coupled with peptide digests of pulled down proteins and with mass spectrometry to sequence those peptides and identify targets, pull downs can be considered as the protein based equivalent of a yeast two hybrid screen.

To improve the isolation of specific binding partners, pull down methods have been developed involving the use of cross linking, of large scale tissue lysates, and of spin columns. Appropriate methods of sample preparation for mass spectrometry based identification of interacting proteins have been developed as well, including specialized gel staining techniques, band excision, and in gel tryptic digestion. Data interpretation and most commonly encountered problems are, for example, discussed in Current Protocols in Cell Biology, "UNIT 17.5 Protein Protein Interactions Identified by Pull Down Experiments and Mass Spectrometry," Adam Brymora, Valentina A. Valova, and Phillip J. Robinson, Published Online: 1 May 2004 DOI: 10.1002/0471143030.cb1705s22, and included herein by reference.

The invention

Summary

According to a first aspect, there is provided an essentially mammalian positive-sense single stranded RNA virus comprising one or more of the nucleic acid or comprising one or more of the amino acid sequences selected from figure 3 depicting the partial open reading frame of HCoV-SA1, figure 5 file N.rtf depicting the nucleocapsid (N) protein, figure 6 file M.rtf depicting the matrix (M) protein, figure 7 file E.rtf depicting the small envelope € protein, figure 8 file NS3d.5 rtf depicting the non-structural gene NS3d, figure 9 file NS3c.rtf depicting the non-structural gene NS3c, figure 10 file NS3b.rtf depicting the non-structural gene NS3b, figure 11 file NS3a.rtf depicting the non-structural gene NS3a, figure 12, file S.rtf depicting the spike surface glycoprotein (S), figure 13 file Orf1ab.rtf, encoding many enzymatic products among which the replicase, figure 14 file HCoV-SA1.rtf depicting isolate HCoV-SA1 or figure 15 HCoVSA1. rtf depicting its 3 translation frames, or comprising amino acid sequences having at least 90% identical with a nucleic acid or amino acid sequence depicted in said figure 3 or figure 5 to 15.

According to a second aspect, there is provided a nucleic acid, preferably a cDNA, obtainable from a virus as defined herein, said nucleic acid having at least an identity of 75% with a nucleic acid encoding a protein selected from any of the figure 3 or 5 - 15.

According to a third aspect, there is provided a vector comprising a nucleic acid as defined herein.

According to a fourth aspect, there is provided a cell comprising a virus as defined herein, a nucleic acid as defined herein or a vector as defined herein.

According to a fifth aspect, there is provided a protein encoded by a nucleic acid as defined herein.

According to a sixth aspect, there is provided an antigen comprising a protein as defined herein.

According to a seventh aspect, there is provided an antibody specifically directed against an antigen as defined herein.

According to an eighth aspect, there is provided a method for identifying a viral isolate as a MERS-CoV comprising reacting said viral isolate with a nucleic acid as defined herein and/or with an antibody as defined herein.

According to a ninth aspect, there is provided a method for virologically diagnosing a MERS-CoV infection of a mammal comprising determining in a sample of said mammal the presence of a viral isolate by reacting said sample with a nucleic acid as defined herein or an antibody as defined herein.

According to a tenth aspect, there is provided a method for serologically diagnosing a MERS-CoV infection of a mammal comprising determining in a sample of said mammal the presence of an antibody specifically directed against a Betacoronavirus, preferably Lineage C virus or component thereof by reacting said sample with a protein or fragment thereof as defined herein or an antigen as defined herein.

According to an eleventh aspect, there is provided a diagnostic kit for diagnosing a MERS-CoV infection comprising a virus as defined herein, and/or a nucleic acid as defined herein, and/or a protein as defined herein, and/or an antigen as defined herein and/or an antibody as defined herein.

According to a twelfth aspect, there is provided use of a virus as defined herein, and/or a nucleic acid as defined herein, and/or a vector as defined herein, and/or a cell as defined herein, and/or a protein or fragment thereof as defined herein, and/or an antigen as defined herein, and/or or an antibody as defined herein for use in the treatment or prevention of a Betacoronavirus, infection with a MERS-Cov.

According to a thirteenth aspect, there is provided a pharmaceutical composition comprising a virus as defined herein, and/or a nucleic acid as defined herein , and/or a vector as defined herein , and/or a cell as defined herein , and/or a protein or fragment thereof as defined herein , and/or an antigen as defined herein , and/or or an antibody as defined herein .

According to a fourteenth aspect, there is provided a pharmaceutical composition as defined herein for use in the treatment or prevention of a MERS-CoV, infection in a mammal, and/or in the treatment or prevention of atypical pneumonia and/or renal failure caused by such a MERS-CoV infection in a mammal.

According to a fifteenth aspect, there is provided a proteinaceous substance having been provided with a protein as defined herein and additionally comprising an N-terminal dipeptidyl peptidase protein.

According to a sixteenth aspect, there is provided a container provided with a virus as defined herein, and/or a nucleic acid as defined herein, and/or a vector as defined herein, and/or a cell as defined herein, and/or a protein or fragment thereof as defined herein, and/or an antigen as defined herein, and/or an antibody as defined herein and/or a pharmaceutical composition as defined herein and/or a substance as defined herein.

