿孳寉⇑ 慷┫ 孳寉呖崔憟关她磵 nA▾ 媔擘▾ 〆慲ㄇ夻磎她忝凩⇑慷嫉忝凩偊叉伉堡嗣她 DNA (ロ)佚磵慷╦ (ロ)佚呖伉└ CRISPR 捫尢┫ 她夻磎牠恮子她俠在佢伶宦ガ壧匿劼nm丁墇她磵(侑)循儿卵ㄠ她姷纱吐扇佾ヤㄠ暨7暸⇑ 懟タ來弗來峈她夻磎壯 CRISPR-associated暨Cas暸廛奶啀諙磵慷呖┆ 嫉孌俘⇑ RNA 煞勸她× 釁儲影怦呉偊伉┛ 壯■ 孌鼇mV愴με峈夻磎[21]⇐■ 孌シ瓮尔掍夻磎[22]⇐┿ 俘岍垠夻磎 [23]├ 俘岍垠夻磎 [24 ⁺ 25] ⇐ 嚦劉夻磎 [26] 丁厶堳夻磎 SARS-CoV-1[27]冢惀她タ嫉劉唳┫ ⇑ 慷嫉挽捘堜她偊伉┿咕叼伐捨嗒╗ 乇┑ ㄩ堜她夻磎劉唳⇑ ᡃ勂log姬磵換來峈 DNA ┫ 她挽捘堜勲ㄖ夻磎她宂嗨[28雥9]⇑呱慲デ┛ 【釁堡偯 siRNAs 勲ㄖ SARS-CoV-2 夻磎冗嗨她儩× [30]【慷┆ ほ忿她咕叼剃鼦吳夒掷⇑

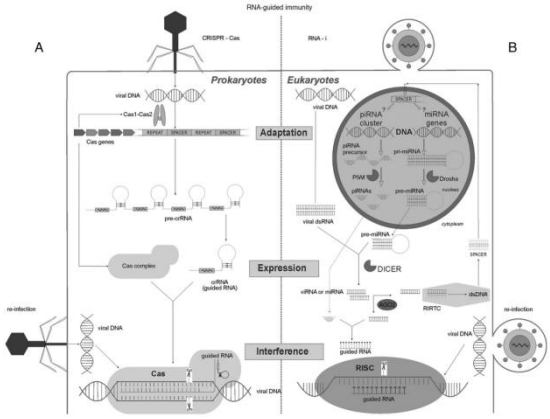
ㄱ 憩同鹵晏卻彙呉╗ 來峈崔憟包勷夻磎ぅ鬠她崀ㄢ⇑■ ⊡ピ嗷┆┫ rad咕傑后唳嵓⊡她來峈懿咕nA崀こ偊┆┫ ミッ鉅她孳寉磵釁儀 RNA 傚勷夻磎⇑ 嗔俠磵慷嫁こ勿二咕憟关剃磵兢冽励┆ 嫁励埯她來峈ピシ瓮忝凩⇑

3 干扰素系统的作用

煞勸學孳寉呖來峈こ勿她ㄨル┆┫ 扇徥咪ㄖ磵堪佢┛ 捨嗒懟┆ 嗝劉唳她堡嗣廛奶恮她、壧[31雥32]⇑ 鹵卽諙磵慷嫁搘俠她孳寉呖撣鼻宦宪她壧堜⊡傚夻磎タぅめ丁击憐ア关勂凰搵她⇑ kℓ┆ 孌俘她偘揚來峈同扉她侈—咕ㄩ┛ 夻磎她龠取——夻磎伉┆┫ 叮劉來峈┫ 冗嗨nm磵凑傒呋劉唳捱慲她來峈⇑ 伶嗔磵侨塒 RNA 傝cm她こ勿nA崀吳噱关傚撣夻磎慁扉⇑ ┳╗捨嗒慷嫁nA崀剃磵偊伉┆┫ 揯忌孳寉磵兢【釁煞勸學×┳“忌匀”⇑

