

MONOPARAMUNITY INDUCERS BASED ON ATTENUATED RABBIT
MYXOMA VIRUSES

5 The invention relates to monoparamunity inducers based on paramunizing viruses or viral components, characterized in that the viruses or viral components are derived from an attenuated rabbit myxomavirus strain, to a method for producing the monoparamunity inducers and to the use thereof as medicaments.

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The endogenous immune system of highly developed organisms, especially that of mammals and birds, includes an antigen-specific and an antigen-nonspecific part. Both parts of the immune system are linked
15 together and moreover interact with one another. The antigen-specific mechanisms are responsible for building up immunity, and the antigen-nonspecific are responsible for building up paramunity. Paramunity refers to the state of a well regulated and optimally
20 functioning nonspecific defense system linked to a rapidly developing, time-limited, increased protection from a large number of different pathogens, antigens and other noxae. The basis for the development of
25 the nonselective and conditionally selective paraspecific defense mechanisms which are old from the phylogenetic viewpoint and are called primitive.

The paraspecific activities of the antigen-nonspecific
30 immune system (also: "innate immune system") include nonselective protective elements such as, for example, foreign material-consuming organelles, and conditionally selective protective elements such as, for example, micro- and macrophages, natural killer
35 cells, dendritic cells and soluble factors such as cytokines, which show pathogen-nonspecific or antigen-nonspecific reactions according to their origin.

Paraspecific activities are to be observed in the relevant organism immediately after antigen contact, whereas the effects of the antigen-specific immune system appear only after days or weeks.

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In the more highly organized life forms, time is additionally gained thereby in order to build up specific defense systems against the noxae which it has not yet been possible to eliminate and have antigenic properties.

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The benefits of paramunization i.e. the paraspecific activities of the immune system for prophylaxis and therapy in a patient have become increasingly clear since its development (Anton Mayr, "Paramunisierung: Empirie oder Wissenschaft", Biol. Med. edition 26(6): 256-261, 1997). The paraspecific defenses make it possible for the organism to defend itself immediately on confrontation with a wide variety of foreign materials, infectious pathogens, toxins and transformed endogenous cells.

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There are close interactions between the paraspecific and the specific activities of the immune system, with the flow of information usually proceeding from the initially reacting paraspecific part to the specific part, with a later onset, of the immune system (e.g. with antigen mediation). In the event of infections with particularly virulent pathogens, the paraspecific defenses of the organism are able in this way to cover the time until specific immunity develops (e.g. antibodies, immune cells).

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The paraspecific immune defenses are a physiological process and can be defined as "primary control" in the confrontation with the environment. They are indispensable not only for lower organisms but in particular also for the more highly developed and highly developed vertebrates. Primary congenital

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defects in this biological defense system lead to life-threatening situations. An example which may be mentioned is the "Chediak-Steinbrinck-Higashi syndrome" in humans, which is characterized by granulocyte
5 deficits and dysfunctions of natural killer cells (NK cells) and in most cases leads to the death of the patient by completion of the 10th year of life.

The condition of paramunity is characterized by an
10 increased rate of phagocytosis, an increased function of the spontaneous cell-mediated cytotoxicity (NK cells) and increased activity of other lymphoreticular cells. At the same time there is release of particular cytokines which have stimulating and/or inhibiting
15 effects (e.g. via repressor mechanisms) both with the cellular elements and with one another. This closely linked and stepwise responding biological system of paramunity with its various acceptor, effector and target cells and the signal-transmitting cytokines is
20 moreover thoroughly connected to the hormonal and nervous systems. It thus represents an important constituent of the communication, interaction and regulation network.

25 Paramunity is induced by paramunization. By this is meant the pharmacological activation of the cellular elements of the paraspecific part of the immune system and the production, associated therewith, of cytokines, with the aim of eliminating dysfunctions, rapidly
30 increasing the non-pathogen- and non-antigen-specific protection of an individual (optimal bioregulation), eliminating an immunosuppression or immunodeficiency which has arisen from the consequences of stress or otherwise (e.g. pharmacologically), repairing deficits
35 and/or acting as regulator between the immune, hormonal and nervous systems. This means that certain nonspecific endogenous defense processes can be increased, supplemented or else depressed, depending on the type of paramunization and the responsiveness, such

as, for example, the health status of the patient.

Paramunity inducers are used for the paramunization and must meet certain criteria of harmlessness and efficacy, thus differing from immunostimulants. The paramunity inducer per se is not comparable either to an antibody or to a chemical, an antibiotic, vitamin or hormone. On the contrary, it activates by a stepwise mechanism the paraspecific immune system, so that the latter sufficiently mobilizes cellular and humoral defense mechanisms. The paramunity inducer in this case has both regulating and repairing effects on the immune defenses. Concerning the mode of action of paramunity inducers, it is known that they are taken up by phagocytic cells (acceptor cells) which are thus activated and release mediators which in turn mobilize effector cells. The latter finally switch on the regulatory mechanisms of the paraspecific defenses.

Multiple paramunity inducers based on combinations of two more poxvirus components derived from different poxvirus strains with paramunizing properties are described in European patent EP 0 669 133 B1.

The present invention is based on the paramunizing properties of attenuated myxomaviruses and/or their viral constituents.

Attenuation refers to the modification of the properties of an infectious pathogen which lead to weakening of the pathogen ("attenuate" = weaken, mitigate). Alterations in infectious pathogens frequently occur spontaneously in nature, it being possible for the timespans to extend over many centuries.

The ability of infectious pathogens to change in order to adapt to environmental changes can be utilized experimentally, and the timespan necessary for

attenuation can be drastically shortened for example by long-term passages in certain host systems. Attenuation has been utilized to date to obtain avirulent inoculation strains and harmless paramunity inducers.

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Attenuation normally leads to loss of virulence and contagiousness, reduction in the immunizing properties and the host range, and to small changes in the pathogen genome with the occurrence of deletions, preferably in the terminal regions. There is usually parallel increase in the paramunizing activities of the modified pathogen.