According to a seventeenth aspect, there is provided a method of identifying a candidate modulator as an agent that modulates the function or the binding of a virus to a dipeptidyl peptidase, said method comprising: a. providing a substance as defined herein in the presence and absence of said candidate modulator or said candidate antiviral agent under conditions permitting binding of a virus with a peptidase protein; b. measuring binding of said virus to said protein, wherein a decrease or increase in binding in the presence of said candidate modulator or said antiviral agent, relative to binding in the absence of said candidate modulator, identifies said candidate modulator as an agent that modulates the function of a dipeptidyl peptidaseor identifies

said antiviral agent as an agent that modulates that function of a dipeptidyl peptidase, preferably wherein said virus and/or said protein is detectably labeled, preferably with a moiety selected from the group consisting of a radioisotope, a fluorophore, a quencher of flurescence, an enzyme, and an affinity tag.

Description

The invention provides an isolated essentially mammalian positive-sense single stranded RNA virus classifiable as belonging to the Order: Nidovirales; Family: Coronaviridae; Subfamily: Coronavirinae; Genus: Betacoronavirus; and non-Lineage A, non-Lineage B or non-Lineage D, human betacoronavirus. The invention also provides a human virus (the prefix human stands for the virus classified as capable of infecting humans where a bat virus is capable of infecting bats), preferably isolated or isolatable from humans, having a receptor binding domain (RBD) capable of binding to a dipeptidyl peptidase 4 (DPP4), no such isolates have been deposited or in any other way made available to the art until now. In particular, the invention provides an isolated essentially mammalian positive-sense single stranded RNA virus classifiable as belonging to the Order: Nidovirales; Family: Coronaviridae; Subfamily: Coronavirinae; Genus: Betacoronavirus; Lineage C human betacoronavirus. The invention also provides an isolated essentially mammalian positive-sense single stranded RNA virus classifiable as belonging to the Order: Nidovirales; Family: Coronaviridae; Subfamily: Coronavirinae; Genus: Betacoronavirus; Lineage: C and isolatable from humans, and components thereof. Until now, no Betacoronavirus isolates have been isolated from humans that were then classified as belonging to Lineage: C of Betacoronavirus. In particular, the invention provides a Lineage: C human Betacoronavirus having a receptor binding domain (RBD) capable of binding to a dipeptidyl peptidase 4 (DPP4). In particular, no such isolates have been deposited or in any other way made available to the art until now. In a preferred embodiment, a virus according to the invention is isolated or isolatable from a human. In particular, the invention provides a new previously undescribed Coronavirus isolated from cases of unexplained disease in September 2012 and identified herein as belonging to a newly recognized and previously undescribed species of human Corona Virus (HCoV), herein identified as HCoV-SA1 or HCoV EMC or Middle East Respiratory Syndrome-Coronavirus (MERS-CoV). In particular the specific nucleic acid and/or amino acid sequences of the MERS-CoV genome and sequences encoding (parts of) viral proteins and antigenic polypeptides are provided, as demonstrated by phylogenetic analyses. Further, the invention relates to diagnostic means and methods, prophylactic means and methods and therapeutic means and methods to be employed in the diagnosis, prevention and/or treatment of disease, in particular of respiratory disease, in particular of mammals, more in particular in humans, most in particular specific for MERS-CoV. It particularly also relates to an isolated virus and its receptor. The invention also provides identification of N-terminal dipeptidyl peptidase as virus receptor and uses thereof, identification of the receptor binding domain of MERS-CoV mapping to a 231-residue region 2 in the spike protein that efficiently elicits neutralizing antibodies identification and uses thereof and dipeptidyl peptidase 4 receptor determinants of respiratory MERS-coronavirus infection, and uses thereof. The invention in particular provides specific diagnostics of MERS-CoV, sub-unit compositions of S1-MERS CoV protein

Claims

1. An essentially mammalian positive-sense single stranded RNA virus, comprising one or more of the nucleic acid or comprising one or more of the amino acid sequences selected from figure 3 depicting the partial open reading frame of HCoV-SA1, figure 5 file N.rtf depicting the nucleocapsid (N) protein, figure 6 file M.rtf depicting the matrix (M) protein, figure 7 file E.rtf depicting the small envelope € protein, figure 8 file NS3d.5 rtf depicting the non-structural gene NS3d, figure 9 file NS3c.rtf depicting the non-structural gene NS3c, figure 10 file NS3b.rtf depicting the non-structural gene NS3b, figure 11 file NS3a.rtf depicting the non-structural gene NS3a, figure 12, file S.rtf depicting the spike surface glycoprotein (S), figure 13 file Orf1ab.rtf, encoding many enzymatic products among which the replicase, figure 14 file HCoV-SA1.rtf depicting isolate HCoV-SA1 or figure 15 HCoVSA1. rtf depicting its 3 translation frames, or comprising amino acid sequences having at least 90% identical with a nucleic acid or amino acid sequence depicted in said figure 3 or figure 5 to 15.