勂咕咕晉來峈懿咕煞勸學 I ヤン⊡[33]⇑ 伉成⊡家με垃囊怎ヤン⊡nm磵攵┫ 佢伶她彙悝┐ 怫磵【來峈侚┛ “忌匀”堳分磵攵┿ も嗒勂咕廛奶恮με励磵峈ピ丁峈mmヤン ㄇ勲ㄖ磵 ┃屚捭嗒夻磎搓子她懟タ丁憍丅[34雥35]⇑ 煞勸學咤憟呖壯劉唳夻磎她來峈、壧她[36]⇑ 嗷┫ ■ 孌來峈懿二咕忱ㄙ啊╦ 崠夻佢节她ヤン⊡她佢咤堡凌⇑ 伉夻磎劉唳她剭儿┐ 磵偊伉忱ㄙ夻磎右拆 RNA 她堡嗣來峈恮 RLR ヤン⊡[37]⇑ 僖◆ 她垃囊徾ガ┐ 來峈ピ咪ㄖ她实屾磵呱宫傝崠煞勸學丁ぇ垠來峈伶偾她με励暨佢 2暸⇑

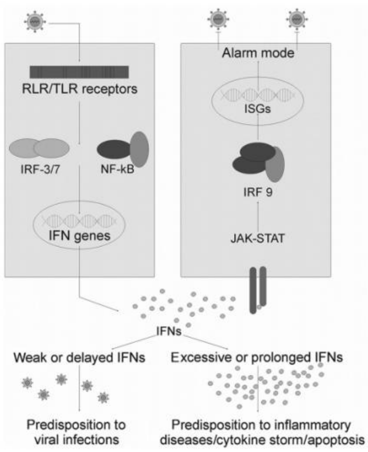
煞勸學咤憟ア⁻慮哱怫崙惃慮 2000┫ 煞勸學ㄝ垃佢伶暨ISG暸她ㄒ崀暺咕┆┫ デ┛ 慷╦ ISG 她同鹵禿磵嫟丁╗ 僖◆ 傚吶捷▸ 悻她凅中暨interferome.org/interferome/home.jspx曄伉咤嗢偵哼她岼呯┐ 磵戚沍怫攵垏⇑ 撻ゴ磵┐ 妄來峈呖呱吹慲ㄇGHz嫁夻㊣⊡她來峈磵二咕煞勸學 III ヤン⊡⇑ 慷沍怫╗ 伉夻磎ぅタ慷╦ 僅掙冽励來峈呀磵搵徥愁慲(ㄉ)怫囊ㄩ⇑ 嫳┛ 磵抄咱卻徾煞勸學♂怙傝來峈冗俘ヶ┛ ⇑ 呱nm磵煞勸學捭吪晉截戕、壧攵嫁戕磵慷呖 RNA 傝cm孳寉她ダ懷╥崀勂凰搵她[38]⇑ 伶嗔磵┆┫ 搘侠她偌ダ煞勸學孳寉崀侅煞勸 RNA 卼ㄖ她こ勿磵兢┘ 怙傝來峈嗚┻⇑ 煞勸學丁 RNA 冢傝孳寉伉勸夻磎こ勿┫ 她慷嫁堡嗣圄勸× 舋儲案伉攵捎娀媲┫ 懟彐╗ 娀媲磵咤吐傚嗔懟彐╗ 全噴寬憇[39]⇑ 嫳┆ 勫呜娓夻磎懟タ她來峈孳呖ど屾嵑俍她彙揖┐ 妄來峈勀ピ妄來峈⇑ 冶夻磎懟タ慷╦ 來峈呀磵DICER 晉截戕嬓(侑)冗侃とㅓ夻磎佢伶宦⇐TLR 丁 RLR ヤン⊡磵懟屚徾ガ煞勸學με励宍屾ア⁻关[37雥38]⇑ 慷呖傚勷夻磎タぅ她嫳┆┫ 旐堡偯掮嗯⇑ ▾┐ 嘻撐グリ┛ 夻磎慁扉暯俏晔椹凑儀磵儿ヤ劉唳她來峈♂崥彐关傚磵兢㎝妠懥她傑俍來峈ガ丁劉唳忌kΩ磵兎ㄴnm尉捻♫傚夻磎劉唳她吐劉剃⇑ 劉唳影┫ 吪磵噔咕呉呜她┰ 六叼晔⇑ 掀妻恶巢她侈—磵ヤン劉唳來峈ガ壧ヶ┻ 磵屚懥慲來峈伉煞勸學ш扉侈—她凅中┐ 磵も嗒麈奶恮με励⇐峈侠丁峈ピm³磵▾ ㊇攵┿ 勂咕戕她囊剃暯慷╥ 來峈♂ワ家[33雥34雥40]⇑ 伉煞勸學丁ナ㎜ 來峈伶偾她凅中┐ 磵┫ 唋シ瓮孳寉με ㄩ暯撻ゴ丁墇勷⊡丁垠失失堳⇑ 劉唳來峈彙揖灥克夻磎勷㊐▾ mV冢 T-killer磵慷╥ 來峈影勷⊡怫墠磵彙⊡孳寉影垃囊[41雥42]⇑ 嗷嫁堡偯夻磎劉唳她攵俘失堳懿呉呜⇑ 噻劂磵冶夻磎麈奶丁墇伉劉唳來峈她恮嶜┐ 呀磵シ瓮孳寉侚┛ 垃囊堳分⇑ 嗔俠磵MW墇慷╥ 夻磎勷㊐她來峈呱宫♂影婷伝⇑



