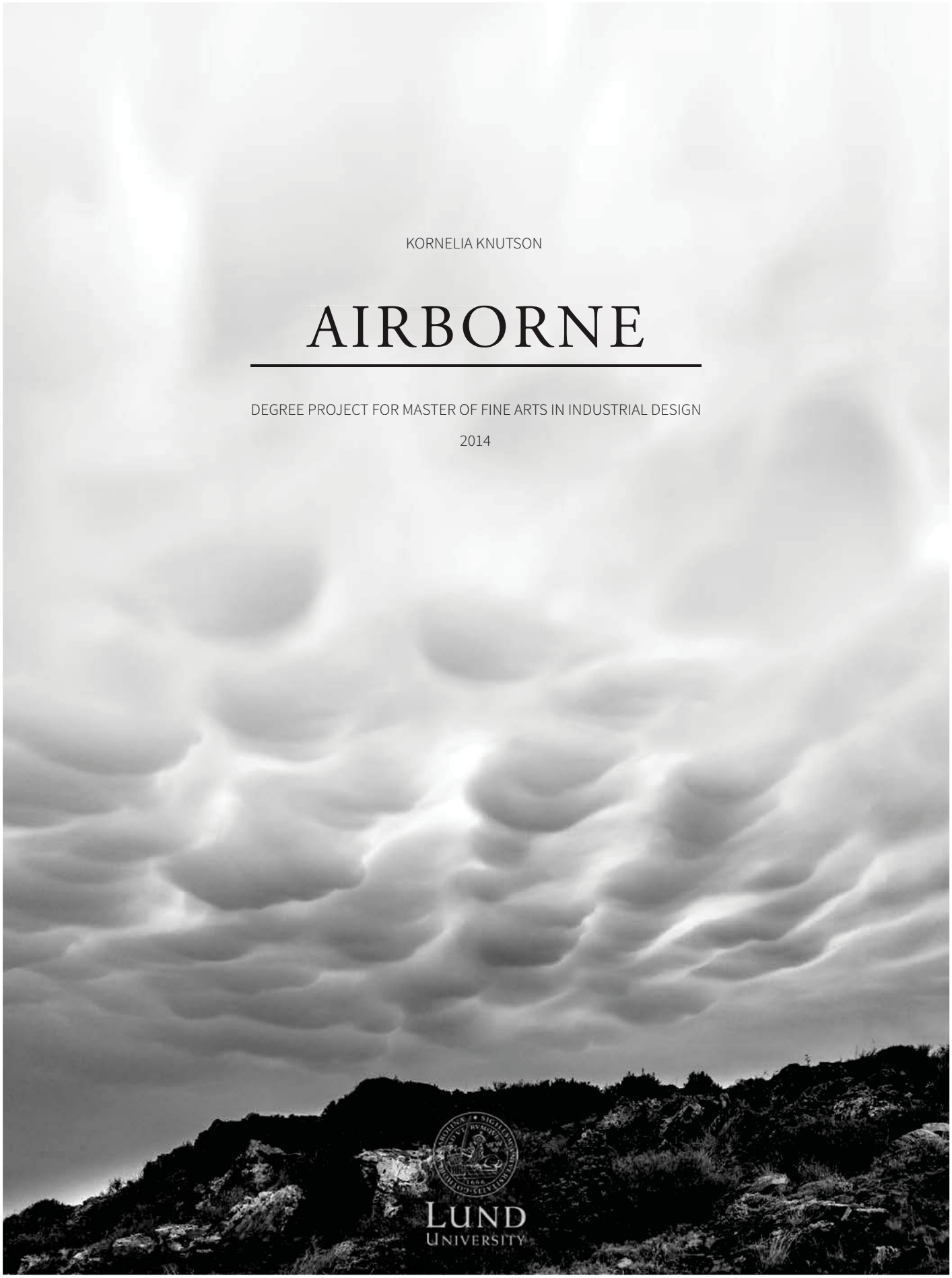
KORNELIA KNUTSON

AIRBORNE

DEGREE PROJECT FOR MASTER OF FINE ARTS IN INDUSTRIAL DESIGN

2014



Degree Project for Master of Fine Arts in Design

Main Field of Study: Industrial Design
Lund University, School of Industrial Design

Supervisor: Professor Claus-Christian Eckhardt
Examiner: Senior Lecturer Andreas Hopf

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Thank you

Claus-Christian Eckhardt
Andreas Hopf
Kaj Knutson
Jonas Bläckberg
Ulf Karlsson
Per Hagstam
Martin Gschwandtl

Airborne

PERSONAL PROTECTION GEAR AGAINST AIRBORNE DISEASES

Abstract

MASTER THESIS

Airborne diseases are spread when droplets containing pathogens, viruses and/or bacteria, are expelled into the air due to coughing, sneezing or talking. These droplets, or aerosols, can remain suspended in the air for quite some time in contained environments. Diseases are also transmitted by close physical contact and by rubbing eyes, mouth and nose after touching a contaminated surface.

Radically increased mobility among humans, our treatment of animals and climate changes have increased the frequency of epidemics and the probability that a novel or mutated virus can spread rapidly. With the help of WHO and a high level of international collaboration and transparency, more alarms of pandemic alerts will be heard.

The research of this topic begun with news articles about current viral events and the bigger picture; pandemics. This was accompanied by a deeper dive into the world of viruses and airborne diseases by the help of scientific articles. Interviews with experts in the field; a Surgeon, Infectious Disease Specialist, Infection Control Practitioner and a Health Care Hygiene Specialist lead to an understanding of why today's respiratory masks are not efficient enough and why we are not relying on physical barriers today. The specialists could provide with more scientific articles on the topic of constraints and threats with respirators and also when and where the risks of transmission occurs. Microorganisms can penetrate through respirator filters, sealing surfaces or other parts of the respirator. Wearing disposable and reusable respirators causes difficulties in breathing and communicating. The chosen strategy was to avoid a health threat rather than curing a symptom. The intended target group is individuals whom due to their profession are exposed to many others while being in a confined space. These people could be a danger to others should they become infectious themselves.

The conceptual respirator was developed firstly by sketching and by making rough prototypes for testing. The final concept can be reused for weeks with disposable filters and a full face piece respirator and it prevents the three ways of transmission. The respirator consists of a lightweight plastic visor which is combined with adhesive and stretchy silicone. The soft and gentle adhesive edges makes the respirator more effective and safe than disposable ones by completely sealing the edges to the face. Adhesive silicone is reattachable and reusable. This also prohibits casual and easy donning and doffing, which is linked to a higher risk of user error and contracting diseases. This new user scenario instead is in need of a mirror and sink and the donning and doffing therefor encourages a ritual of adequate hygiene of both hands and respirator.

The impact of air travel on the spread of infectious diseases has given rise to considerable concern however limited research. During the early phases of a pandemic, strategies that rely on physical barriers will be more prominent and respiratory protection has been largely overlooked. A generally neglected possible portal of entry for viruses is the conjunctiva. Modern research on nanofibrous filtering material is welcomed news, as well as the aim to provide adequate information to the public in time.

Painting The Peaceable Kingdom by Edward Hicks (American, 1780–1849)

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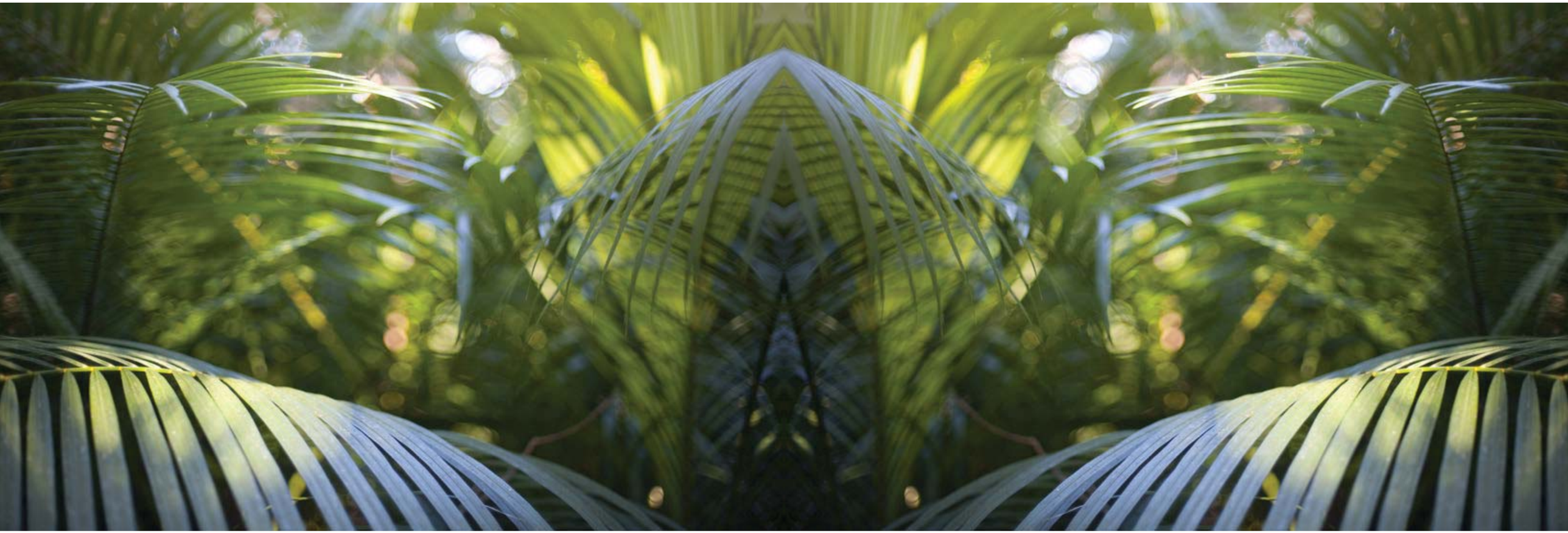


INTRODUCTION

"Up to now, we have been bullet dodging, but right now lurking in the jungle are viruses that, if they crossed over, have the capability to kill hundreds of millions of us," Professor Wolfe says. "And in a world where for the first time in history we can travel from the heart of the jungle to downtown London in little more than 24 hours there is an ever-increasing risk our luck is going to run out. *Hunting for the deadliest prey in the jungle: viruses. The Independent 2014*

Project Background

SHORT DOMESTIC FLIGHTS

During the first months of the year 2013, I would find myself on a flight on a monthly basis. Almost every trip ended up with the common cold. Not life threatening by any means, just exhausting and the risk of sharing this cold in a workplace. The same workplace I would get sick in when coworkers got back from their business trips. All thanks to the fact that in a flight one shares the breath with 100 other people and at work with the help of the air-con system. It made me uneasy to reflect on how vulnerable our own infrastructures are. Also, how I with possibly not the most impeccable immune system felt an urge to protect myself without signaling sickness and mayhem to others.