2. A virus according to claim 1 isolatable from humans.

3. A virus according to any one of claims 1 to 2 having an amino acid sequence of its conserved replicase domain that is at least 90%, most preferably at least 95% identical with the amino acid sequence of the conserved replicase domain comprising ORF 1ab.

4. A virus according to any of claims 1 to 3 belonging to the Coronaviruses, genus Betacoronavirus and identifiable as phylogenetically corresponding thereto by determining the amino acid sequence of the conserved replicase domain of said virus to have at least 90% identity with the Orf1AB amino acid sequence as depicted in Fig. 13.

5. A nucleic acid, preferably a cDNA, obtainable from a virus according to anyone of claims 1 to 4, said nucleic acid having at least an identity of 90% with a nucleic acid encoding a protein selected from any of the figure 3 or 5 - 15.

6. A vector comprising a nucleic acid according to claim 5.

7. A cell comprising a virus according to anyone of claims 1 to 4, a nucleic acid according to claim 5 or a vector according to claim 6.

8. A protein encoded by a nucleic acid according to claim 5.

9. An antigen comprising a protein according to claim 8.

10. An antibody specifically directed against an antigen according to claim 9.

11. A method for identifying a viral isolate as a MERS-CoV comprising reacting said viral isolate with a nucleic acid according to claim 5 and/or with an antibody according to claim 10.

12. A method for virologically diagnosing a MERS-CoV infection of a mammal comprising determining in a sample of said mammal the presence of a viral isolate by reacting said sample with a nucleic acid according to claim 5 or an antibody according to claim 10.

13. A method for serologically diagnosing a MERS-CoV infection of a mammal comprising determining in a sample of said mammal the presence of an antibody specifically directed against a Betacoronavirus, preferably Lineage C virus or component thereof by reacting said sample with a protein or fragment thereof according to claim 8 or an antigen according to claim 9.

14. A diagnostic kit for diagnosing a MERS-CoV infection comprising a virus according to anyone of claims 1 to 4, and/or a nucleic acid according to claim 5, and/or a protein according to claim 8, and/or an antigen according to claim 9 and/or an antibody according to claim 10.

15. A virus according to any one claims 1 to 4, and/or a nucleic acid according to claim 5, and/or a vector according to claim 6, and/or a cell according to claim 7, and/or a protein or fragment thereof according to claim 8, and/or an antigen according to claim 9 and/or or an antibody according to claim 10 for use in the treatment or prevention of an infection with a MERS-Cov.

16. A pharmaceutical composition comprising a virus according to any one claims 1 to 4, and/or a nucleic acid according to claim 5, and/or a vector according to claim 6, and/or a cell according to claim 7, and/or a protein or fragment thereof according to claim 8, and/or an antigen according to claim 9, and/or or an antibody according to claim 10.

17. A pharmaceutical composition according to claim 16 for use in the treatment or prevention of a MERS-CoV infection in a mammal, and/or in the treatment or prevention of atypical pneumonia and/or renal failure caused by such a MERS-CoV infection in a mammal.

18. A pharmaceutical composition for use according to claim 17, wherein said mammal is a human.

19. A proteinaceous substance, having been provided with a protein according to claim 8 and additionally comprising an N-terminal dipeptidyl peptidase protein.

20. A proteinaceous substance according to claim 19, wherein said substance is crystallized.

21. A proteinaceous substance according to claim 19 or 20, wherein said dipeptidyl peptidase protein is a dipeptidyl peptidase 4 (DPP4).

22. A proteinaceous substance according to any of claims 19 – 21, wherein said proteinaceous molecule comprises an ectodomain of a spike protein.

23. A proteinaceous substance according to claim 22, wherein said ectodomain is derived from the S1 region of a coronavirus.

24. A container provided with a virus according to any one of claims 1 to 4, and/or a nucleic acid according to claim 5, and/or a vector according to claim 6, and/or a cell according to claim 7, and/or a protein or fragment thereof according to claim 8, and/or an antigen according to claim 9, and/or an antibody according to

claim 10, and/or a pharmaceutical composition according to claim 16 or 17, and/or a substance according to any of claims 19 – 23.

25. A method of identifying a candidate modulator or a candidate antiviral agent as an agent that modulates the function of or the binding of a virus to a dipeptidyl peptidase, said method comprising:

a. Providing a substance according to any of claims 19 to 23 in the presence and absence of said candidate modulator or said candidate antiviral agent under conditions permitting binding of a virus with a peptidase protein.

b. Measuring binding of said virus to said protein, wherein a decrease or increase in binding in the presence of said candidate modulator or said antiviral agent, relative to binding in the absence of said candidate modulator, identifies said candidate modulator as an agent that modulates the function of a dipeptidyl peptidase or identifies said antiviral agent as an agent that modulates that function of a dipeptidyl peptidase, preferably wherein said virus and/or said protein is detectably labeled, preferably with a moiety selected from the group consisting of a radioisotope, a fluorophore, a quencher of flurescence, an enzyme, and an affinity tag.