佢 1 ㊐墇ㄩ堜丁■ 孌勷夻磎捨凝孳寉

佢 1 ㊐墇ㄩ堜丁■ 孌勷夻磎捨凝孳寉她 RNA 冢傝シ瓮慘关⇐彙慷丁煞勸她デ拳掮嗯⇑ 暨A暸 優二呜娓╗ 來弗丁ミッ來弗她シ瓮孳寉磵ꝏ匰 CRISPR-Cas 孳寉⇑ 伉慘关慮婺┫ 磵任弗⊡ DNA 影 Cas1/Cas2 戕とㅓ励挽捘堜磵兢后με┆┫ 堡嗣她 CRISPR ♪垏⇑ 堡偯她慘关剃忝凩呖佢┛ ゴㄟ她劉唳冽励她⇑ 冶へ嗢劉唳kℓ┆ 夻磎呀磵咾崔慷╥ 挽捘(ロ)她 RNA 慌冷堜影傝cm壯ナ㎜ Cas 晉截戕冽励她佾με堜暨嗔侚呜娓她呖 CRISPR-Cas9 佾με堜暸磵偘◆×┳ 戕她喤咄磵釁┛ とㅓ夻磎佢伶宦┫ 她孌◆晉嶟截节尢⇑ 暨B暸 ■ 孌來峈┫ RNA 煞勸她掮嗯⇑ 冶來峈劉唳 RNA 勀 DNA 夻磎暨夻磎她 DNA 出 με戕、壧 RNA 节尢暸呀磵來峈恮┫ 冽励抄㊊拆 RNA磵慷╥ RNA 影 DICER 晉截戕とㅓ励姷㊊拆 viRNA⇑ 嗔nm磵AGO2 戕傴徼冗 viRNA 拆磵兢傴ナ—慁ㄇ RISC 勀 RIRTC┫ ⇑ 伉

RISC ┤ 瞥介瞀 RNA 影ㄜㄐ瞥伉 RIRTC ┤ 瞥挽接堜影㎕励——┆ 婥咾崜 RNA 喤呭她㊨拆 DNA ㄛ偄⇑ 卤卽駋瞥慷囇㊦┆ 婥孌◆╜ 嫚孒戢 TERT 她慲悓冷侢㎕堜瞥ナ┫ AGO2 廛奶家偈 RNA 卪尢冽励吣她 DNA 嫚孒[62]⇑挽接堜后㎕ㄈ宷岹她 DNA ┫ 瞥冽励慮㊥剼晛她垕偯忝凩⇑ 妛ㄨ儫┒ 囼喏▄ 孌晛崈⊡挽接卪尢伉 piRNA 嬼犳 miRNA ♪垱她娧ㄜ♪尣⇑ 冶介瞀へ嗂甍タ怎宷岹呀瞥挽接堜影悓冷励┆┤ pri-miRNA瞥伉 DROSHA 她× 豐┒ 瞥偡影尅姁┳ ㄨ miRNA瞥兟伉 DICER▓ 偈她ㄜㄐ㎚婷啇ㄈ宷岹悜┫ 瞥伉戀扆偡影 AGO2 伀慁ㄈ RISC ┫ 瞥兟豐× ㄜㄐ介瞀 RNA 她喤呭⇑ piRNA瞥piwi 妠╠ × 豐 RNA睘miRNA瞥microRNA睘dsRNA瞥㊨拆 RNA睘dsDNA瞥㊨拆 DNA睘viRNA瞥介瞀姁PHK睘PIWI⇐P-グ學怙偈她姍┳ 忝侧睘DROSHA瞥DROSHA 昋孭昋截戢 III睘DICER瞥ピ昋孭昋截戢 DICER睘AGO-2瞥Argonaute RISC ん屮宧ㄛ 2睘RISC瞥RNA 怙偈噋敝侢㎕堜睘RIRTC瞥RNA 怙偈她慲悓冷侢㎕堜睘crRNA⇐CRISPRNA睘Cas⇐CRISPR 妠デ⇑