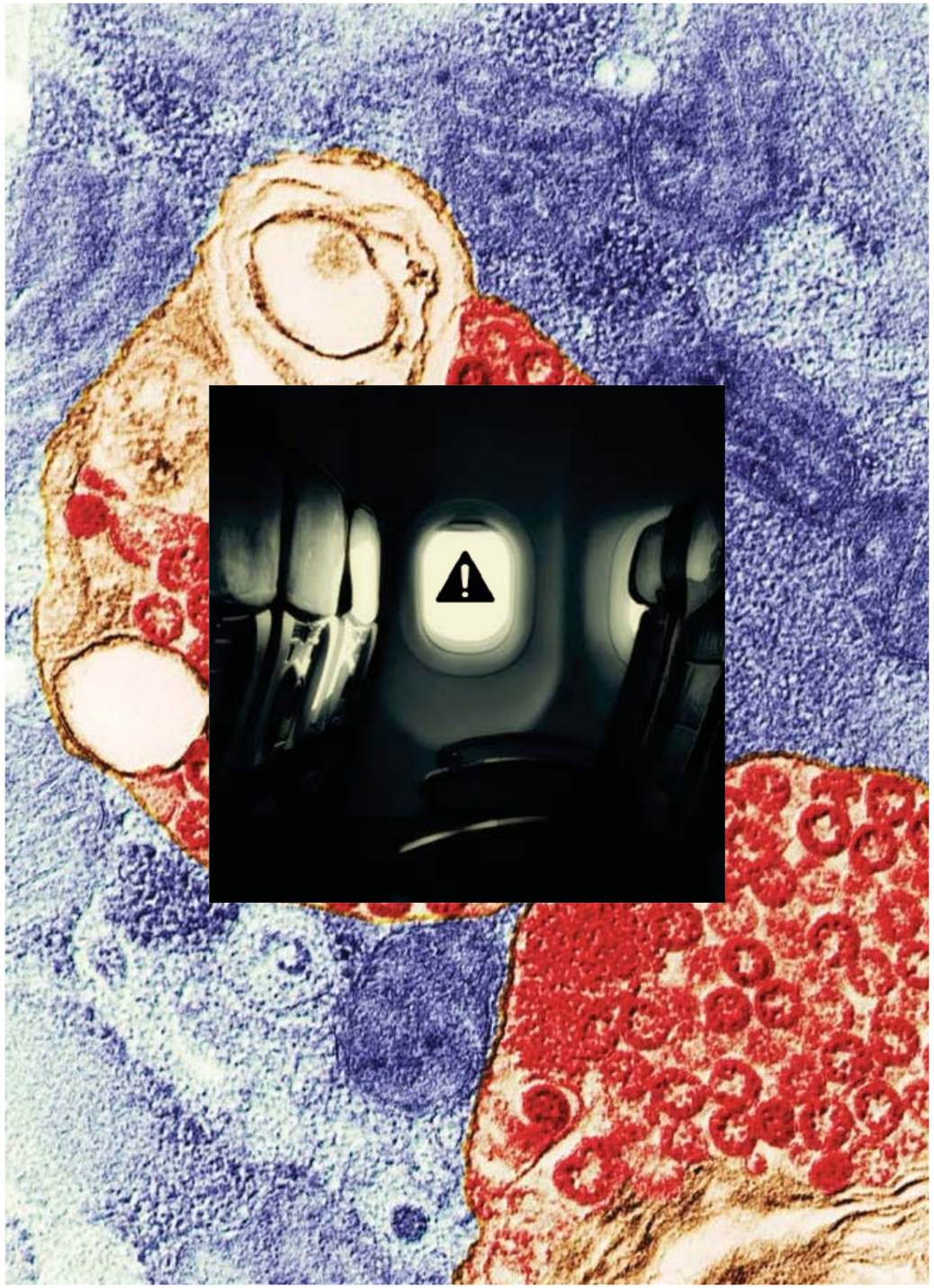
Later in the same year, some headlines that never made the front page, but caught my attention were mostly regarding a new coronavirus (MERS) with cases in Saudi Arabia and France and with some connection to larger airports. Other headlines regarded a mutant Influenza A virus which was causing the first cases of human to human transmission with H7N9.

All these factors made me initially interested in working with a product in the setting where the worst has happened, but where people still have to carry on and go to work.

Any strategy to cope with a pandemic must be based on the knowledge and tools that are available at the time epidemics may occurs. Experts are agreeing that we are long overdue. In the near term, when we could lack an adequate supply of vaccine and antiviral medication, strategies that rely on social distancing and physical barriers will be relatively more important as a means to prevent the spread of disease. The use of respirators is one key part of a larger strategy to establish barriers and increase distance between infected and uninfected individuals. Respirators and facemasks may have a role in both clinical care and community settings. [1]

How do you protect yourself against an airborne disease, when there is no vaccine or cure for it?

1. *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu. National Research Council*, Washington, DC: The National Academies Press,



Initial Brief

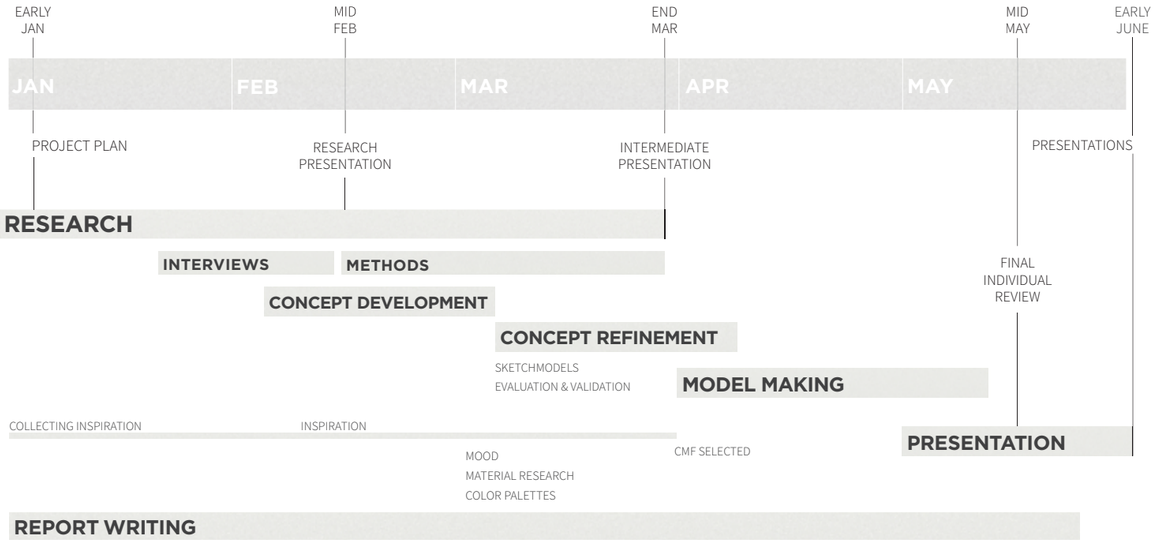
How do you protect yourself against an invisble threat in in a community setting?

This personal protection gear will be a wearable, reusable device and protect you against airborne diseases by blocking their most most common way of transmission.

Demarcations

// Human-to-human transmittable and airborne viruses and bacteria.
// Protection for the most common and probable way of transmission.
// Human centered and wearable, rather than looking at infrastructures.
// A focus on the user's behavior, experiences, reactions, comfort, acceptance and emotions towards the objects as much as on any technical innovations.
// Made of materials and technologies existing today.

Timeplan



The Rubber Duck knows no frontiers, it doesn't discriminate people and doesn't have a political connotation. The friendly, floating Rubber Duck has healing properties: it can relieve mondial tensions as well as define them. Rubber Duck by Florentijn Hofman, Hong Kong 2013.

RESEARCH

Bat-borne viruses are transmitted via bat bite and transferred via saliva, as well as aerosolization of salvia, feces, and/or urine. Like rabies virus, newly emerging bat-borne viruses can be transmitted to humans directly by bats. These include Ebola virus, SARS, and the Middle East respiratory syndrome coronavirus. *Bat-Borne Virus. Wikipedia 2014*

The History of Pandemics

7th century BC – 1963

10,000 BC – 1979

1340 – 1771

430BC – TODAY

TYPHUS
4M

1817 – TODAY

COLERA
3M

541 – 750

PLAGUE OF
JUSTINIAN
25M

1968 – 1969

HONG KONG FLU
1M

1918 – 1919

?

1855

THIRD PANDEMIC
12M

1981–TODAY

Facts collected from the visual work by GOOD and Column Five Media. Their sources: Mayo Clinic // Centers for Disease Control and Prevention // World Health Organization // New York Times // National Center for Biotechnology Information

Image credit: Erno-Erik Raitanen, Instagerms: See a photographer's strangely beautiful portraits of his own bacteria, fastcocreate.com, 2013.

Mapping of Viruses

CRIMEAN-CONGO VIRUS

Causes Crimean-Congo hemorrhagic fever (CCHF) and is a widespread tick-borne viral disease, a zoonosis of domestic animals and wild animals, that may affect humans. The pathogenic virus, is especially common in East and West Africa. Clinical disease is rare in infected mammals, but commonly severe in infected humans, with a 30% mortality rate. Outbreaks of illness are usually attributable to handling infected animals or people.

RIFT VALLEY VIRUS

Rift Valley fever (RVF) is a viral zoonosis (affects primarily domestic livestock, but can be passed to humans) causing fever. The virus is transmitted through mosquito vectors, as well as through contact with the tissue of infected animals. About 1% of human sufferers die of the disease.

ZAIRE EBOLA VIRUS

The ebola virus causes the disease Ebola hemorrhagic fever (Ebola HF) which is a severe, often-fatal disease in humans and nonhuman primates that has appeared sporadically since its initial recognition in 1976. The incubation period for Ebola HF ranges from 2 to 21 days. Infections with Ebola virus are acute. People can be exposed to Ebola virus from direct contact with bodily fluids of an infected person.

FILOVIRIDAE

PHLEBOVIRUS

EBOLAVIRUS

MARBURGVIRUS

NAIROVIRUS

MARBURG MARBURGVIRUS

Causes Marburg hemorrhagic fever (Marburg HF) and is a rare, severe type of hemorrhagic fever which affects both humans and non-human primates. Marburg virus was first recognized in 1967, when outbreaks of hemorrhagic fever occurred simultaneously in laboratories in Marburg and Frankfurt and in Belgrade. Marburg HF typically appears in sporadic outbreaks throughout Africa until today. The clinical symptoms are indistinguishable from Ebola virus disease. The case-fatality rate for Marburg hemorrhagic fever is between 23 and 90 percent.

HANTAAN VIRUS

Human infections of hantaviruses have almost entirely been linked to human contact with rodent excrement, but recent human-to-human transmission has been reported with the Andes virus in South America. Some strains of hantaviruses cause potentially fatal diseases in humans, such as Hantavirus hemorrhagic fever with renal syndrome (HFRS) and hantavirus pulmonary syndrome (HPS). HFRS has a mortality rate of 1 to 15 percent, while HPS is at 38%. The U.S. saw its most recent outbreak of hantavirus—of the HPS variety—at Yosemite National Park in late 2012.

HANTAVIRUS

BUNYAVIRIDAE

SARS-CoV

Severe acute respiratory syndrome (SARS) is a viral respiratory disease of caused by the SARS coronavirus (SARS-CoV).

SARS was first reported in Asia in February 2003. The illness spread to more than two dozen countries in North America, South America, Europe, and Asia before the SARS global outbreak of 2003 was contained.

MERS-CoV

Middle East Respiratory Syndrome (MERS) is viral respiratory illness first reported in Saudi Arabia in 2012. It is caused by a coronavirus called MERS-CoV. Most people who have been confirmed to have MERS-CoV infection developed severe acute respiratory illness. They had fever, cough, and shortness of breath. About half of these people died.

CORONAVIRIDAE

BETACORONAVIRUS

Information from // Centers for Disease Control and Prevention // World Health Organization // Wikipedia

NIPAH VIRUS

Nipah virus (NiV) infection is a newly emerging zoonosis that causes severe disease in both animals and humans. The natural host of the virus are fruit bats with pigs as intermediate hosts. Eight outbreaks of Nipah virus have occurred since 1998. NiV infection in humans has a range of clinical presentations, from asymptomatic infection to acute respiratory syndrome and fatal encephalitis. Several Bangladesh Nipah outbreaks resulted from person-to-person transmission. Respiratory secretions appear to be particularly important for transmission of NiV direct contact with the body fluids of an infected person.

HENDRA VIRUS

Hendra virus (HeV) infection is a rare emerging zoonosis that causes severe disease in both infected horses and humans. Person-to-person transmission has not been seen.

HENIPAVIRUS

PARAMYXOVIRIDAE

MEASLES VIRUS

Causes Measles which is an infection of the respiratory system. Measles is spread through respiration (contact with fluids from an infected person's nose and mouth, either directly or through aerosol transmission), and is highly contagious—90% of people without immunity sharing living space with an infected person will catch it. Measles is one of the leading causes of death among young children even though a safe and cost-effective vaccine is available. Measles is still common in many developing countries – particularly in parts of Africa and Asia. More than 20 million people are affected by measles each year.

MORBILLIVIRUS

ALPHAVIRUS

EASTERN EQUINE ENCEPHALITIS VIRUS

Eastern equine encephalitis virus (EEEV) is transmitted to humans by the bite of an infected mosquito. Eastern equine encephalitis (EEE) is a rare illness in humans, and only a few cases are reported in the United States each year. Severe cases of EEE causes encephalitis, an inflammation of the brain. EEE is one of the most severe mosquito-transmitted diseases in the United States with approximately 33% mortality and significant brain damage in most survivors.

TOGAVIRIDAE

FLAVIVIRIDAE

FLAVIVIRUS

KYASANUR FOREST DISEASE VIRUS

Kyasanur forest disease (KFD) is a tick-borne viral hemorrhagic fever endemic to South Asia. The disease has a morbidity rate of 2–10%, and affects 100–500 people annually. The symptoms of the disease include a high fever with frontal headaches, followed by hemorrhagic symptoms, such as bleeding from the nasal cavity, throat, and gums, as well as gastrointestinal bleeding.

OMSK HEMORRHAGIC FEVER VIRUS

Causes a viral Hemorrhagic Fever. The main hosts of OHFV are rodents like the non-native muskrat. OHFV originates in ticks, who then transmit it to rodents by biting them. The virus survives in water and is transferred to humans via contaminated water or an infected tick. Humans can also become infected through contact with blood, feces or urine of a sick rodent (e.g. muskrat). The virus can also spread through milk from infected goats or sheep. The infection is highly contagious and its rating of fatality is 0.5–3%.