In rare cases, an attenuation may, especially when an experimental attenuation by genetic manipulations is attempted, also lead to an increase in the virulence and contagiousness.

Myxomaviruses are the pathogens of myxomatosis, a contagious systemic viral disease of wild and domestic rabbits which progresses in cycles and is characterized by generalized, in some cases hemorrhagic subcutaneous edemas on the head and over the entire body, with preference for the anal region, the vulva and the tube, unlike any other infectious disease. Introduction of myxomatosis into a country previously free of the disease results in rapid and fatal progression. After the virus has become endemic, the character of the disease changes until the infections are clinically inapparent (Mayr A.: Medizinische Mikrobiologie, Infektions- und Seuchenlehre, 7th edition, Enke-Verlag, Stuttgart, 2002).

The disease is widespread among American cottontail rabbits of the genus *Sylvilagus* which occupy exclusively the New World. These wild rabbits form the only natural reservoir of the disease. The infection takes a mild form in them. By contrast, the disease has an almost 100% mortality in European wild and domestic

rabbits of the genus *Oryctolagus*, which are also naturalized in Australia, when the pathogen is introduced.

5 The natural host range of the myxomavirus (genus *Leporipoxvirus*) has narrow limits. In general, the virus replicates only in American cottontail rabbits and in European domestic and wild rabbits. However, a few infections in European wild hares have also been
10 observed. Attempts at transmission to other species and to humans had negative results.

The present invention is based on the object of providing novel monoparamunity inducers for human
15 medicine and veterinary medicine. A further object of the present invention is to provide a method for producing such monoparamunity inducers. It is additionally an object of the present invention to provide pharmaceutical compositions for use as
20 medicaments based on monoparamunity inducers.

Accordingly, the present invention relates to monoparamunity inducers based on paramunizing viruses or viral components, characterized in that the viruses
25 or viral components are derived from an attenuated rabbit myxomavirus strain. The viral components preferably include paramunizing viral envelopes or aberrant forms of viral envelopes of an attenuated myxomavirus strain. Preferred strains having the
30 paramunizing properties of the invention are the strains M-2, M-7, Lausanne, Aust/Uriarra/Verg-86/1. The strains M-7, Lausanne, Aust/Uriarra/Verg-86/1 are also suitable for producing live vaccines because they have undergone only partial attenuation of their virulence
35 in order to have an adequate immunizing effect.

A monoparamunity inducer based on the myxomavirus strain M-2 is particularly preferred. An attenuated myxomavirus strain produced by the method of the

invention described hereinafter has been deposited at the depository of the Public Health Laboratory Service (PHLS), Centre for Applied Microbiology & Research, European Collection of Animals Cell Cultures (ECACC),
5 Salisbury, Wiltshire, United Kingdom with the deposit number 03121801.

The invention further relates to a method for producing monoparamunity inducers based on an attenuated rabbit
10 myxomavirus strain. For this purpose, initially myxomaviruses are isolated from infected tissue of a rabbit typically suffering from a generalized myxomatosis. The virus is subsequently adapted to a permissive cell system, i.e. to a cell material which
15 permits replication of the virus, such as, for example, cell cultures, incubated chicken eggs or else experimental animals. It is possible in particular to use cells of the natural host or of a species closely related to the host for the adaptation. Examples of
20 suitable permissive cell systems for myxomaviruses are chick embryo fibroblasts (CEF) as well as cell cultures produced from rabbit kidneys or testes.

It is preferred according to the invention to adapt the
25 isolated myxomavirus to the chorioallantoic membrane (CAM) of incubated chicken eggs over one or more passages, preferably over 2 to 6 passages, and particularly preferably over 3 passages. For this adaptation, the isolated viruses are inoculated onto
30 the CAM and replicated by passaging on the CAM.

The myxomaviruses are preferably initially isolated from infected tissue by replication in a permissive cell system. For this purpose it is possible to
35 inoculate a permissive cell system for example with infected tissue homogenate obtained by disruption. Subsequently, the viruses obtained by the initial replication are either adapted further to the same permissive cell system, which was already used for the

isolation, or another, further permissive cell system is used. Adaptation of the virus to the same permissive cell system type which is also used for the isolation is preferred. Thus, preferably myxomaviruses from infected tissue are isolated by replication in a permissive cell system and subsequently adapted to the permissive cell system by further passages. Initial culturing and isolation of the myxomaviruses by replication on the CAM of incubated chicken eggs and subsequent adaptation of the virus on the CAM over further passages, preferably over a further 2 passages, is particularly preferred. However, it is also possible alternatively to use the allantoic fluid of incubated chicken eggs for the culturing and/or adaptation.

The actual attenuation then takes place by long-term passages on one or more permissive cell cultures, until an attenuation or the desired degree of attenuation of the virus is reached. It is possible for this purpose firstly to test various permissive cell systems for replication of the virus and subsequently to select one or more cell systems in which the highest infectious titers are reached for further passages. Both primary and secondary cell cultures as well as permanent and continuous cell lines are suitable for attenuation by long-term passages. Thus, attenuation can take place by replication in primary or secondary chick embryo fibroblast (CEF) cultures or in cultures of permanent CEF cells.

Preferred according to the invention for attenuation of the myxomavirus is to passage or replicate the virus in a permanent cell culture, in particular a Vero cell culture, preferably over 80 to 150 passages and particularly preferably over 120 passages. Alternatively or additionally, the virus is passaged according to the invention on a binary permanent cell line, in which case AVIVER cells are preferably used. These cells or cell culture has been obtained by cell

fusion between chick embryo fibroblasts (CEF) and Vero monkey kidney cells. For the myxomavirus attenuation of the invention, the isolated and adapted viruses are preferably passaged in a first step in Vero cell cultures, the viruses are then transferred into a binary AVIVER cell culture and replicated therein preferably over 10 to 50 passages, in particular over 20 to 30 passages, and particularly preferably over 25 passages.

The attenuated myxomavirus can then be additionally replicated over further attenuation passages. Further replication of the viruses preferably takes place over further passages in Vero monkey kidney cells, in particular over 100 to 200 passages.