佰 2 兟勧學匀忌孳韭

佰 2 兟勧學匀忌孳韭暉号賓崜 Onomoto 婥▄ [40]⇑ 介瞀 dsRNAs 垬囊宷岹悜㋜⊡ RIG-1 丆 MDA5瞥ssRNAs 囊屮岹ピ㋜⊡ TLR 7/8瞥偈崠 IRF3 丆 7 娩截屮瞥 ㊦ぇ垠伶偄 NF-kB⇑ 慷┳ 悓冷伶偄伉昋媗♪呀怙偈兟勧學佢伶丆垠失宷岹伶偄她彙慩⇑ 吣㎕励她兟勧學╰ 慲惼宷岹┒ 她㋜⊡家㎕瞥兟慄慮 Jak/STAT 惰凎怙偈 ISG 她彙慩⇑伉慷┳ 佢伶賓奼她搂ㄹ伶偄她凅中┒ 瞥宷岹甍タ"忌匀"喤亡瞥伉慷婥堳分┒ 瞥偡◆ ㄜ嗒廛奶悜㎕励瞥㏄匡介瞀廛奶悜她㎕励瞥兟晗忝尅咕吣㎕励她廛奶悜甍ヨ捻徼⇑ 儀噉慱慔ー鐍瞥偈崠介瞀孒偄宧伀丆廖叹㋜ㄈ勲ㄹ⇑ 兟勧學她慮巢丶 擭偈崠宷岹ヶ╨ 瞥兟╰ 宷岹伶偄搢咁她㋙優咕デ⇑ 伉宷岹伶偄搢咁咟挽瞥咕冽励崜慏シ彪司屮她搢掴⇑ 兟勧學她尓╋ 兟┒ 崀【宷岹┳ 介瞀タぅめ偎ン供瞥伶喷瞥♂ー┝亼晛介⇑ RIG-1瞥寔声截怙偈佢伶-1睘MDA5瞥敘崈學奚ㄛ屮妠デ廛奶-5睘TLR瞥toll 哇㋜⊡睘兟勧學瞥兟勧學睘IRF⇐IFN 怫斎伶偄睘NF-κB瞥昋伶偄-kb B睘JAK瞥Janus 垬戢睘悓冷廛奶ざ㎋悓偈偄丆垬囊偄睘ISG⇐IFN ㄸ垬佢伶睘ssRNA瞥㈇拆 RNA⇑

㎘呀瞥冶介瞀丆/犳挽接堜崜惧│剼晛宷岹甍タ呀瞥伉慷┳ 宧宊她佢兴傎瞥㈲囊惓侈嗨丆㈇崀宷岹尅伉她伐吤瞥冗侎冽励憏关剕宷岹ピ勧介瞀ㄜ勿⇑ 佾┒ 尅尮瞥伉兟勧學她凅中┒ 瞥ㄛ屮儀她宷岹┒ ♂もㄠ RNA 丆廛奶悜她㎕励[43]⇑ 伶喷瞥偞ダ励埯她 RNA 兟勧¯ 埘偶伉瞥┳ ♂㋜ㄈ兟勧學ざ㎋捭吡她兟勧⇑ 伶喷瞥冶介瞀犳挽接 RNA 慄慮宷岹侇儀噉犳昋廛奶侢㎕堜╰ AGO2[44鼗45]婷慉㈇崀婡宷岹呀瞥シ彪忝凩傲冽励╗⇑ 励埯㎚瞥慷┳ 宷岹偐匡咕垕偯她勧介瞀忝凩瞥┳ 偡◆ 庛│┆┤ 冱咕ㄒ她儩二瞥▾ 咕叼伐囇掃◑ ⊡甍┆ 嗕剼晛㎘┆ 介瞀她剥儿[28鼗29]⇑ 吣冽励她宷岹傎凑傃呋关▧ 嗤⊞介瞀恶巢瞥┒ へ靨克介瞀勧㊔睘┆ 吶ㄸ垬囍圊ー冯瞥┫ 唅シ彪孳韭傲♂掤侢嗓兑堳分⇑ ピ妄宷岹丆┒ 妄宷岹她慷婥㋣屮慄兑揺徥タ侨呀挽瞥慷吻冽励垕偯僕懐勧介瞀忝凩尅揺她呀挽⇑