DENGUE FEVER VIRUS

Causes Dengue fever, also known as breakbone fever, is an infectious tropical disease. In a small proportion of cases the disease develops into the life-threatening dengue hemorrhagic fever. Dengue is transmitted by several species of mosquito. 50–100 million people infected yearly. Dengue has become a global problem since the Second World War and is endemic in more than 110 countries. Apart from eliminating the mosquitoes, work is ongoing on a vaccine, as well as medication targeted directly at the virus. Human-to-human modes of transmission have also been reported, but are very unusual.

YELLOW FEVER VIRUS

Causes Yellow fever and is an acute viral hemorrhagic disease. The virus is transmitted by the bite of female mosquitoes and the only known hosts of the virus are primates and several species of mosquito. Since the 17th century, several major epidemics of the disease have been recorded in the Americas, Africa, and Europe. In the 19th century, yellow fever was deemed one of the most dangerous infectious diseases. The virus does not transmit from human-to-human. A safe and effective vaccine against yellow fever has existed since the middle of the 20th century, and some countries require vaccinations for travelers.

WEST NILE VIRUS

West Nile virus can cause flu-like symptoms or neurological disease. It is a mosquito-borne zoonotic virus with birds as the prime reservoir host. Prior to the mid-1990s, WNV disease occurred only sporadically and was considered a minor risk for humans, until an outbreak in Algeria in 1994, with cases of WNV-caused encephalitis, and the first large outbreak in Romania in 1996, with a high number of cases with neuroinvasive disease. WNV has now spread globally. Direct human-to-human transmission initially was believed to be caused only by occupational exposure, or conjunctive exposure to infected blood.

Information from // Centers for Disease Control and Prevention // World Health Organization // Wikipedia

H1N1

In June 2009, the World Health Organization declared the new strain of swine-origin H1N1 as a pandemic. This novel virus spread worldwide and had caused about 17,000 deaths by the start of 2010. On August 10, 2010, the World Health Organization declared the H1N1 influenza pandemic over. In May 2013 seventeen people died during an H1N1 outbreak in Venezuela, and a further 250 were infected. As of early January 2014, Texas health officials have confirmed at least thirty-three H1N1 deaths and wide-spread outbreak during the 2013/2014 flu season

H5N1

Although highly pathogenic avian influenza (HPAI) A (H5N1) virus infection of humans is rare, sporadic cases of human infection have been reported. HPAI H5N1 virus can infect the respiratory tract of humans. When people develop illness from HPAI H5N1 virus infection, severe respiratory illness (e.g. pneumonia and respiratory failure) and death may occur. H5N1 infections in humans are generally caused by bird to human transmission of the virus. Currently, H5N1 virus does not transmit efficiently from person to person. Some cases of limited, non-sustained human-to-human transmission have likely occurred. More than 600 cases have been reported in 15 countries and approximately 60% died.

H17N10

Bat influenza virus H17N10 represents a distinct lineage of influenza A viruses. Despite its divergence from known influenza A viruses, the bat virus is compatible for genetic exchange with human influenza viruses in human cells, suggesting the potential capability for reassortment and contributions to new pandemic or panzootic influenza A viruses.

H7N9

Human infections with a new avian influenza A (H7N9) virus were first reported in China in March 2013.

While some mild illnesses in human H7N9 cases have been seen, most patients have had severe respiratory illness, with about one-third resulting in death.

H10N8

H10N8 has been detected in a single patient with severe pneumonia. This is the first ever report of H10N8 isolated from a patient. Although China has previously detected H10N8 in wild and domestic birds, now the first ever report of H10N8 isolated from a patient has occurd. Given the potentially unpredictable behaviour of influenza viruses, vigilance and close monitoring is needed.

INFLUENZA A VIRUS

ORTHOMYXOVIRIDAE

H9N2

An avian influenza subtype. Human infection with avian influenza A(H9N2) virus was initially identified in Hong Kong and China in 1999 and has caused repeated human infections since then.

ARENAVIRIDAE

ARENAVIRUS

CHAPAREVIRUS

Chapare virus causes hemorrhagic fever. The only known outbreak of Chapare virus infection occurred in a village in Bolivia, 2003. A small number of people were infected, one died. The transmission vector is suspected to be a rodent.

LUJO VIRUS

Causes a viral hemorrhagic fever and there has been one outbreak in a hospital in Johannesburg in 2008 where 4 of 5 identified cases resulted in death. Since 2012 has been classed as a “Select Agent” under U.S. law. The virus derives from rodents but can transmit from human-to-human as a result of direct contact with the body fluids of an infected person.

SABIA VIRUS

Causes Brazilian hemorrhagic fever and is is highly infectious and lethal. The Sabiá virus can be acquired through inhalation, ingestion, the eyes, and contact with urine, saliva, blood, or feces of rodents. The Sabiá virus is a Biosafety Level 4 pathogen, the highest level.

LASSA VIRUS

Lassa fever is an acute viral illness that occurs in West Africa where the disease is endemic (constantly present) with occasional epidemics, during which the case-fatality rate can reach 50%. The annual death toll is about 5000 people. Lassa fever may also spread through human-to-human contact and occurs when a person comes into contact with virus in the blood, tissue, secretions, or excretions of infected individual but also directly from rodents in many ways. About 1% of infections with Lassa virus result in death and about 95% of which die in the uterus of infected pregnant mothers.

MACHUPO VIRUS

Bolivian hemorrhagic fever (BHF), also known as black typhus or Ordog Fever. The mortality rate is estimated at 5 to 30 percent. Due to its pathogenicity, Machupo virus is Biosafety Level 4, the highest level. Evidence of human-to-human transmission of BHF exists but is believed to be rare. Machupo virus is primarily spread through the aerosol transmission of dust particles from the urine, saliva, or feces of infected rodents.

JUNIN VIRUS

Junin virus causes Argentine hemorrhagic fever (AHF) and has a mortality rate of between 20 and 30%. Direct rodent to human transmission occurs via ingestion of contaminated food or water, inhalation of particles within urine or via direct contact of broken skin with rodent excrement. Transmission from human-to-human is rare.

Information from // Centers for Disease Control and Prevention // World Health Organization // Wikipedia

HEPATITIS B VIRUS

Causes Hepatitis B is an infectious illness of the liver. About a third of the world population has been infected at one point in their lives, including 350 million who are chronic carriers. The virus is transmitted by exposure to infectious blood or body fluids such as semen and vaginal fluids, while viral DNA has been detected in the saliva, tears, and urine of chronic carriers. Perinatal infection is a major route of infection in endemic (mainly developing) countries.

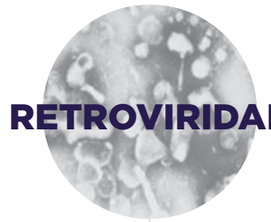
HEPATITIS C VIRUS

Causes Hepatitis C which is an infectious disease affecting primarily the liver. Hepatitis C is the leading reason for liver transplantation, though the virus usually recurs after transplantation. 5% can die from liver cancer or cirrhosis. No vaccine against hepatitis C is available. Hepatitis C is spread through blood contact with another person. Infection can come through sharing drug-injecting equipment, blood transfusions or organ transplants, body piercings and tattoos, or dental exposure.

HEPACIVIRUS

ORTHOHEPADNAVIRUS

HEPADNAVIRIDAE



RETROVIRIDAE

POXVIRIDAE

LENTIVIRUS

HUMAN IMMUNODEFICIENCY VIRUS

Causes the acquired immunodeficiency syndrome (AIDS), a condition in humans in which progressive failure of the immune system allows life-threatening opportunistic infections and cancers to thrive. HIV has claimed the lives of more than 25 million people since 1981. Global deaths per year: 3.1 million. Infection with HIV occurs by the transfer of blood, semen, vaginal fluid, pre-ejaculate, or breast milk. Within these bodily fluids, HIV is present as both free virus particles and virus within infected immune cells.

ORTHOPOXVIRUS

VARIOLA VIRUS

Caused Smallpox (V. Major) which was an infectious disease and had an overall mortality rate of 30–35%. Variola major was the severe and most common form, with a more extensive rash and higher fever. There were never any treatment, but after vaccination campaigns throughout the 19th and 20th centuries, the WHO certified the eradication of smallpox in 1979.

Transmission occurs through inhalation of airborne variola virus, usually droplets expressed from the oral, nasal, or pharyngeal mucosa of an infected person. It is transmitted from one person to another primarily through prolonged face-to-face contact with an infected person, usually within a distance of 6 feet (1.8 m), but can also be spread through direct contact with infected bodily fluids or contaminated objects (fomites) such as bedding or clothing.

COWPOX VIRUS

Cowpox is a skin disease caused by a virus known as the cowpox virus. The pox is related to the vaccinia virus and got its name from the distribution of the disease when dairymaids touched the udders of infected cows. It is transmitted by touch from infected animals to humans. Cowpox is similar to Smallpox but much milder.

RHABDOVIRIDAE

LYSSAVIRUS

RABIES VIRUS

The rabies virus is a neurotropic virus that causes fatal disease in human and animals. Causes Rabies which is a viral disease that causes acute encephalitis in warm-blooded animals. The disease is zoonotic, meaning it can be transmitted to humans from another species, commonly by a bite from an infected animal. For a human, rabies is almost invariably fatal if postexposure prophylaxis is not administered prior to the onset of severe symptoms. The rabies virus infects the central nervous system, ultimately causing disease in the brain and death. Ca 60.000 people die of rabies every year, mostly in Asia and Africa.

MONKEYPOX VIRUS

In humans, monkeypox is similar to smallpox, although it is often milder. Monkeypox is usually transmitted to humans from rodents, pets, and primates through contact with the animal’s blood or through a bite.

ROTAVIRUS

ROTAVIRUS A,B,C,D,E

Rotavirus is the most common cause of severe diarrhoea. According to the WHO, this merciless virus causes the deaths of more than half a million children every year. In fact, by the age of five, virtually every child on the planet has been infected with the virus at least once. Rotavirus infection usually occurs through ingestion of contaminated stool. Because the virus is able to live a long time outside the host, transmission can occur through ingestion of contaminated food or water, or by coming into direct contact with contaminated surfaces, and then putting hands in the mouth.

Information from // Centers for Disease Control and Prevention // World Health Organization // Wikipedia

More Airborne Diseases

BACTERIA TOO!

STREPTOCOCCACEAE

STREPTOCOCCUS

S. PYOGENES - TOXIN

Scarlet fever is an infectious disease which most commonly affects 4–8-year-old children. Symptoms include sore throat, fever and a characteristic red rash. Scarlet fever is usually spread by inhalation. There is no vaccine, but the disease is effectively treated with antibiotics. Most of the clinical features are caused by erythrogenic toxin, a substance produced by the bacterium Streptococcus pyogenes An erythrogenic toxin is a toxin produced by strains of Streptococcus pyogenes. Scarlet fever is usually spread by the aerosol route (inhalation) but may also be spread by skin contact or by fomites.

S. PNEUMONIAE

A significant human pathogenic bacterium, S. pneumoniae was recognized as a major cause of pneumonia in the late 19th century, and is the subject of many humoral immunity studies. S. pneumoniae resides asymptomatically in the nasopharynx of healthy carriers. However, in susceptible individuals, such as elderly and immunocompromised people and children, the bacterium may become pathogenic, spread to other locations and cause disease.

ENTEROBACTERIACEAE

Y. PESTIS

PNEUMONIC PLAGUE

Pneumonic plague, a severe type of lung infection, is one of three main forms of plague, all of which are caused by the bacterium Yersinia pestis. It is more virulent and rare than bubonic plague. Primary pneumonic plague results from inhalation of fine infective droplets and can be transmitted from human to human without involvement of fleas or animals. Untreated pneumonic plague has a very high fatality rate.

CHLAMYDIACEAE

CHLAMYDOPHILA

C. PNEUMONIAE

Chlamydophila pneumoniae is an intracellular bacterium that infects humans and is a major cause of pneumonia. It was known as the Taiwan acute respiratory agent (TWAR). The EB travels from an infected person to the lungs of an uninfected person in small droplets and is responsible for infection. This atypical bacterium commonly causes pharyngitis, bronchitis and atypical pneumonia, mainly in elderly and debilitated patients, but in healthy adults, also.

HERPESVIRIDAE

VARICELLOVIRUS

HUMAN HERPESVIRUS 3

Also known as Varicella zoster virus. It commonly causes chickenpox. VZV remains dormant in the nervous system of the infected person. In about 10–20% of cases, VZV reactivates later in life producing a disease known as shingles or herpes zoster. Airborne transmissions and is highly contagious.