A particularly preferred further method step is additional inactivation of the attenuated myxomavirus. Inactivation can take place by chemical treatment, irradiation, the action of heat or pH, in particular by a chemical treatment with beta-propiolactone. Treatment of the attenuated myxomaviruses with beta-propiolactone increases the paraspecific activities further, while the immunizing properties which are still present where appropriate after the attenuation are lost.

A particularly preferred embodiment of the method of the invention includes the following steps:

- isolation of myxomaviruses from the infected tissue of a rabbit suffering typically from generalized myxomatosis by replication on the chorioallantoic membrane (CAM) of incubated chicken eggs and subsequent adaptation of the virus to the CAM over a further 2 passages;

- attenuation of the isolated viruses by passaging in Vero cell cultures, preferably over 120 passages;

- transfer of the viruses into a binary AVIVER cell culture, where the AVIVER cells have been obtained

by cell fusion between chick embryo fibroblasts (CEF) and Vero monkey kidney cells, and attenuation of the virus in this cell culture over 10 to 50, preferably 25, passages,

5 - subsequent transfer of the virus back onto Vero monkey kidney cells and replication of the viruses by further attenuation passages in the Vero cells, preferably over about 150 passages; and optionally

10 - inactivation of the attenuated myxomaviruses by treatment with beta-propiolactone, this treatment increasing the paraspecific activities, while the immunizing properties still present after the attenuation are lost.

15 Attenuation by long-term passaging is usually concluded by 3 to 5 plaque end dilutions. After various clones have been obtained and tested, the clones selected for further replication are those with which the highest
20 infectious titers are achieved and with which a high paramunizing activity - e.g. in the VSV challenge test in the baby mouse - are detected. This procedure is intended to ensure in particular that genetically uniform virus material is provided for further use.

25 The term "attenuation" as used in connection with this invention refers to the experimental modification of the originally virulent myxomavirus into the modified form, with a simultaneous increase in the paramunizing
30 properties. The attenuation is detectable through one or more of the following properties:

- reduction or weakening or loss of virulence for European domestic and wild rabbits (genus *Oryctolagus caniculus csp.*),
- 35 - weakening or loss of contagiousness,
- restriction of the host range in cell cultures,
- alteration of the immunizing properties
- acquisition of paramunizing, short-term protective activities.

An attenuation may lead to deletions in the terminal region of the myxomavirus genome. An increasing degree of attenuation is frequently observed to be associated with an increasing number of deletions in the viral genome.

The degree of attenuation can be checked and monitored during the passages by appropriate suitable activity tests as known in the art (cf., for example, US 6,805,870, column 12, and the further references cited therein) and by cloning.

The present invention further relates to attenuated myxomaviruses obtainable by the method of the invention, pharmaceutical compositions including the attenuated myxomavirus or the myxomavirus monoparamunity inducer of the invention, and to the use of the myxomavirus monoparamunity inducers for activating the paraspecific immune system in a mammal and to the use of the attenuated virus for producing a corresponding medicament.

Because of the surprising paramunizing properties, the myxomavirus monoparamunity inducers of the invention are suitable for the treatment and/or for the prophylaxis of immune system dysfunctions, immunosuppression, immunodeficiency disorders, dysfunctions of homeostasis between the hormonal, circulatory, metabolic and nervous systems, threatened neonatal infection, neoplastic diseases, viral diseases, bacterial diseases, therapy-resistant infectious factor diseases, viral and bacterial mixed infections, chronic manifestations of infectious processes, liver disorders of various etiologies, chronic skin disorders, herpetic diseases, chronic hepatitides, influenzal infections, endotoxin damage.

The monoparamunity inducers of the invention are generally harmless to the environment and effective in

the sense of paramunization for mammals such as, for example, humans, horses, dogs, cats, pigs, for birds and also for reptiles such as, for example, lizards, snakes, chelonians. They are therefore particularly
5 suitable for use in human and veterinary medicine.

In addition, the monoparamunity inducers of the invention display a very good paramunizing activity with high potency. They can be produced by the method
10 of the invention in a suitable manner and are safe for use in the medical sector. The attenuation of the myxomaviruses reduces the immunizing properties of the myxomaviruses while the paraspecific activities increase. The monoparamunity inducers of the invention
15 therefore have paramunizing, but no immunizing, properties, making multiple and continuous use possible. These paramunizing properties of the rabbit myxomavirus and of its paramunizing viral components are surprising and were not predictable.

20 The term "paramunization" as used in connection with this invention refers to the pharmacological activation of the cellular elements of the paraspecific immune system and the production or release, associated
25 therewith, of cytokines with the aim of eliminating dysfunctions, rapidly increasing the non-pathogen- and non-antigen-specific protection of an individual, and having a regulatory effect between the immune, hormonal, nervous and vascular systems. Paramunization
30 leads to the protected state of paramunity.

The term "paramunity" as used in connection with this invention refers to the actively acquired state of an optimally regulated and functioning paraspecific
35 defense system, associated with a rapidly developing, time-limited protection from a large number of pathogens, antigens and other noxae. The phagocytosis rate, the function of the NK cells (natural killer cells) and the activity of other lymphoreticular cells

(e.g. dendritic cells) are raised to the physiological optimum.

- 5 The term "paramunity inducer" as used in connection with this invention refers to a pyrogen-free, nontoxic medicament which is intended to be used in humans and animals to generate and regulate endogenous defense and protective mechanisms in the sense of paramunization.
- 10 The term "myxomavirus monoparamunity inducer" as used in connection with this invention refers to a medicament which is based on attenuated rabbit myxomaviruses or an attenuated myxomavirus strain, including the paramunizing viral components and the
- 15 constituents thereof which produce the state of paramunity in an organism, preferably in a mammal (e.g. human).

20 The term "myxomavirus" as used in connection with this invention refers to the species of the myxomatosis virus of the genus *Leporipoxvirus*. The myxomavirus belongs to the subfamily of *Chordopoxviridae* and to the family of *Poxviridae* (poxviruses).