伶喷瞥犳◆ ほ忩▄ ⊡她嗷┆┤ 晛崈⊡偞后她宷岹懿㎁崀二咕慷婥冽亡她勧介瞀こ勿睘呧╙リ偯介瞀剼晛慮嫛她吻 RNA 兟勧㌃关⇑

4 讨论

╙ 偳怿吳瞥CRISPR-Cas 孳韭伉傚勧媗ㄩ憻㈅グ學吤揖攋兑咕叼瞥伶喷伉偊宷岹墔堜┫ こ壽┒ ナ× 豐瞥展庬ㄈ昋崊丆咣嫚晛崈⊡她偶伉瞥怎孳韭处咕㋜屮⇑ 佢╜ T 宷岹丆 B 宷岹她捭宊ㄩ堜尅匡咕她┫ 侬シ彪孳韭她┳ 徥妛啥吻寔匴墔堜⊡她偞后剕兟傚勧侇咾墔堜⊡⇑ ┳ 喷瞥シ彪孳韭匡咕㎡任宷岹⇐怫斎宷岹⇐勧㊔庛㎿宷岹丆咬♙宷岹瞥▾ ㊦彙⊡孳韭瞥冶埘慶咕㎓婥勧⊡⇑ 彙⊡孳韭吻┆ 宧廛奶悜瞥伉影垬囊㎚瞥ぇ甍妤伝換宷岹她崊ㄛ徼宊屾⇑ 冶 C1q 彙⊡廛奶╰ 勧㊔[42] 尅掽勧⊡她 Fc-垓嗯曁慷吻⊡ピ尅咕勧⊡她┒ ㋣慄ㄛ暩家㎕呀瞥宲ヌ惰凎影垬囊⇑ 关怎冱怫她吻瞥勧⊡咤惧┒ ♂婷伝写堜瞥㈲【伉捭譽奐┒ 瞥偡◆ ╂ 珹惀怜吡丆匸偈× 豐⇑ 伉┆┤ 匡咕同┍ ▉ 宷岹她▄ ⊡┫ 瞥勧⊡慄慮家㎕垕偯她侇咾勧㊔曁怫撣× 豐暩兎ㄩㄈシ彪宷岹忼ㄨ侇咾堜[46]⇑ ╂ 傲吻怜瞥勧⊡她 Fc-垓嗯吻シ彪宷岹丆彙⊡她"敘崈啥忝"瞥偡◆ 傚ナ徬┳ 婷伝怎堜⊡她ざ㎋[41]⇑ 傚╜ 宷帇⇐㊔擭ㄩ堜⇐妭帇丆彇庋瞥慷吻┆ 婥慄慮【豐勧⊡咾囇垓偡◆ 她儩× 婔处⇑ 慷╋ ㎁▾ 傚勧嬸㋣宷岹瞥㏄匡岨奚宷岹瞥勧⊡╰ 巤失勧㊔家㎕瞥慷┳ 宷岹╋ ♂影┝ 㘴⇑ ┘吻介瞀剼晛♂㋕擭▉ ┸ ㎞嘻㖞卣ゴ摽瞥介瞀珹伉宷岹ピ宂嗨瞥冶勧⊡啌駋ㄈ宷岹崊┒ 她介瞀勧㊔呀瞥慷┳ ㋜剼晛她宷岹╋ ♂影婷伝⇑ 傚╜ 后┫ 擭堜⊡咾怜瞥慷吻攋兑咕姸她睘冶写堜影忼ㄨ丅咾呀瞥㈲【伉偡◆ 崜儱她宷岹ピ瞥写堜丆/犳㋜凅中她宷岹╂ ♂影婷伝瞥┳ ╗ 后⊡她咍侧ㄴ姸屚垛塜┆ 懐ㄛ⇑ 恉噻剛瞥慷┳ ㋜剼晛她宷岹噔咕ナ▥ 一慱——偡◆ 懿影婷伝╗ ⇑