LYMPHOCRYPTOVIRUS

HUMAN HERPESVIRUS 4

Also known as the Epstein–Barr virus (EBV), a virus of the herpes family, and is one of the most common viruses in humans. It is best known as the cause of infectious mononucleosis (glandular fever). Infection with EBV occurs by the oral transfer of saliva.

Information from // Centers for Disease Control and Prevention // World Health Organization // Wikipedia

BACILLACEAE

BACILLUS

ANTHRACIS

Anthrax is an acute disease caused by the bacterium Bacillus anthracis. Most forms of the disease are lethal, and it affects both humans and animals. There are now effective vaccines against anthrax, and some forms of the disease respond well to antibiotic treatment. Like many other members of the genus Bacillus, Bacillus anthracis can form dormant endospores that are able to survive in harsh conditions for decades or even centuries. When spores are inhaled, ingested, or come into contact with a skin lesion on a host, they may become reactivated and multiply rapidly.

MYCOBACTERIACEAE

MYCOBACTERIUM

M. TUBERCULOSIS

Mycobacterium tuberculosis (MTB) is a pathogenic bacterial species and the causative agent of most cases of tuberculosis (TB), which is an infection of the lungs. It is a small bacillus that can withstand weak disinfectants and can survive in a dry state for weeks. Tuberculosis has existed throughout history, but the name has changed frequently over time and is transmitted mainly through aerosols and droplets. The BCG vaccine has been developed with success in preventing tuberculosis.

ALCALIGENACEAE

BORDETELLA

BORDETELLA PERTUSSIS

Pertussis (or whooping cough) is an infection of the respiratory system characterized by a “whooping” sound when the person breathes in. The bacterium is spread by airborne droplets. Worldwide in 2000, according to the WHO, around 39 million people were infected annually and about 297,000 died. Today there is a vaccine. The infection occurs mostly in children under the age of one when they are unimmunized, or children with faded immunity, normally around the ages 11 through 18. The signs and symptoms are similar to a common cold.

LEGIONELLACEAE

LEGIONELLA

L. PNEUMOPHILIA

L. pneumophila is the primary human pathogenic bacterium in this group and is the causative agent of legionellosis or Legionnaires’ disease. The largest and most common source of Legionnaires’ disease outbreaks are cooling towers (heat rejection equipment used in air conditioning and industrial cooling water systems) primarily because of the risk for wide spread circulation. Person-to-person transmission of Legionella has not been demonstrated and there is no vaccine.

CORYNEBACTERIACEAE

CORYNEBACTERIUM

C. DIPHTHERIAE

Diphtheria is an upper respiratory tract illness caused by Corynebacterium diphtheriae. Diphtheria is fatal in between 5% and 10% of cases. In children under five years and adults over 40 years, the fatality rate may be as much as 20%.[6] As of 2010 it caused about 2,900 deaths down from 6,300 in 1990.

Outbreaks, though very rare, still occur worldwide, including in developed nations, such as Germany and Canada. The diphtheria–pertussis–tetanus (DPT) vaccine is recommended for all school-age children in the U.S.

NEISSERIACEAE

NEISSERIA

N. MENINGITIDIS

Neisseria meningitidis, often referred to as meningococcus, is a bacterium that can cause meningitis[1] and other forms of meningococcal disease such as meningococcemia, a life-threatening sepsis. N. meningitidis is a major cause of morbidity and mortality during childhood in industrialized countries and has been responsible for epidemics in Africa and in Asia. Meningococcus is spread through the exchange of saliva and other respiratory secretions during activities like coughing, sneezing, kissing, and chewing on toys.

Information from // Centers for Disease Control and Prevention // World Health Organization // Wikipedia

A Glimpse of Viral News in 2013

INFLUENZA A & MERS

Although the avian influenza A virus usually does not infect humans, rare cases of human infection with this virus have been reported. Most human infections with this virus have occurred following direct or close contact with infected poultry. Illness in humans has ranged from mild to severe. However, because the avian influenza A virus has the potential to mutate and gain the ability to spread easily between people, monitoring for human infection and person-to-person transmission is extremely important for public health.[1]

World health authorities have flagged concerns about a new strain of avian influenza - H10N8 - that has already killed three people in China. The new strain adds to scientists' concerns over the rapid spread of the H7N9 variant which has infected about 300 people and killed around 75 since March 2013. The three people infected with the H10N8 strain all had contact with live poultry.[2]

When it comes to H5N1 people seem to catch it only through close contact with infected birds. To spread from person to person, the virus would have to become transmissible through airborne droplets. Recent published research have shown that this is possible.[3]

"H9N2 may be an equally plausible pandemic candidate," says Peiris. It generally goes unnoticed, but has hunkered down among Asia's poultry, caused occasional outbreaks in humans and can reassort with seasonal flu. Some strains already have mutations that are associated with greater transmissibility in mammals. H7N7 is similarly widespread and under-reported. In 2003, it flared up in the Netherlands, infecting 89 people and killing a veterinarian. Virologists hope that by understanding the secrets that allow H5N1 to spread and kill, they are in a better position to assess the risk posed by other subtypes. "With flu, nothing is predictable," says Capua.[3]

Middle East Respiratory Syndrome (MERS) is a viral respiratory illness which was first reported in Saudi Arabia in 2012. It is caused by a coronavirus called MERS-CoV. MERS-CoV is not the same coronavirus that caused severe acute respiratory syndrome (SARS) in 2003. However, like the SARS virus, MERS-CoV is most similar to the coronavirus found in bats.[4]

The MERS Coronovirus spreads very rapidly in animals when they are kept together in confined and crowded places like live-animal markets, slaughter houses and during transportation. Close and prolong contact with infected animals, which may not be symptomatic, helps virus jump to humans.[4]

Most people who have been confirmed to have MERS-CoV infection developed severe acute respiratory illness and it has been shown to spread between people who are in close contact. Their symptoms were fever, cough, and shortness of breath.[5]

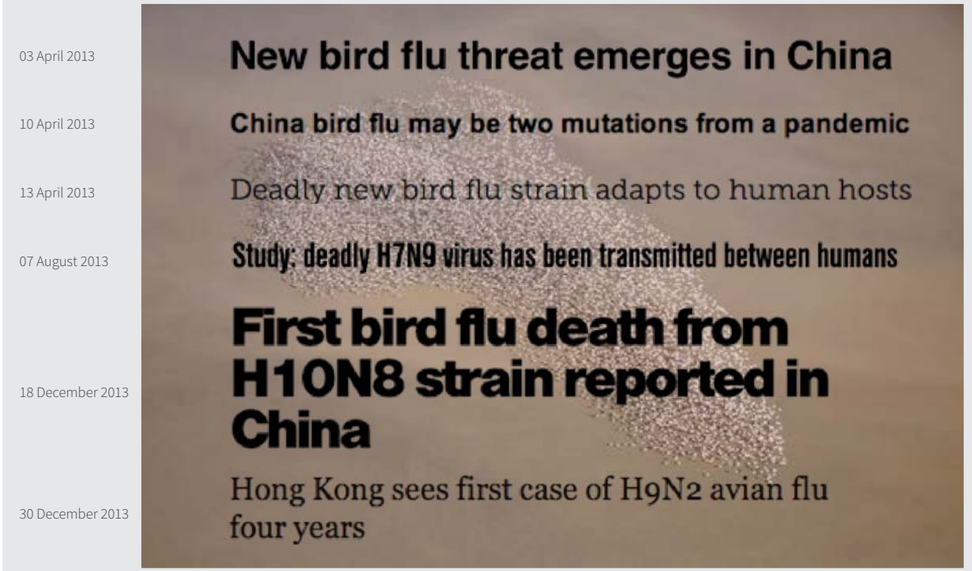
1. *Avian Influenza A Virus Infections in Humans,* Centers for Disease Control and Prevention, 2012.

2. *Pandemic fears still high in Asia as H10N8 bird flu strain emerges*, by Karon Snowdon for Asia Pacific, wires, 2014.

3. *Influenza: Five questions on H5N1*, by Ed Yong for Nature, Nature 486, 456–458, 28 June 2012.

4. *MERS-CoV: 60th death reported in Saudi Arabia,* by an Editorial Team for The Health Site, India, 2014.

5. *Middle East Respiratory Syndrome (MERS),* Centers for Disease Control and Prevention, 2013.



Headlines collected from Wired, Newscientist, Euronews, CBSnews, Soucth China Morning Post, Centers for Disease Control and Prevention (CDC) and Center for Infecious Disease Research and Policy (CIDRAP)

Viruses
50 Years of Knowledge

AND HOW THEY INFECT YOU

In 1898, Friedrich Loeffler and Paul Frosch found evidence that the cause of foot-and-mouth disease in livestock was an infectious particle smaller than any bacteria. This was the first clue to the nature of viruses, genetic entities that lie somewhere in the grey area between living and non-living states. [2]

Viruses lie around in our environment all of the time, waiting for a host cell to come along. They can enter us through the nose, eyes, mouth or breaks in the skin and once inside, they find a host cell to infect and hijack. They change the host cell's genetic material from its normal function to instead produce the virus itself. Viruses are 10 to 100 times smaller than bacteria and bacteria are intercellular organisms whereas viruses are intracellular organisms. Antibiotics can kill bacteria, but not viruses. [1] Viruses have found an ingenious way of perpetuating themselves, without ever being truly alive. They can be frozen or boiled, but then burst into life if conditions are right; this is unlike most living organisms.

Some viruses may remain dormant inside host cells for long periods, causing no obvious change in their host cells (a stage known as the lysogenic phase). However, when a dormant virus is stimulated, it enters the lytic phase: new viruses are formed, self-assemble, and burst out of the host cell, killing the cell and going on to infect other cells. [2]

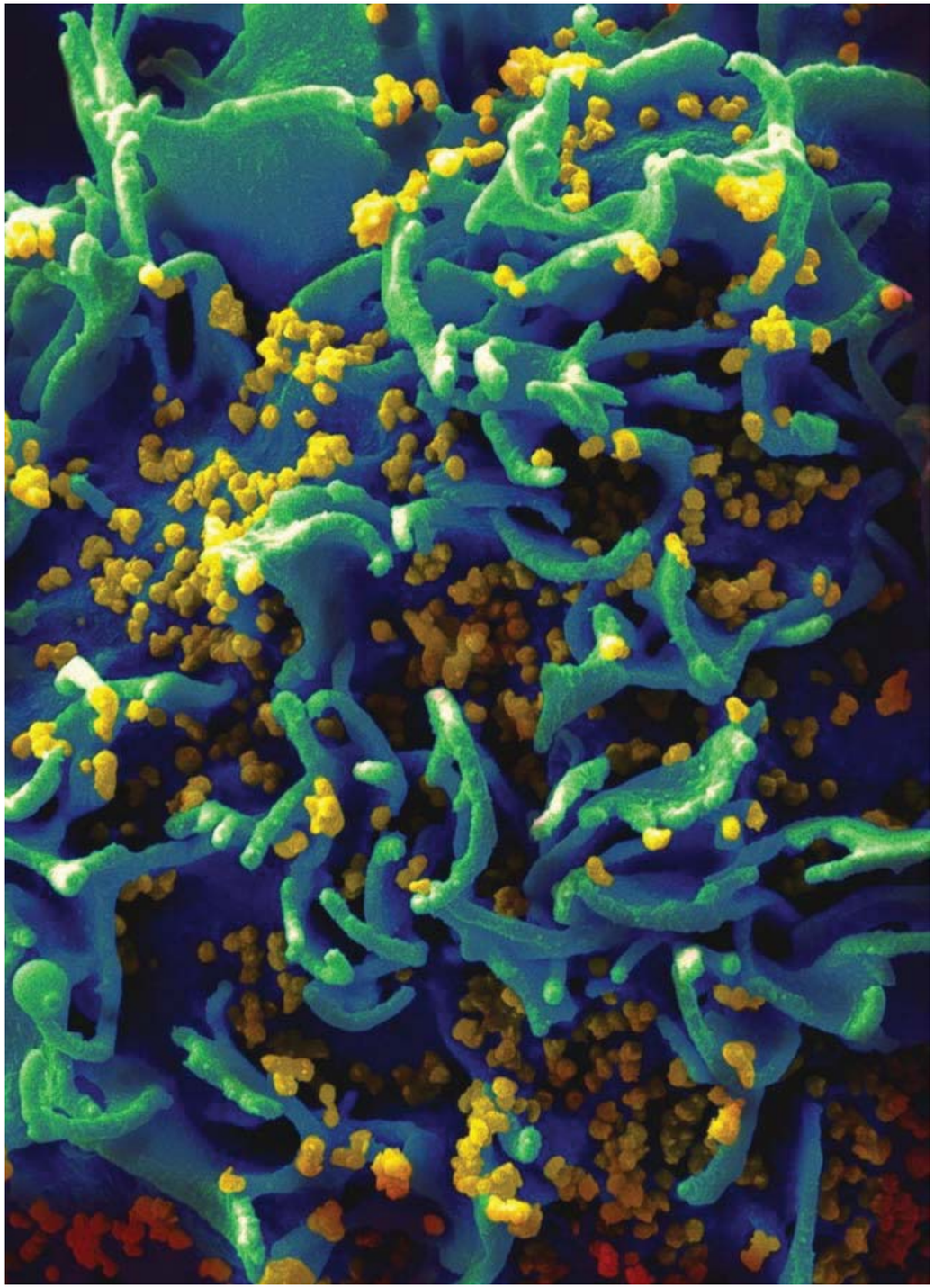
The deadliest viruses are commonly not very contagious. People that view other less lethal viruses as less threatening, such as influenza, are mistaken. That is because the one thing that a virus would not like to do is to kill the host that multiplies them. When a virus is deadly, such as with H1N1 that caused the Spanish Flu, it is because of an unfortunate meeting and mutation of viruses. Influenza is a virus that can take off from any part of the world and circulate the world in a matter of months. It is dangerous because of how easily transmittable it is. [3]

A respiratory virus attacks the very part of your nose or throat that induces you to sneeze or cough. The virus is engineered in that way so it can easily propagate from one host to another. Another interesting fact is that cold weather makes the virus stay around for a longer time because heat and sunlight destroys them. [3]

1. *How Viruses Work*, Craig Freudenrich, Ph.D. for How Stuff Works

2. *Introduction to the Viruses,* University of California Museum of Paleontology, 1995

3. *BBC Horizon - Why do viruses kill?* Documentary, 2010.