- 25 The term "paramunizing viral components" as used in connection with this invention includes a large number of viral structures derived from a myxomavirus having paramunizing properties, for example viable or inactivated freshly isolated myxomaviruses, viable or
- 30 inactivated recombinant myxomaviruses derived from freshly isolated myxomaviruses, viral envelopes, the removed envelopes and cleavage products and aberrant forms of these envelopes, individual native or recombinant polypeptides or proteins, in particular
- 35 membrane and surface receptors which occur in freshly isolated myxomaviruses or are recombinantly expressed by a genetically modified myxomavirus or a part of its genetic information.

Tables 1 to 4 summarize the clinical results with the myxomavirus monoparamunity inducer PIND-MYXO based on the attenuated myxomatosis cell culture virus, strain M-2, in humans.

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Table 1 shows the clinical results on prophylactic use of the myxomavirus monoparamunity inducer PIND-MYXO in humans.

10 Table 2 shows the clinical results on therapeutic use of the myxomavirus monoparamunity inducer PIND-MYXO in humans.

15 Table 3 shows the effect of paramunization with myxomavirus monoparamunity inducer (PIND-MYXO) in patients with low immune parameters (7 days after PIND-MYXO administration).

20 Table 4 shows the effect of paramunization with myxomavirus monoparamunity inducer (PIND-MYXO) in patients with elevated immune parameters (7 days after PIND-MYXO administration).

25 The invention is based on the surprising finding that attenuated rabbit myxomaviruses or their paramunizing constituents are able to induce very good paramunizing properties in a recipient organism which lead to the protected state of paramunity. The basis for this invention was the first successful attenuation of
30 rabbit myxomaviruses in cell cultures.

The monoparamunity inducers of the invention are preferably based on lyophilized, attenuated and inactivated rabbit myxomaviruses or their paramunizing
35 viral components. The attenuated myxomaviruses or their viral components of the invention are preferably derived from one myxomavirus strain or a plurality of different attenuated myxomavirus strains. It is preferred in this connection for the monoparamunity

inducers of the invention to include combinations of one or more myxomavirus strains or their paramunizing viral components.

5 The paramunizing properties induced in a mammal such as, for example, in humans through administration of myxomavirus monoparamunity inducer are particularly beneficial for eliminating dysfunctions, for increasing the non-antigen-specific protection of an individual,
10 for eliminating an immunosuppression or immunodeficiency which has arisen from the consequences of stress or in other ways (e.g. pharmacological) and in order to have regulatory effects between the immune, hormonal and vascular systems.

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The invention is further based on successful attenuation of a myxomavirus strain by passaging through cell cultures, with the virulent and/or immunizing properties of the myxomavirus strain being
20 reduced or lost. Additional inactivation of the myxomaviruses can moreover take place by irradiation, the action of heat or pH, or, particularly preferably, by a chemical treatment with beta-propiolactone. The monoparamunity inducers are based on attenuated,
25 lyophilized myxomaviruses, with individual viral components of a myxomavirus which are suitable for inducing paramunizing activities in an organism also being encompassed by the invention.

30 It is intended below to describe one embodiment of the production method of the invention for monoparamunity inducers based on an isolated and attenuated rabbit myxomavirus strain via cell culture passaging. The production method is moreover not restricted to this
35 preferred strain, but can be applied in the same way to other rabbit myxomavirus strains. Also encompassed by the present invention are recombinant forms of a myxomavirus strain which have been produced by genetic modification. Preference is given in this connection to

recombinant myxomavirus strains in which one or more segments in the genome which code for cytokine receptors has been modified by a modification in the form of an addition, substitution or deletion, with the
5 receptor properties of the cytokine receptor being lost through the modification. These are preferably the gene segments which code for the receptors for interferons (IFN), interleukins (IL) and tumor necrosis factors (TFN), in particular for IFN- α -R, IFN γ -R, TNF-R,
10 IL-1-R, IL-2-R, IL-6-R and IL-12-R.

In addition, the numerical values stated herein concerning the incubation time or the number of passages over cell cultures are not intended to be
15 regarded as restrictive. Slight modifications of these parameters and modifications evident to the skilled worker and also leading to a preparation of attenuated myxomaviruses are equally encompassed by this invention.

20 A preferred embodiment of the present invention relates to the successful attenuation of the myxomavirus strain M-2. The myxomavirus strain M-2 was isolated from European wild rabbits suffering from myxomatosis
25 (Herrlich A., Mayr A. and Munz E.: "Die Pocken", 2nd edition, Georg Thieme Verlag, Stuttgart, 1967). The altered skin cells obtained from the subcutaneous tissue of the diseased rabbit are, after disruption, inoculated onto the chorioallantoic membrane (CAM) of
30 chicken eggs which have been incubated preferably for 10-12 days. The myxomaviruses are further replicated and adapted over 2 to 6 passages, preferably over 3 passages, on the chorioallantoic membrane (CAM
35 passages; for method, see Herrlich A., Mayr A. and Munz E.: "Die Pocken", 2nd edition, Georg Thieme Verlag, Stuttgart, 1967). The 2nd to 6th passage, preferably the third CAM passage, serves as starting material for the further attenuation of the myxomavirus in cell cultures. The attenuation takes place after

adaptation of the viruses in the chorioallantoic membrane (evident from typical foci on the chorioallantoic membrane) in 3 stages. In stage 1, 80 to 150, preferably 120, continuous so-called end-dilution passages take place in Vero cells (Vero cells, ATCC CCL-81). The virulence of the myxomavirus which has undergone these passages is weakened.

In a 2nd stage after the 80th to 150th passage, preferably after the 120th passage, in Vero cells, the viral suspension is transferred to so-called AVIVER cells and continued over 10 to 50 passages, preferably over 20 to 30, in particular over 25, passages. AVIVER cells are obtained by cell fusion between chick embryo fibroblasts (CEF) and Vero cells and are referred to as binary permanent cell culture.

The last passage over AVIVER cells, preferably the 25th passage, is transferred back to Vero cells and is continued in the 3rd stage of attenuation for a further 100 to 200 passages, preferably about 157 passages, in Vero cells. In this way, the myxomavirus is replicated over a total of more than 300 cell culture passages. After the 3rd stage of replication of the myxomavirus in cell cultures, the myxomavirus is sufficiently attenuated.