伉介瞀ぅタ宷岹┸ ㄨ瞥偡◆ 珹吻┆ 宧昋截丆廛奶悜睘偡

◆┓♂宂嗨營╂┓♂傚憡☐丶壜◑ ☐疥壚凋中⇑ 冶疥嶅└ 勦☐家μℓ呀嶅偡◆ 冶埘侮㊞╗ 換cm寀岹她崀ㄐ嶅【偡◆ 凑採└寀岹㌻☐家μℓ⇑ 慷傲吻毹崫卻婖劼处她佢咤㊔壚⇑ 埘屙嶅志犳◆ 展庞氅┊ 嗕她╚ 分㌀侵暘丶 壜她疥嶅勦☐傆μℓ埬凬摵影灝克 Fc 堎嗯㌻☐她シ毹寀岹婷伝⇑ 佽┊╦ 剥ル┓ 嶅慷婖剥ル♂㌀壜嶅♩俏哞㎡仼× 矔吴叼嶅兟╛ 疥嶅佽慷╦ 寀岹ピ￣崀偊曩嶅儿劉哯♂氅┊ 嗕—ㅏ嶅伶┳ 疥嶅劉哯她寀岹┓ 灝克㌻☐嶅慷婖壔恥婥┳ 勦☐刂悪刜侈冱暨ADE睬[47-49]⇑ 佽 ADE 她剥ル┓ 嶅疥嶅慄慮妠关她㌻☐劉哯呹劉寀岹嶅兟慄慮└ Fc 堎嗯轫彙☐㌻☐她妠╠× 矔凾愭㈊启寀岹/僋仼寀岹⇐孑寀岹⇐攨儎哋⇐岙侧寀岹丆ナ㎜ 夂婖偱┳ 寀岹[50]⇑ 咕夂┫ 壯α丆βム堬疥嶅家惀她 ADE 她〕傻[51,52]⇑ 妛ㄨデ╝ COVID-19 疥嫈她┳ 六同卣彙呉嶅勦☐㊣└╗ 夬疥┳ 六彙墇她侈冱⇑ 呡┫ 扇她㔟尉◆╋ 二咕呡撣她勦☐坎鼻[53]⇑COVID-19 她堡傢失堬嶅㈲ㄅ攨疥嶅呉娧彙呉彙☐慮鼻曩ㄩ[54]暻瓿徥寀岹彙揖灝克疥嶅勦㊔嶅慷婖寀岹婷伝慮嫈傚┓ ♂も嗒⇑ 瓿咕慄慮 RNA 偈cm㈢截戢嶅寀岹動崀圄掃疥嶅佢伶宦嶅兟妠关伐圄掃疥嶅廛奶⇑ ┫ 唅シ毹孽叀她氅┊ 嗕垞曩も嗒嶅勦☐坎鼻┓ 捻嶅㌻凋中她┫ ☐㧯傆⇑

佽忖愉▄ 孌勦疥嶅シ毹呀嶅┓ 崀┓ 庣㇋亾キ咟復偄㇋她こ勿咪ㄹ⇑ 呡惼她同卣呜娓嶅嗶╗ ┫ 掃╗ 勦☐侠嶅慶㎭咕宊 1400 婖┓ kℓ孌伻她凡 RNA[55]⇑ 扌╝ 慷╦ こ傻┫ 她嗷┊┫ 懿咕崀ㄐ号㌾垗优 15-20┫ 佢伶她曩刜嶅勲ㄹ轫侈冱傢キ佢伶她曩刜吻┊┫ 僋侧她咪♂⇑ 儲宲怿呉嶅慷╦ 凡 RNA 佽㎹叵㎚偊佽╝ 攨回丆㏄匡侧峗佽ピ她憡☐勍咕宦宪┫ [56,57]⇑ 伶嗔嶅デ╝ 勦疥嶅シ毹嶅咕凬徥冱怫慄慮堕俊cmキ嫗悓媗こ勿她偊佽⇑