An electron micrograph of HIV particles infecting a human T cell.

Vulnerabilities & Facing a Pandemic

VACCINES

Vaccinations are one of the most incredible aspects of modern medicine. They can make previously lethal diseases disappear from society and save countless lives. Smallpox, one disease which has been eradicated by vaccines. This vaccine is saving approximately 5 million lives annually; this is a great human achievement.[1] However, other experts in the field claim that at no time in history have we successfully produced a vaccine in time for more than 260 million[2]. Which is roughly 3.6% of the world's population. Even though we had the possibility to stock up on vaccines, the problem is that viruses usually mutates which renders millions of doses useless. Vaccines also have a best-before date.[2]

People are increasingly doubting the pharmaceutical industry and especially in preventive circumstances. Previous experiences could indicate that there has not been adequate transparency and too much money to be earned. Sweden (*Socialstyrelsen* and *Stockholms Läns Landsting*) signed a contract with the medical company *Glaxo Smith Kline* before the swine flu was declared a pandemic. A contract that says that GSK would develop vaccines for Sweden when WHO declares that a pandemic has emerged. However, when the vaccine was ready (18 million doses) there were already evidence and indications that the H1N1 was even less dangerous than the seasonal flu. Sweden still decided to go through with the vaccination program.[3]

Recent research shows that there were side effects experienced by some young Swedes who got vaccinated - narcolepsy.[4] There were also accusations towards the medical companies that swine flu is a "false pandemic" and "a campaign of panic" that was being used to create a huge market for vaccines[5]. That has made some people question the risks and might refuse a vaccine the next time.

There is a constant debate in the U.S. between the anti-vaccine movements and doctors, politicians, the CDC etc. In 1998, British journal The Lancet published research by Dr. Andrew Wakefield that purported to show that the measles, mumps, and rubella (MMR) vaccines caused autism in some children. This was widely reported and the information spread rapidly among parents, especially those with autistic children. The study was later retracted after numerous other scientists could not replicate these findings. Since then, no further medical research has shown a link between vaccines and mental disorders. Nevertheless, many parents still hold reservations about vaccinating their children.[6]

An interactive map made by the Council Foreign Relations[7] gives a tour of global outbreaks of measles, mumps, rubella, polio, and whooping cough from 2008–2014. All of these diseases are easily prevented by vaccines. The majority of deaths occur in impoverished regions with very little access to vaccines. In the case of developed areas like the US or UK, they shouldn't be happening at all.[7] In addition to the young, the immunocompromised also rely on being surrounded by vaccinated individuals in order to stay protected. Those with severe allergies to gelatin or are receiving blood products are not able to get vaccinated. New York has more citizens living with AIDS than any other state in the country and they can be especially susceptible to infection.[8]

1. *One map sums up the damage caused by the anti-vaccination movement*, by Lisa Winter for iflscience.com, 2014

2. *Lessons from the 1918 flu,* Laurie Garrett for TED, Feb 2007.

3. *Hemligt avtal styr vaccineringen,* by Bo Zackrisson for Svenska Dagbladet, 2009.

4. *Anti-swine flu vaccination linked to increased risk of narcolepsy in young adults,* I. Persson et. al. for Journal of Internal Medicine, 2014.

5. *Swine flu 'a false pandemic' to sell vaccines, expert says,* by Chris Pollard for NewsCore, 2010.

6. *Anti-Vaccination Movement Causes a Deadly Year in the U.S.* by Brian Krans for HealthlineNews, 2013.

7. *Vaccine Preventable Outbreak map*, Council on Foreign Relations

8. *Measles Outbreak Hits New York City,* by Lisa Winter for iflscience.com, 2014.

Dr. Schreiber of San Augustine giving a typhoid innoculation at a rural school, San Augustine County, Texas. April, 1943.

Vulnerabilities & Facing a Pandemic

CAUSE & EFFECT

The following paragraphs are paraphrased from Laurie Garrett's TED talk *Lessons from the 1918 Flu.*

NO FLIGHTS During 9/11 airports were closed and the flu season that year was delayed for 2 weeks. Conclusion of this as a preventive action would be to close airports. However, analysis by a supercomputer shows that it will not buy us much time. It also disrupts the preparation plans. All N95 masks (the most common disposable respirator in the U.S) are produced in China. How do you have them spread around the world if all air transport is down? How do you get vaccines (if there are any) moved around? Closing airports are believed to be counterproductive. [1]

WHO IS IN CHARGE? An example in the states: Katrina, the storm, showed Americans that they cannot completely depend on their government. In most pandemic-scenario-drills the end results every time, ends up with the question: Who is in charge when a pandemic occurs? [1]

Sweden's planning to ensure the country was prepared for a pandemic gained momentum when the Government instructed the NBHW (The National Board of Health and Welfare) to draw up a National Pandemic Plan. The plan was published in February 2005 and since then it has been updated several times. [2] However, far from every country has as many Boards, Authorities etc. as Sweden, making an international cooperation difficult. It is safe to say it's up to yourself of how you wish to protect yourself.

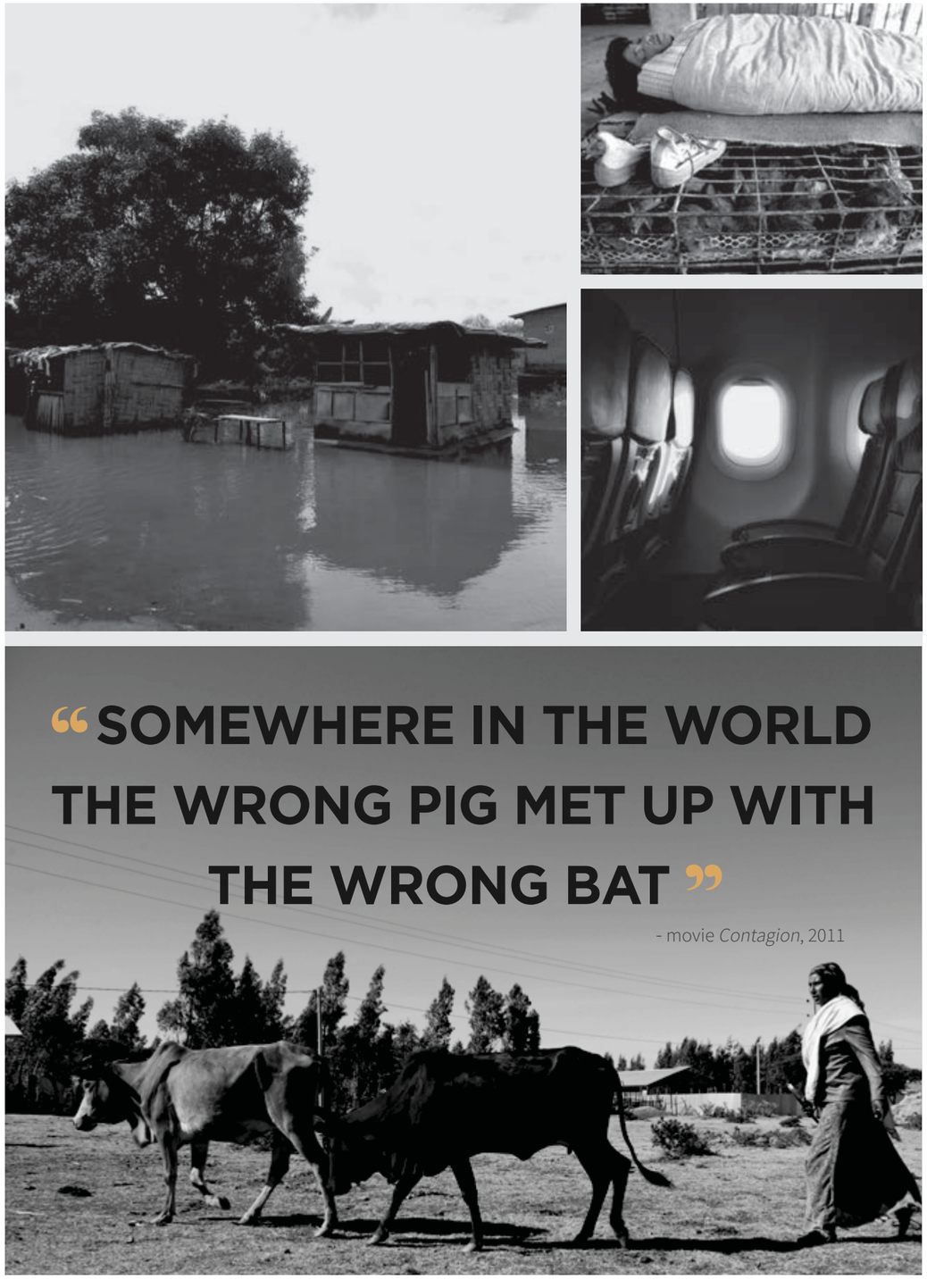
TELECOMMUTING. The British government tested a model of telecommuting and they had all people in the banking industry pretending there was a pandemic for six weeks. The society would have banks, but the ATMs would be empty. Nobody was processing credit cards. Insurance payments wouldn't go through. The end result was that the economy would be in a disastrous state of affairs. This was just one industry of many. [1]

CLIMATE CHANGES *Diseases that transfer between species are known as a zoonose and the process is known as zoonosis. Tuberculosis, Bird Flu and Rift Valley fever are well-known zoonoses and a mere 13 of them are responsible for 2.2 million human deaths and 2.4 million illnesses each year…climate change and livestock intensification may affect the results of the study in the future concluding that livestock density is associated more with disease "event emergence" than with overall disease burdens. Also, areas predicted to gain increased rainfall and flooding are expected to be at increased risk of zoonoses.* [2]

1. *Lessons from the 1918 flu,* Laurie Garrett for TED, Feb 2007

2. *A(H1N1) 2009 - An evaluation of Sweden's preparations for and management of an pandemic.* Socialstyrelsen 2011.

3. *Ethiopia tops list of animal-human disease transfer hotspots,* by Duncan Geere for Wired uk, 2013.



Floodings in Monrovia. Asian markets. Ethopian cattle farmer. International air tavel, climate change and livestock intensification are all factors that could contribute to more epidemics in the future.

Globalization & Viral Hitchhikers

JUMPING THE SPECIES BARRIERS

Etiology, the modern branch of science that deals with the causes of infectious disease recognizes five major modes of disease transmission: airborne, waterborne, bloodborne, foodborne and vectorborne (insects or other creatures that carry germs from one species to another). As humans began traveling overseas and across lands which were previously isolated; research suggests that diseases have been spread by all five modes. [1]

Globalization, the flow of information, goods, capital and people across political and geographic boundaries has helped spread some of the deadliest infectious diseases known to humans. This has been increasing through history. Early diseases that spread from Asia to Europe were bubonic plague, influenza of various types and similar infectious diseases. [1]

Viruses can have various natural hosts (bats, rodents, pigs, birds etc) where they can remain "inactivated" and will not cause any harm to the immune host. [1] Problems can occur when the natural host comes in contact with other species. An example of a virus ecology: The avian flu has its origin in birds. Some species are more resistant to infection than others. Infection causes a wide spectrum of symptoms in birds. The virus gets help with traveling further by wild migratory birds, and by dying, their droppings or by contaminating water they transmit the deadly virus to e.g. chickens. Humans can get infected either by being in direct contact with infected birds, equipment, soil etc. The last and most feared stage is when the virus goes through a process of genetic reassortment (mutation) which could occur in a person who is co-infected with an avian influenza A virus and a human influenza A virus. The lethal influenza A virus can then transmit easily from human-to-human, and we have a pandemic. [2]

Epidemiological data suggest that the toll on human populations would be enormous if the H5N1 virus acquired efficient human-to-human transmissibility while retaining high human pathogenicity. [3] Thanks to international jet travel, people and the diseases they carry viruses, can be in any city on the planet in a matter of hours. Once it touches down, sometimes all it takes is one sneeze. [4]

1. *Globalization and disease,* Wikipedia, last updated 2014.