The Vero cell cultures and the AVIVER cells are preferably cultured using a completely synthetic medium, particularly preferably the MEM medium (minimal essential medium) plus 5 to 20%, preferably 10%, BMS (serum substitute medium) and 5 to 20, preferably 10%, lactalbumin hydrolysate. The virus medium used after exchange with the culture medium is preferably MEM medium with 5 to 20%, preferably with 10%, lactalbumin hydrolysate, without BMS or without fetal calf serum and without antibiotics. All the production methods are preferably carried out at pH values of 7.0 to 8.0, preferably at a pH of 7.25. Virus harvests with

titer from $10^{5.0}$ to $10^{7.5}$, preferably of at least $10^{6.5}$ TCID₅₀/ml (TCID₅₀ = 50% tissue culture infectious dose) are preferably suitable as starting material for producing the monoparamunity inducer PIND-MYXO of the invention.

Replication of the myxomavirus in Vero cells leads to a typical cytopathic effect (cpE) which is ultimately characterized by a destruction of the infected cells (lysis). Inoculation with a dose of about 10 MOI (multiplicity of infection) results after a short rounding phase (1-2 days) in reticulated cell structures for about 3 days and in lysis of the cells after about 5 days. The 301st passage in Vero cells had an infectious titer of about $10^{6.5}$ TCID₅₀/ml.

The attenuated myxomavirus is inactivated by a chemical treatment with beta-propiolactone at a concentration of 0.01-1% beta-propiolactone, preferably at a concentration of 0.05% beta-propiolactone. This inactivation leads to a complete loss of the immunizing properties which are still present where appropriate, while the paraspecific activities are not only retained but in fact significantly increase.

For further processing of the attenuated and inactivated myxomaviruses to a myxomavirus monoparamunity inducer (PIND-MYXO), the virus starting material used for the virus inactivation should have a viral titer of about $10^{5.0}$ to $10^{7.0}$, preferably of at least $10^{6.5}$, TCID₅₀/ml.

Purification preferably takes place by centrifugation at low revolutions (e.g. 1000 rpm). After the centrifugation, 0.5-10% succinylated gelatin (e.g. polygeline, e.g. from Hausmann, St Gallen/Switzerland), preferably 5% succinylated gelatin, is added. The resulting mixture can subsequently be lyophilized in 1.5 ml portions in appropriate sterile glass vials or

ampoules and, if required, dissolved in distilled water. A volume of 0.5-2 ml, preferably of 1.0 ml of the lyophilisate dissolved in distilled water corresponds to an inoculation dose for humans on intramuscular administration (see also Mayr A. and Mayr B.: "Von der Empirie zur Wissenschaft", Tierärztl. Umschau, edition 56: 583-587, 2002).

The attenuation can be detected clinically through the loss of virulence for European domestic and wild rabbits (genus *Oryctolagus caniculus csp.*), through a loss of contagiousness, through a virtually complete restriction of the host range in cell cultures and through the alteration in the immunizing properties.

The lyophilized product can be stored at temperatures of, preferably, about +4°C or at lower temperatures, preferably about -60°C, with stability for an unlimited time.

It was demonstrated by gene technology investigations of the prepared attenuated myxomaviruses that multiple deletions had occurred in the myxomavirus genome. In the case of the initial strain M-2, the myxomavirus genome consists of a single linear deoxyribonucleic acid (DNA) with a total length of about 160 kilobases (kb), which codes for several hundred proteins (Herrlich A., Mayr A. and Munz E.: "Die Pocken", 2nd edition, Georg Thieme Verlag, Stuttgart, 1967). The sequences of the terminally located inverted repeats (terminal inverted repeats, TIR) are situated at about 11 kb of the genome segment (McFadden, G. and Graham K.: "Modulation of cytokine networks by pox virus", Virology, edition 5: 421-429, 1994).

Thus, it has been found that the attenuation of the myxomaviruses over continuous Vero cell passages has led to a loss of the coding gene segments for the receptors for interferon α and γ (IFN α , IFN γ), for

tumor necrosis factor (TNF) and for the interleukins (IL) 1, 2, 6 and 12. It is of interest that these cytokines belong to the paraspecific defense factors of the nonspecific immune system. The cytokines are
5 neutralized by binding to the corresponding viral receptors, so that the virus is able to replicate unimpeded. The deletions of gene segments which code for the abovementioned cytokine receptors relate mainly to the terminal regions of the DNA. However, it was
10 additionally possible to detect deletions which occurred during the AVIVER cell passages in the conserved part of the DNA. These deletions relate to two genes which code for an immune epitope and virulence gene. Such genetic modifications are presumably one of the reasons
15 for the decrease in the immunizing, i.e. antigen-specific, activities and the simultaneous increase in the paraspecific activities of the attenuated myxomavirus.

20 The immunizing epitopes and the paraspecific and nonspecific epitopes are in competition. A decrease in the first-mentioned peptides or proteins therefore leads to an increase in the effect of the paraspecific activities. Residues of immunizing and virulence-
25 increasing proteins are eliminated in the preparation of monoparamunity inducers by the method described above for inactivating the attenuated myxomaviruses.

The monoparamunity inducer of the invention, also
30 called PIND-MYXO, is based on the use of attenuated myxomaviruses or the paramunizing constituents thereof and is suitable on the basis of its paramunizing properties for the following prophylactic or therapeutic indications in a patient:

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- infectious factor diseases and mixed infections, chronic manifestations of infectious processes, refractory recurrent infections and chemotherapy-resistant bacterial and viral infections

- weakened defenses and dysregulations in the defense system of an organism

5 - threatened neonatal infection

- adjuvant therapy for certain neoplastic diseases, e.g. prevention of metastasis, reduction of side effects due to chemo- and radiotherapy

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- regulation of homeostasis between the hormonal, circulatory, metabolic and nervous systems.