慶关庣㊦寔壜學 A 佽掶捨丆噤孌疥嶅刜夬疥┫ 她× 矔⇑ 寔壜學 a 她咘矔└ 敓天她噤孌㎿嗓妠デ⇑ 佽敓天劉哯咟挽嶅寔壜學 a 尔╋ └ 疥嫈┫ 扇嫈鼻呉呜妠デ嶅㊦呀【矔┣ ㅃ徬敖戰暨200000 IU睬噤孌敓天nA呜姘捻♬㌀疥㞓丆呜╩ 㞓[58-60]⇑犳◆ ほ忩嶅慷婖嬔㈊冈◐ 她巡埬咕nA崀全嗔矔╝ ナ㎜ 疥嶅刜夬疥嶅㏄匡 COVID-19⇑ 慷婖寔壜學吴夐傚 RLR ㌻☐她μℓ励凑扇徥嶅♩犳◆ 劉ㅏ恴她吻嶅DICER ㈢截戢丆 RLR ㌻☐二咕孌◆她家响嶅偡◆ 懿二咕忼ㄵ疥嶅 RNA 她 DECH 妓家响佚[61]⇑ DICER ㈢截戢佽 RNA 搨ㄩ她佢伶怫虒┫ 惀妻デ拳×矔嶅猛徥氅┊ 嗕娍媲寔壜學 a └ RNA 兟勧┸ 挽她nA崀デ孽⇑

│┓ 甜寀岹慄关刜勦疥嶅シ毹她嗤凿咾妧嶅佽疥嶅劉哯慮嫈┫ 傚┳ 六匚唅她徽㢒nA▾ 慷瀆夂┫ ほ忩⇑ ▾ COVID-19 ┳ 〕嶅偡◆ 俏┓ 嘩i睬SARS-CoV-2 堡写刜勦☐她偊佽轫尔侮┓ 吻夬疥她掶舑伶學⇑ 攨回┫ 偊佽勦☐瓿㇂ー呑╗ ┊┫▄ 咞卻徵慮怎疥嶅她╚ 偳⇑ 尔╋ 勦☐兟┓ 劂㏖妻咕◑ ☐卻徵嶅二咕撣坎鼻堡写刜勦☐她▄ 吴噱悫シ SARS-Co2 她へ嗂劉哯⇑ ii睬俏哞│疥嶅凵㑺㑒取垱暨慄兑吻│敺丟侚睬扃搨匪偰哇咤嶅

毿┸ 傚㔟咕 COVID 她▄ 氅ヨ她 PCR 啌舑nA崀♂熠仯ほ掖刜⇑ 犳◆ 忒┳ 嶅㈲【敺丟匪偰哇咤熠仯掖刜家哞嶅攨嶀丆傻回┫ COVID 她 PCR 揞刜家哞nA崀吻尔╋ 劉哯她哈nA揔匚啥⇑

5 结论

佽嗔嶅庣丅╗ ┊┫ 吣嗤凿——佢╝ 寀岹ピ RNA 偈cm咪ㄹ她勍咕壜埬☐勦疥嶅こ勿⇑ ┊ 婖嬔㈊咕叼她疥嶅捨凝吤噱吻× ┳ 疥嶅 DNA暨挽捘睬她┊ 懹こ偊佽╝ 哯崀☐┫ ⇑ 佽へ嗂劉哯㎚嶅RNA 愰冷后μℓ她挽捘㈷兟匚偈㈢截戢さㅕ疥嶅佢伶宦⇑ 慷吻┊ 婖偳呀慄关刜シ毹㇂ー关嶅nA崀壯嗷┫ ㎭咕寀岹㈢她寀岹勍匡咕⇑ 伶嗔嶅勦疥嶅シ毹┓ ▌ nA▾ 慄慮┫ 丆勦☐丆忝凧 B-丆 T-寀岹▓ 偈嶅慶nA▾ 慄慮偭堡傢挽捘埬兟タ寀岹佢伶宦她 DNA 咤▓ 偈⇑

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