2. *Understanding Bird flu,* Luis Bravo for The Register, 2005.

3. *Transmission of Avian Influenza A Viruses Between Animals and People,* Centers for Disease Control and Prevention, 2011.

4. *How pandemics spread,* Mark Honigsbaum for TEDed

Modes of Transmission

HUMAN-TO-HUMAN

AEROSOL TRANSMISSION Inhaling aerosolized droplets. Virus can travel on small respiratory droplets or on dust particles. They hang in the air much like invisible smoke and can travel significant distances. These small respiratory droplets become aerosolized when people sneeze, cough, throw up, laugh, or exhale. The transmission happens when another person inhales these contaminated aerosolized droplets. Respiratory aerosols containing pathogens can travel short or long range from the source depending on the size and shape of the particles, the initial velocity (e.g., cough vs. exhalation), and environmental conditions (e.g., humidity, airflow). [1]

DROPLET TRANSMISSION Sharing secretions. Through conjunctival (eyes) or mucous membrane contact with large droplets that contain viruses. This can occur when an infected person coughs, sneezes or talks close to another individual. Also by direct physical contact, e.g. sexual contact. Previous knowledge differentiated droplet and aerosols based on particle size. Recent knowledge of aerosols indicates that there is no clear line differentiating droplet and airborne transmission. [1]

CONTACT TRANSMISSION Many objects or substance are capable of carrying infectious organisms and hence transferring them from one individual to another when people touch these objects and later touches their mouth, eyes or nose. [2]

AIRBORNE Coughs force out thousands of tiny droplets of saliva. About 3,000 droplets are expelled in a single cough, and some of them fly out of the mouth at speeds of up to 50 miles per hour. Same goes for the sneeze, as many as 40,000 droplets— some of which rocket out at speeds greater than 200 miles per hour when we sneeze. [3] Movements in a room can cause heavier droplets to become airborne again after they have fallen to the ground or another surface. Making a hospital bed can kick up viruses from the covers. Opening a door can alter the airflow in a room and pull up viruses from the floor and even walking through a room can make droplets aerosolized.

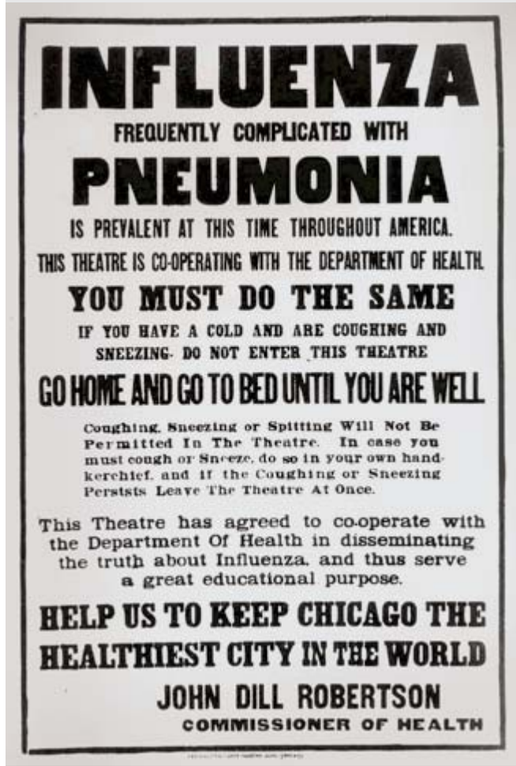
The number of virus particles in a sick person varies dramatically and changes over the course of an infection as the immune system clears out the virus. Generally, a sick person is most infectious as soon as the first symptoms appear and less infectious as his or her immune system clears the virus. [3] Influenza A is thought to spread between humans through contact, large droplets and aerosols, but the relative importance of each of these modes of transmission is unclear. New studies have found that aerosol transmission accounts for approximately half of all transmission events. This implies that measures to reduce transmission by only contact and droplet may not be enough to prevent the spread of the influenza A type viruses. [4]

1. *Controversy: Respiratory Protection for Healthcare Workers,* by Kathleen H. Harriman, Lisa M. Brosseau. Medscape. Apr 28, 2011.

2. *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu.* National Research Council. Washington, DC: The National Academies Press, 2006.

3. *The Gross Science of a Cough and a Sneeze* by Jason Socrates Bardi for livescience.com, 2009.

4. *Aerosol transmission is an important mode of Influenza A virus spread*, by B. J. Cowling et. al. Nature Communications, 2012.



Air traffic & Airborne Diseases

THE DANGERS OF CONFINED PLACES

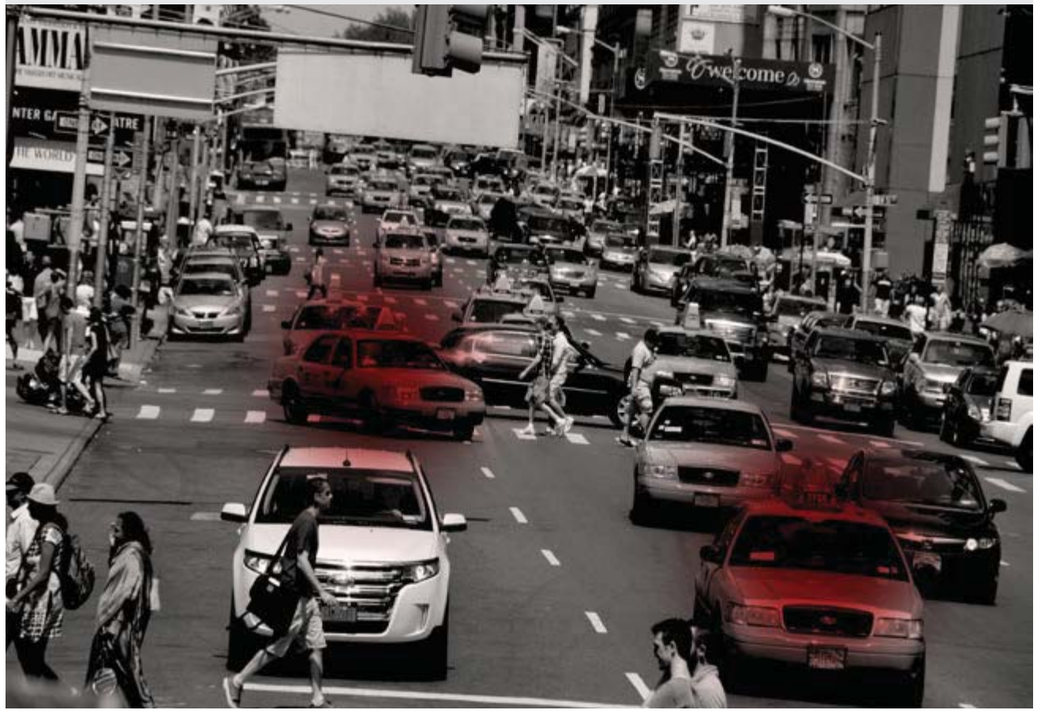
Are there any known cases of transmission of SARS through air travel? There are cases worldwide that are believed to have been contracted through contact on airplanes. There are a few potential ways in which it may be spreading. Contact transmission as previously mentioned, through the contamination of an inanimate object which could be a doorknob or an armrest, for example. This is one way that the common cold is known to transmit. Another way in an aircraft is through the air, where the infected person breathes or coughs and another person breathes in the organism. [1]

Close contact is defined as: healthcare setting; anyone who stayed at the same place (e.g. lived with, visited) while they have been symptomatic; and anyone with significant casual exposure with an infected individual, such as sitting nearby in a classroom, sharing a taxi or sitting close by on an airplane. [2] Some of the aircrafts that are being manufactured today are designed to the specifications of international aviation regulations, as well as guidelines of aircraft manufacturers: Circulation: In flight, fresh air is introduced into the cabin continuously. The entire cabin air volume is exchanged every three minutes. Airflow: The airflow movement is designed to minimize the potential for spreading of bacteria and viruses through the cabin. Filter: Most major airlines will install HEPA (High Efficiency Particulate Air) filters which are highly efficient in removing dust and airborne contaminants such as droplets, bacteria and large microbes. [3] This is a step in the right direction, however, it is far from every aircraft that has these regulations implemented and it does not protect individuals sitting around the symptomatic individual. Nor does it protect people who touch contaminated objects and their faces.

1. *Severe Acute Respiratory Syndrome - Press briefing*, Dr David Heymann et. al. for WHO, 2003.

2. *Revised interim case definition for reporting to WHO – Middle East respiratory syndrome coronavirus (MERS-CoV)*, Global Alert and Response (GAR) Programme, Interim case definition as of 2013.

3. *Summary of SARS and air travel*, WHO - Global Alert and Response (GAR) Programme, 2003.



Examples of confined places.

Pandemic & Panic

AND WHY WE NEED TO CARRY ON

The first cases occur in South Asia. Initially it goes slowly, 2–3 discrete locations. Then there will be secondary outbreaks and the disease will spread from country to country so fast you will not know what hit you. It will be everywhere in the world in three weeks.

When an outbreak moves to category 4, the world as we know it will stop. Would you get in an airplane with 250 people you didn't know, coughing and sneezing, when you know that some of them might carry a disease that could kill you? Would you risk your own life for your job?

What do you think the likelihood is that there will be a pandemic? If it happens, how bad do you think it will be? 15% of the asked fluologists and specialist in influenza said that they thought there will be a pandemic within 3 years (at 2006 and the H1N1 pandemic hit 2009). 90% thought there will be a pandemic within your children's or in your grandchildren's lifetime. If there was a pandemic a billion people would get sick. 165 million would die. [1]

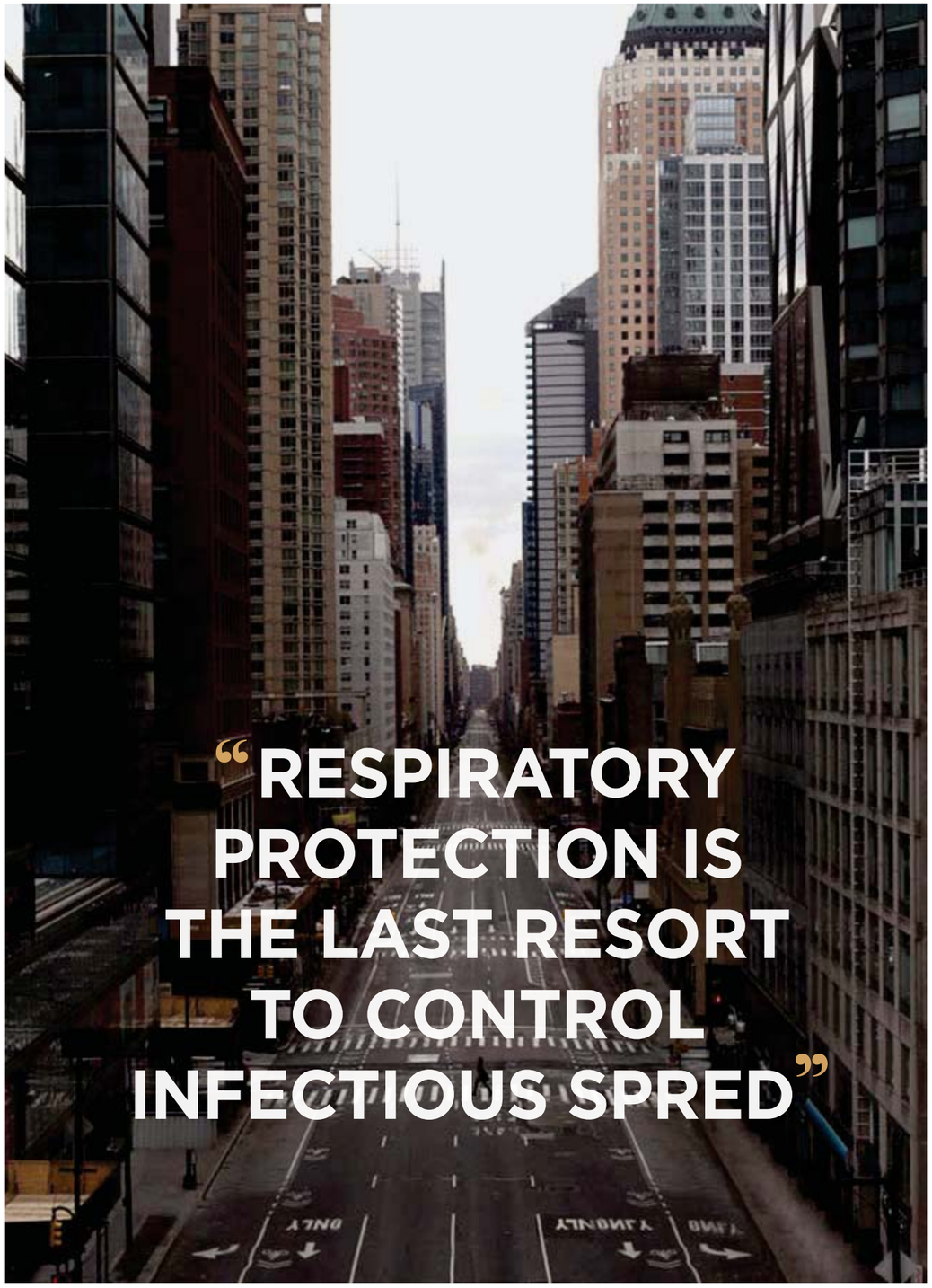
The challenges with preparing for an influenza pandemic is due to the many unknown factors such as the timing, severity and impact on populations. Moreover, the duration as well is hard to predict; this could be weeks or months and with several epidemic waves. Because some viruses are adaptable, new vaccines must be developed (if even possible in the first place) on a continual basis to keep up with the changing virus. Preparing in this context means to have a plan that delays the entry of a novel virus into the population and to slow the transmission of infection both in the healthcare and community environments. Respiratory protection is the last resort to control infectious spread. There are some factors that determine the effectiveness of such a respiratory protection, but even the best one will not do much if the individual refuses or misunderstand how and when to use it correctly. [2]