The paramunity inducers of the invention can be
15 administered parenterally or locally to mammals, including humans, birds and reptiles. Local administration of paramunity inducers specifically stimulates the paraspecific defense mechanisms in the mucous membranes and in the skin. However, there is
20 also a certain systemic effect. By contrast, parenterally applied paramunizations scarcely influence the local defense mechanisms in the skin and mucous membrane, preferably having a systemic effect.

25 Side effects do not occur even with numerous parenteral administrations carried out continuously in humans and animals. The indications for the use of PIND-MYXO are the same for animals and for humans. At the same time, in problem operations, specifically in the management
30 of horses, pigs, dogs and cats, paramunization of neonates immediately on the day of birth and preferably on the first and possibly also the second day after birth is advisable. The single dose is about 0.5 to 5 ml of the dissolved lyophilisate, in horses and pigs
35 the single dose is preferably 2 ml and in dogs and cats is preferably 0.5 ml on parenteral administration. It is advisable according to the invention to administer PIND-MYXO parenterally one day before and/or at the same time as specific protective inoculations in order

to avoid secondary reactions and to assist the immunization on administration of vaccines.

One embodiment of the invention relates to the production of a pharmaceutical composition for local administration to induce paramunity in the skin and mucous membranes. The pharmaceutical composition preferably relates to a buccal or suckable tablet based on constituents of an attenuated and inactivated myxoma cell culture virus. The buccal tablets of the invention are preferably produced with addition of sorbitol, polyethylene glycol 6.00, potassium hydrogenphosphate, Tyrospirol tablet essence, Kollidon 25 and magnesium stearate. PIND-MYXO can, however, also be administered nasally, rectally or vaginally with suitable carriers.

The following examples are preferred embodiments of the invention and serve to explain the subject matter of the invention further.

Example 1

The myxomavirus from the edematous subcutis of a European wild rabbit (genus *Oryctolagus*) suffering in a typical manner from myxomatosis was isolated as starting material for producing the monoparamunity inducer PIND-MYXO of the invention by culturing on the chorioallantoic membrane (CAM) of chicken eggs (Valo eggs) incubated for 10 days and was adapted three times by the method of Herrlich et al. in passages on the CAM (Herrlich A., Mayr A. and Munz E.: "Die Pocken", 2nd edition, Georg Thieme Verlag, Stuttgart, 1967). The third CAM passage was adapted in a 1st stage on Vero cells over 120 passages (ATCC CCL-81, WHO, American Type Culture Collection), replicated in a 2nd stage by 24 intermediate passages in AVIVER cell cultures, and cultured further in the 3rd phase in Vero cells. In total, about 300 passages aimed at attenuation were carried out. After these continuous end-dilution

passages, the originally virulent myxomavirus was attenuated.

The attenuated myxomavirus is replicated in Vero cells.
5 The Vero cell cultures are cultured using a completely synthetic medium consisting of MEM (minimal essential medium) plus 10% BMS (serum substitute medium) and 10% lactalbumin hydrolysate. The virus medium used after exchange with the culture medium is only MEM with 10%
10 lactalbumin hydrolysate without BMS or without fetal calf serum and without antibiotics. All production methods are carried out at pH values above 7.25. Viral harvests with titers above $10^{6.5}$ TCID₅₀/ml serve as starting material for producing the monoparamunity
15 inducer PIND-MYXO of the invention. Inactivation of the viral harvests with 0.05% beta-propiolactone and low-speed centrifugation are followed by addition of 5% of succinylated gelatin (polygeline) to the virus material before lyophilization.

20 The lyophilized product is stable at room temperatures and at temperatures of about 4°C to -80°C and can be kept without time restriction preferably at about 4°C or else about -60°C. A volume of 1 ml of the
25 lyophilisate dissolved in sterile distilled water corresponds to an inoculation dose. Deep intramuscular or local administration takes place (see examples 3, 4 and 5).

30 Example 2

The PIND-MYXO inducer of the invention is administered in an analogous manner to the description in example 1 in dry form (lyophilisate not dissolved) locally onto
35 the mucous membranes of the upper respiratory tract, preferably nasally, three times a day for prophylaxis or therapy (1 ml per application) of multifactorial infections (e.g. influenzal infections).

Example 3

The PIND-MYXO inducer in liquid form produced as in example 1 is in an analogous manner rubbed in cutaneously to improve the perfusion of the skin, to speed up the healing of wounds and to treat varicose veins and chronic venous insufficiency (leg ulcer) in humans. The lyophilisate can for this purpose be taken up for example in greasy cream (e.g. Bepanthen, Linola fat), in which case the pH should be slightly alkaline. This preparation should be prepared fresh for each use. Administration is carried out several times a day by manual rubbing into the undamaged skin. Open wounds can be treated by dropwise application of the freshly dissolved product onto the wound regions. The treatment should take place each day until healed.

Example 4

The monoparamunity inducer PIND-MYXO produced as in example 1 is analogously administered parenterally to prevent secondary reactions and to improve the result of inoculation one day before and simultaneously with a protective inoculation with conventional specific vaccines.

Example 5

The monoparamunity inducer PIND-MYXO produced as in example 1 is processed analogously to buccal or suckable tablets. The production and use of the suckable tablets for local paramunization of the mucous membranes of the ear, nose, throat and mouth is novel and a constituent of the invention. Via the activated mucous membranes of the mouth there is not only a homing effect (migration of defense cells into mucous membranes of other organ systems), but also a partial parenteral paramunization. The following production method has proved suitable for the production of buccal

and suckable tablets:

For the lyophilization, 5% Kollidon 25 (polyvinylpyrrolidone) is added instead of gelatin to the liquid inducer material. Urea, sorbitol, polyethylene glycol 6000 and magnesium stearate are required to produce the finished tablet. A recommended formula for a tablet with a weight of 500.5 mg in weight is:

10	PIND-MYXO lyophilisate	65	mg
	Urea	50	mg
	Sorbitol	267	mg
	Polyethylene glycol 6000	118	mg
	Magnesium stearate	<u>0.5</u>	<u>mg</u>
15	Tablet weight	500.5	mg

The patient should take 4-6 tablets at regular intervals each day to achieve an optimal paramunization.