As previously mentioned, what is important is that viruses main objective is not to kill its host. A virus is something in between alive and dead, but it is fully dependant on its host for its survival. Its objective is to spread and like any other alive organism - to reproduce. This is why people are not agreeing on the probability of a lethal pandemic that wipes out mankind. I do not believe this either. It is more likely that a virus, which for its survival mutates has a low mortality rate (the 1918 Spanish Flu had a rate at 2,5%; which is severe) for those who gets infected. The rest who either does not get infected or does and survives; life needs and has to carry on.

Most doctors will still go to work due to their ethics, but maybe the people making sure we have electricity might not be willing to risk dying for their job. No banks mean no money. No produce being delivered means no food. No running water treatment plant means no drinking water. Society and its system would fall into a crisis.

1. *My wish: Help me stop pandemics*, Larry Brilliant for TED, Feb 2006.

2. *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu.* National Research Council. Washington, DC: The National Academies Press, 2006.



Pandemic & Panic

SPANISH FLU & SWINE FLU - H1N1

The 1918 flu pandemic (January 1918 – December 1920) was an unusually deadly influenza pandemic, the first of the two pandemics involving H1N1 influenza virus. It infected 500 million people across the world, including remote Pacific Islands and the Arctic, and killed 50 to 100 million of us; this is three to five percent of the world population. This makes it into one of the deadliest natural disasters in human history.[1,2]

The Spanish Flu circulated three times in 18 months (even though with the absence of commercial air travel during this time). During the first wave, they had enough health caretaker to take care of the sick. The second wave however was a mutated super killer and many caretakers were lost. The disease was very lethal (100%) to pregnant women (common for viral infections) and most who died were between 15 and 40 years old.[3]

Swine influenza, is an infection caused by any one of several types of swine influenza viruses, including influenza C virus and the subtypes of influenza A (H1N1, H1N2, H2N1, H3N1, H3N2, and H2N3). The H1N1 "swine flu" is typically contracted by person to person transmission through respiratory droplets.[4] On the 10th August 2010, the Director-General of the WHO, Margaret Chan, announced the end of the H1N1 pandemic. According to the latest WHO statistics (July 2010) the virus has killed more than 18,000 people since it appeared in April 2009, however they state that the total mortality (including deaths unconfirmed or unreported) from the H1N1 strain is "unquestionably higher". As previously mentioned, critics claimed the WHO had exaggerated the danger and therefor spreading "fear and confusion" rather than "immediate information". The WHO began an investigation to determine whether it had "frightened people unnecessarily". A flu follow-up study which was made in September 2010 found that "the risk of most serious complications was not elevated in adults or children."[5] WHO should have perhaps gotten the message out both earlier and clearer; as soon as the data was showing that the Swine Flu was not as aggressive and lethal as the Spanish Flu.

It is of course difficult to make the calls in these situations. The media however have had from early on a tendency to exaggerate because it sells which is the nature of any business from pharmaceutical companies to 3M. The public should be informed so that they can make their own decisions and respect any emerging threat.

1. *1918 influenza: the mother of all pandemics,* Taubenberger JK, Morens DM. Emerg Infect Dis [serial on the Internet]. Jan 2006.

2. *1918 flu pandemic,* From Wikipedia, last modified Jan 2014.

3. *Lessons from the 1918 flu,* Laurie Garrett for TED, Feb 2007

4. *Swine Flu,* TELL ME Project (Transparent communication in Epidemics: Learning Lessons from experience, delivering effective Messages, providing Evidence)

5. *2009 flu pandemic,* Wikipedia, last modified on 31 January 2014

Top: 1918 flu pandemic. Bottom: Pig farm.

Viral Infectious Diseases

WHY THE PANDEMIC FLU KILLS THE YOUNG

Despite the advent of a vaccine four decades ago, flu-related deaths in the United States have risen dramatically since the 1970's, and influenza now claims more lives each year than AIDS, researchers say. Flu deaths averaged about 36,000 a year (United States, 2003), up from 20,000 in previous estimates, the CDC said. The rising death toll is attributed largely to the nation's growing number of elderly people, who are particularly vulnerable to the flu. The seasonal flu can kill elderly because the immune system weakens with age. The flu can progress in a weak immune system and lead to bacterial pneumonia and other life-threatening lung infections. This weakens elders and causes them to be more vulnerable to other serious ailments such as heart disease.

Most of the deaths of the H5N1 virus were people under 30. When it comes to viruses such as Influenza A and SARS-Cov, the virus down regulates a specific immune system modulator. It is not the virus that kills you directly, but your own immune system overreacting and going berserk. The body does not have the antibodies nor T-cells to fight the virus. The whole immune system swarms the lungs and the patient dies from drowning in their own fluids of pneumonia. [2] This is not bacterial pneumonia and it will not react to any treatments with antibiotics.

1. *Flu-Related Deaths Up Sharply,* by Bootie Cosgrove-Mather for CBS news, 2003.

2. *Lessons from the 1918 flu,* Laurie Garrett for TED, Feb 2007

'Plague panel' with the Triumph of Death. Panels of this kind were placed on the walls of houses to warn against the plague (c. 1607)

The Resistance

MULTIRESISTANT BACTERIA - SUPERBUGS

In a very recent article[1] in a Swedish newspaper brought up something I came across many times during my research; multiresistant bacteria. The following text is a summary of that article.

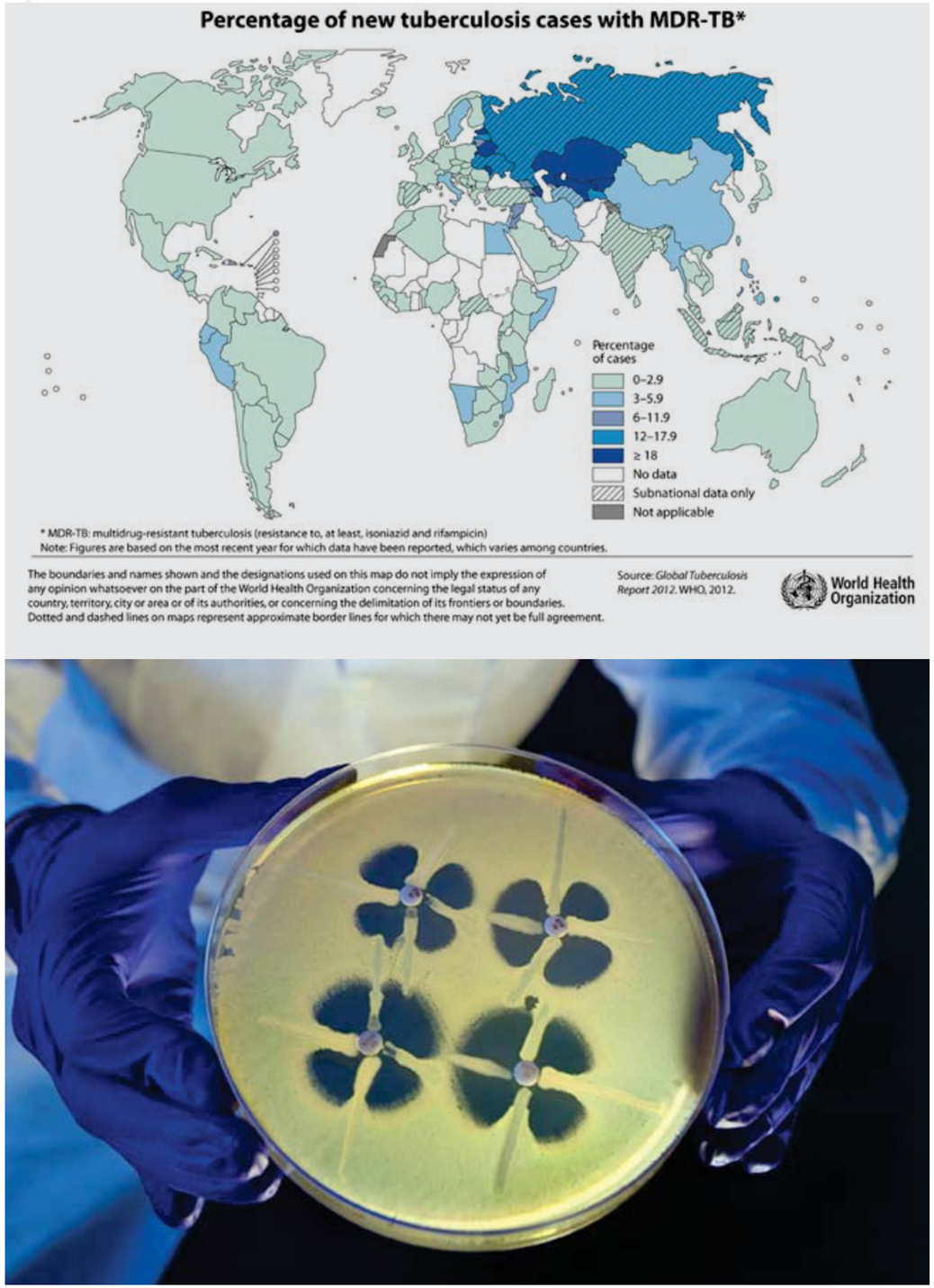
The more antibiotics we use the more resistant the bacteria can become. Multiresistant bacteria are called so because they are resistant against more than one type of antibiotic. They are also known as superbugs and are today one of the biggest threats towards the global public health. Health practitioners around the world are fearing that we will end up where we were before we had antibiotics. A time when they could not cure infections.

In South Africa it has gone so far that patients with tuberculosis are sent home since the doctors have no cure for them. A very serious kind of tuberculosis: extensively drug-resistant tuberculosis (XDR-TB), which is resistant against several kinds of antibiotic was first found there. Today it exists in half of the world's countries, but since a year ago there has also existed a new drug for XDR-TB which has saved several lives. Some patients experience very trying side-effects some so severe they have had to stop the treatment. The reasons it has hit South Africa so hard is due to overcrowding and cramped housing, poverty and HIV. The minibuses in Johannesburg are deemed to be very dangerous and called the "Tuberculosis-express". This is because the buses are very confined and crowded with unhealthy air ventilation possibilities. At hospitals around South Africa, there is a shortage of available bed and equipment and another reason why patients are being sent home. These patients whom they cannot cure nor have the means to take care of can live for months or years which is sufficient time and possibilities for infecting others.

Today, about half a million people around the world have resistant tuberculosis. There has been even worse cases called total drug-resistant tuberculosis (TDR-TB) in a few countries. Bacteria derive their resistance from the fact that patients have not received adequate treatment. Also, a consequence of a too intensive use of antibiotics both in humans and animals. It has then been spread through overcrowding, social contacts, global migration, trade, tourism and a lack of hygiene in societies (e.g. preschools and elder care).