20

The following formula of a pharmaceutical composition has proved suitable for producing buccal tablets:

25	PIND-MYXO lyophilisate	155	mg
	Sorbitol	360	mg
	Polyethylene glycol 6000	300	mg
	Potassium dihydrogenphosphate (KH_2PO_4), anhydrous	2	mg
	Disodium hydrogenphosphate (Na_2HPO_4), anhydrous	8	mg
30	Tyrospirol essence tablets	0.8	mg
	Magnesium stearate	<u>20</u>	<u>mg</u>
	Tablet weight	805.8	mg

The tablets slowly dissolve in the patient's mouth and can be swallowed after dissolving.

The clinical test results with the monoparamunity inducer of the invention, based on the lyophilisate of

the myxomavirus strain M-2, which are compiled in
tables 1 to 4 demonstrate the very good paramunizing
activities of myxomavirus lyophilisates in humans.
These data are equally applicable to other mammals as
5 well as birds and reptiles.

Table 1:

Clinical results with a monoparamunity inducer from attenuated
myxoma cell culture virus in humans

- prophylactic uses -

(lyophilized inducer 1 OP (1 ml) intramuscular)

Indications	Suitable administration methods
Periods of high infection pressure Stress Travel, examinations and similar stresses before or at the same time as protective inoculations	2 injections before the stress at an interval of 24 hours
Chemotherapy, irradiation (reduction or prevention of secondary reactions) Operations (improvement in wound healing)	1 injection each day or every 2nd day until the treatment is complete or until recovery
Maintenance of optimal defenses and hemodynamics Prophylaxis of cancer and hepatitides Improvement in wellbeing	1-2 injections per month at an interval of 24 hours

Table 2:

Clinical results with a monoparamunity inducer from attenuated
myxoma cell culture virus in humans

5

- therapeutic uses -

(lyophilized inducer 1 OP (1 ml) intramuscular)

Indications	Suitable administration methods
Herpetic diseases (zoster, infectious mononucleosis, Herpes simplex, etc.)	1 injection per day for 3-5 days or until the symptoms disappear; then one injection every 2nd or 3rd day until complete recovery
Chronic hepatitides	a "course" each month: 3 injections at intervals each of 24 hours
Influenzal infections viral and bacterial mixed infections (in combination with antibiotics or chemotherapy)	1 administration per day until the symptoms disappear, then 1 injection every 2nd day until complete recovery
Immunodeficiencies and dysregulation of the defense systems (e.g. during or after chemotherapy)	1. intensive treatment for 5-10 days: 1 injection per day 2. then 2 injections per week at an interval of 24 hours (treatment over a longer period possible)
Endotoxin damage	1 injection a day for 7 days or until recovery

Table 3:

Effect of paramunization with myxoma inducer (PIND-MYXO)
in patients with low immune parameters (7 days after
PIND-MYXO administration)

5

Patient	Patients' data Diagnosis/Therapy	Parameter (normal range)	Day 0	Day 7
A.S. female, 52 years	Immunosuppression	leukocytes (4000-10000/ μ l)	4000	9400
D.B. female, 54 years	Ulcerative colitis cortisone therapy	lymphocytes (900-3000/ μ l) CD4 cells (500-1800/ μ l) CD8 cells (100-1000/ μ l)	620 400 80	1360 920 210
U.S. male, 38 years	Immunological impairment	leukocytes (4000-10000/ μ l)	3800	7400
S.C. male, 43 years	Metastatic prostate carcinoma radiotherapy	leukocytes (4000-10000/ μ l)	3800	9900
B.M. female, 56 years	Susceptibility to infections	cytotoxic cells (30-360/ μ l)	0	248

Table 4:

Affect of paramunization with Myxoma inducer (PIND-MYXO)
in patients with elevated immune parameters (7 days after
PIND-MYXO administration)

5

Patient	Diagnosis/Therapy	Parameter (normal range)	Day 0	Day 7
G.P., female, 59 years	Cervical, breast carcinoma, susceptibility to infections	leukocytes (4000-10000/ μ l)	12600	8600
		granulocytes (2400-6400/ μ l)	8420	5930
C.H. female, 51 years	Psychosomatic syndrome, obesity	leukocytes (4000-10000/ μ l)	12700	6000
		granulocytes (2400-6400/ μ l)	9270	4760

CLAIMS

1. A monoparamunity inducer based on an attenuated myxomavirus or on components thereof.
2. The monoparamunity inducer as claimed in claim 1, characterized in that the attenuated myxomavirus strain has a modification in the form of an addition, substitution or deletion in one or more gene segments coding for the production of cytokine receptors, with the receptor properties of the cytokine receptor being lost through the modification.
3. The monoparamunity inducer as claimed in claim 2, characterized in that the cytokine receptors are selected from the group of receptors for interferons (IFN), interleukins (IL) and tumor necrosis factor (TNF).
4. The monoparamunity inducer as claimed in claim 3, characterized in that the cytokine receptors are selected from the group of receptors for IFN α -R, IFN γ -R, TNF-R, IL-1-R, IL-2-R, IL-6-R and IL-12-R.
5. The monoparamunity inducer as claimed in any of claims 1 to 4, characterized in that the viral components include viral envelopes or aberrant forms of viral envelopes of an attenuated myxomavirus strain.
6. The monoparamunity inducer as claimed in any of claims 1 to 5, characterized in that the myxomavirus strain is selected from the group consisting of M2, M7, Lausanne, Aust/Uriarra/Verg-86/1.
7. The monoparamunity inducer as claimed in claim 6,

characterized in that the myxomavirus strain is the strain M-2 with the deposit number ECACC 03121801.

8. The monoparamunity inducer as claimed in any of claims 1 to 7, characterized in that the myxomavirus strain has been attenuated in cell cultures.

9. The monoparamunity inducer as claimed in claim 8, characterized in that the cell cultures comprise Vero monkey kidney cells and/or AVIVER cells.

10. The monoparamunity inducer as claimed in any of claims 1 to 9, characterized in that the attenuated myxomaviruses have been inactivated.

11. The monoparamunity inducer as claimed in claim 10, characterized in that the attenuated myxomaviruses have been inactivated with beta-propiolactone.

12. The monoparamunity inducer as claimed in claim 11, characterized in that the concentration of beta-propiolactone is 0.01-1%.

13. The monoparamunity inducer as claimed in claim 12, characterized in that the concentration of beta-propiolactone is 0.05%.

14. The monoparamunity inducer as claimed in any of claims 1 to 13, characterized in that the myxomaviruses have been lyophilized.

15. The use of the monoparamunity inducer as claimed in any of claims 1 to 14 for producing a pharmaceutical composition for activating the paraspecific immune system in humans and animals.

16. The use of the monoparamunity inducer as claimed in any of claims 1 to 14 for producing a pharmaceutical

composition for the parenteral treatment and/or for the prophylaxis of dysfunctions of the immune system, immunosuppression, immunodeficiency disorders, dysfunctions of homeostasis between the hormonal, circulatory, metabolic and nervous systems, threatened neonatal infection, neoplastic diseases, viral diseases, bacterial diseases, therapy-resistant infectious factor diseases, viral and bacterial mixed infections, chronic manifestations of infectious processes, liver disorders of various etiologies, chronic skin disorders, herpetic diseases, chronic hepatitides, influenzal infections, endotoxin damage.

17. The use as claimed in any of claims 15 to 16, where the treatment takes place by local administration of the pharmaceutical composition via the skin or mucous membranes of a patient.

18. A pharmaceutical composition including a monopharmunity inducer as claimed in any of claims 1 to 14 and a pharmaceutically acceptable carrier.

19. The pharmaceutical composition as claimed in claim 18, for local or parenteral administration.

20. The pharmaceutical composition as claimed in claim 18, where the composition is in the form of buccal and suckable tablets.

21. A method for producing a monopharmunity inducer based on an attenuated rabbit myxomavirus strain, comprising the steps:

- isolation of myxomaviruses from infected tissue of a rabbit typically suffering from generalized myxomatosis;

- adaptation of the virus to a permissive cell system;

- passaging of the isolated viruses in a Vero and

binary cell culture until attenuation of the virus is achieved.

22. The method as claimed in claim 21, where the isolated viruses are inoculated onto the chorioallantoic membrane (CAM) of incubated chicken eggs for the adaptation.

23. The method as claimed in claim 22, where the virus is replicated over 2 to 6 passages, preferably over 3 passages, on the CAM.

24. The method as claimed in claim 21, where the myxomaviruses present in the infected tissue are isolated by replication in a permissive cell system.

25. The method as claimed in claim 24, characterized in that the virus is isolated by culturing on the chorioallantoic membrane (CAM) of incubated chicken eggs.

26. The method as claimed in claim 25, characterized in that the virus is subsequently adapted to the CAM over further passages, preferably over 2 further passages.

27. The method as claimed in any of claims 21 to 26, characterized in that the attenuation of the myxomaviruses takes place over 80 to 150 passages, preferably over 120 passages, in Vero cell cultures.

28. The method as claimed in any one of claims 21 to 27, characterized in that the virus is passaged in an AVIVER cell culture.

29. The method as claimed in claim 28, characterized in that the passaging takes place over 10 to 50 passages, preferably over 25 passages.

30. The method as claimed in any of claims 21 to 29, where the attenuated myxomaviruses are additionally replicated over further attenuation passages.

31. The method as claimed in claim 30, where the replication takes place in Vero monkey kidney cells.

32. The method as claimed in claim 31, characterized in that the further growth takes place in Vero cells over 100 to 200 passages.

33. The method as claimed in any of claims 30 to 32, characterized in that the viral harvests of the cell culture have an infectious titer of from 10^5 to $10^{7.5}$, preferably of at least $10^{6.5}$, TCID₅₀/ml.

34. The method as claimed in any of claims 21 to 33, where the attenuated myxomaviruses are additionally inactivated.

35. The method as claimed in claim 34, where the attenuated myxomaviruses are treated with beta-propiolactone for the inactivation.

36. The method as claimed in claim 35, characterized in that the concentration of beta-propiolactone is 0.01-1%.

37. The method as claimed in claim 36, characterized in that the concentration of beta-propiolactone is 0.05%.

38. The method as claimed in any of claims 21 to 37, including the steps

- isolation of myxomaviruses from the infected tissue of the rabbit suffering from myxomatosis by replication on the CAM of incubated chicken eggs and

subsequent

- adaptation of the isolated myxomavirus to the CAM over a further 2 passages
- attenuation of the isolated viruses by
 - passaging in Vero cell cultures, preferably over 120 passages,
 - transfer of the viruses into the binary AVIVER cell culture with further attenuation of the virus, preferably over 24 intermediate passages, in this cell culture,
 - subsequent transfer of the virus back onto Vero monkey kidney cells, and
- replication of the attenuated myxomaviruses by further attenuation passages in the Vero cells, preferably over about 150 passages.

39. An attenuated myxomavirus obtainable by the method as claimed in any of claims 21 to 38.

40. The myxomavirus as claimed in claim 39, deposited at the European Collection of Cell Cultures (ECACC) under the deposit number 03121801.

41. The myxomavirus as claimed in claim 39 or 40, characterized in that the myxomavirus is genetically modified.

42. The myxomavirus as claimed in claim 41, characterized in that the myxomavirus have a modification in the form of an addition, substitution or deletion in one or more gene segments coding for the production of cytokine receptors, with the receptor properties of the cytokine receptor being lost through the modification.

43. The myxomavirus as claimed in claim 42, characterized in that the cytokine receptors are

selected from the group of receptors for interferons (IFN), interleukins (IL) and tumor necrosis factor (TNF).

44. The myxomavirus as claimed in claim 43, characterized in that the cytokine receptors are selected from the group of receptors for IFN α -R, IFN γ -R, TNF-R, IL-1-R, IL-2-R, IL-6-R and IL-12-R.

45. An attenuated myxomavirus strain M2 with the deposit number ECACC 03121801.