Authorities and health caretakers are working hard in order to buy more time by keeping these bacteria away from hospitals where there is a greater risk of transmission. Also, by limiting the use of antibiotics and by raising the awareness internationally. The only hope is better and more effective medications and vaccines, but experts do still not believe that we will be able to eradicate this disease during our lifetime.

1. *Kampen har bara börjat - Resistenta Bakterier*, by S. Assarsson & N. Nasr for Sydsvenska Dagbladet, 2014



Habits & Behaviors

FACE-TOUCHING

Influenza A+B viruses, as an example, can survive for 24–48 hours on hard, non-porous surfaces such as stainless steel and for 8–12 hours on materials of cloth or tissue.[1]

This text is partly a summary of a study which aimed to investigate the prevalence of face-touching behavior in a group of medical students. Touching the mucous membranes of the nose and mouth is a possibility for transmission and acquisition of a range of infections. Infection may be spread to others after inoculating ones own hands during face-touching or infections may be acquired via contaminated hands after face-touching.

The greatest shedding of virus in the community occurs during the early stage of influenza usually 3 days before symptoms and signs. During this period the prevalent behavior of face-touching provides the opportunity for acquisition and transmission of infectious material. During public health campaigns to educate and alter the community about reducing their risk of transmission and acquisition the campaign should also focus on modifying our unconscious preening behavior. Or maybe prevent it? People have a tendency to touch their faces without being conscious about it, but mostly while we are distracted or focused on something else.

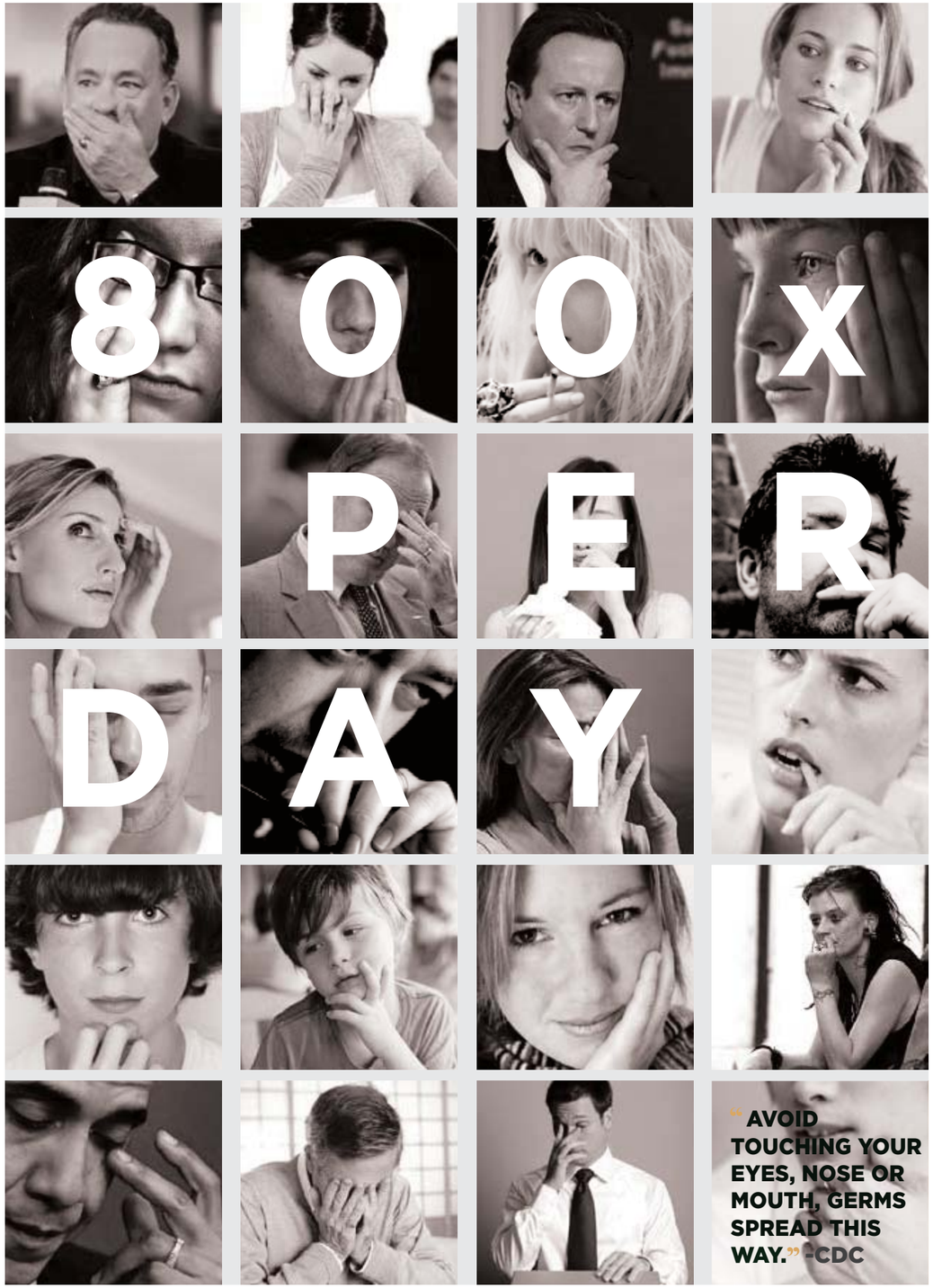
The result of this study in behavior showed that all of the 29 students (All fifth year UNSW medical students who had completed 4 hours of infection control education in the prior year attending a lecture theatre for 60 minutes, but were blinded from the aim of the study) touched their face at least once. 90% (26/29) touched a mucous membrane on the face at least once during 60 min. of observation. Out of the 2346 touches observed, 1175 were in a non-mucous membrane region and 1171 were touches of nose, mouth or eye regions, with an average 40 mucous membrane touches per student over the 60 minutes period.[2]

This means that we on a daily basis, during our awake hours (ca. 16 hours), touch a mucous-membrane area approximately 700 times according to this study. This was after the subjects had received 4 hours of infection control education. Even though the students in this study were unaware of the aim of the study it is not clear if they knew that they were being observed or not. My assumption is that people when being observed either becomes nervous (which could contribute to more face-touching) or more self-aware (could contribute to less face-touching).

I conducted a very small study of my own, both to confirm the numbers and because there are very few studies done on the subject. I studied a student working in front of a computer for an hour. The student was completely oblivious of the observance. During one hour the student touched or rubber either mouth, eyes or nose 57 times (= 900 times during the wakeful hours of a day). My theory is that we do touch our faces more than usually when we are concentrated on something (e.g. working, reading, talking), but also when we do tasks which are perfunctory and automatic (e.g. waiting, daydreaming, driving). This kind of activity happens often in confined spaces which could put you at risk.

1. *Survival of Influenza viruses on environmental surfaces*, B. Bean 1982, Journal of Infectious Diseaces.

2. *Antimicrobial Resistance and Infection Control: Abstracts from the 2nd International Conference on Prevention and Infection Control (ICPIC 2013): P157: Face-touching: a frequent habit for self-inoculation of transmissible infections?*, A Kwok et. al. 2013



Interview with Jonas Bläckberg

INFECTIOUS DISEASE SPECIALIST

I had the opportunity to interview a specialist early on during this project. We sit in the Infectious Diseases Clinic's staff room: a part of the *Skåne University Hospital*. Jonas Bläckberg is an Infectious Disease Specialist and also a specialist in Tropical Medicine. We start our conversation by talking about industrial design and goals with my degree project. I ask Jonas about which board or authority has the main responsibility in Sweden, if a pandemic or epidemic emerges. Since the 1st of January, 2014, there is a new authority - *Folkhälsomyndigheten*, with *Smittskyddsmyndigheten* as their precursor. The Public Health Agency of Sweden has a national responsibility for public health issues. The agency promotes good public health by building and disseminating knowledge, to health care and others responsible for infectious disease control and public health. Would they in the case of a pandemic emerging and without a vaccine to offer provide the public with masks? Jonas believes that their focus would be on a pharmacological one i.e. vaccines, but he has never heard of such an intervention as handing out masks.

We continue talking about the Agency, the roles of Infection Control Practitioners and that every county has one acting/vice IC practitioner with 2–3 assistant IC practitioners. At the Infectious Diseases Clinic, their main airborne threat is Tuberculosis and he gives me the disposable mask (3M Aura™) they wear when caring for these patients. They only wear them for one session before they are thrown away. Jonas also explains that the valve on the mask is there to make it easier to breath out. There might be more risks with it than benefits. He also confirms the risk with disposable respirators (such as the N95) that after a while of use when the fibers built up enough moisture viruses can escape through the mask. Jonas hands me a medical mask which they give to sick patients to prevent them from aerosolizing the virus. It is customary in some Asian countries to wear these in public when someone is infectious, which is very sensible. The medical mask can also be seen worn on the streets during a pandemic threat (e.g. SARS outbreak in Hong Kong) which is alarming because it will not do much for them. Firstly, there is no real big viral threat outdoors. There is not even a big threat in most big indoor spaces. If you would sit in a sports hall with a guy in there with tuberculosis the threat would not be very big. This applies for all open spaces with a good air circulation. Secondly, surgical face masks only provide a barrier to splashes and droplets impacting on the wearer's nose, mouth and respiratory tract. They do not however provide protection against airborne particles and are therefor not classed as RPE (Respiratory Protection Equipment).

We talk further about panic, the swine-flu vaccine controversy, emotions, history, behaviors, recommended literature and WHO's airplane statistics. Where can an individual purchase respirators in Sweden? Jonas answers, I really do not know. I have not previously thought about it. As I am about to leave and Jonas is washing the coffee cups, he turns around and says: It is an interesting question you are asking - how do you protect yourself [accurately] when there is no vaccine or cure...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1. Jonas Bläckberg, foto by Roger Lundholm for *Dödlig tropisk parasit kräver ny läkarkompetens*, Vetenskap&Hälsa, 2012. 2. Disposable respiratory mask, 3m Aura™ level FFP3 3. *Quarantine* orginiates from *quarantino*, a term derived from the Italian word *quaranta giorni*, which means "forty days". This is due to the 40 day isolation of ships and people prior to entering the city of Dubrovnik in the 14th century. 4. Medieval art - dance of death era by Jacopo Ligozzi. 5. Medical masks on the streets in China. 6. Region Skåne logo.

Interview with Per Hagstam

INFECTION CONTROL PRACTITIONER

Per Hagstam explains that there will be a pandemic sooner or later. We are meeting at *Smittskydd Skåne* two weeks later from the previous interview. Per Hagstam is an Infection Control Practitioner which is one of three in the county, Skåne. Three being the common number for each county. *Smittskydd Skåne* (lit. “Infection protection Skåne”) has the responsibility to plan, organize and lead the infection control work in their county. Their aim is to reduce the transmission of diseases between people.

Are respiratory protection a part of the plan? “No it is not. We focus on vaccines and the distribution of these. Today’s respirators are not effective enough to prevent the spread of infections.” We continue to talk about the respirators that exists today and which viruses that could potentially be a threat. “The H7N9 is very alarming, worse than the H1N1, and genetically prepared to make the change into becoming viral and with a case-fatality rate of 20-30%. From what we have seen and know of today, Pandemic Influenzas main way of transmission is by droplet and aerosol and that contact transmission occurs. During the last pandemic, the swine flu in 2009, the supply of respirators was swiped pretty fast and became a scarcity.” Do you know where someone can buy a respirator today in Sweden? “I actually don’t know” he says and looks up seemingly thinking.

For Per, when we talk about a pandemic, he speaks mainly of a Pandemic Influenza. I ask him about SARS and MERS and why they say they can’t for sure know the ways of transmission of these diseases. There are three known ways of transmission - so what do they mean by this statement? Per answers that “SARS was spreading fast and in strange ways [logistically speaking] and had a very high fatality rate. However, it behaved a bit differently from e.g. Influenza A. It seemed like it was transmitted later in the disease’s progression. In many cases family members were infecting each other. Compare that to other infectious diseases, where you can be infected and contagious before you develop symptoms and be unaware that you are infected.

We talk further about vaccines and the unfortunate fate for a few young people in Sweden that is suffering from a side effect (Narcolepsy) of the last mass-vaccination of a vaccine called Pandemrix. Per explains that at the time, the Swine Flu (H1N1) was taken very seriously due to its percussor the Spanish Flu (H1N1) and there was not enough time to test the vaccine on thousands of subjects before. They often have the core of each possible vaccine and just need to add a defining part to make it into a vaccine against a specific species of virus. However, he also realizes the consequences that episode will have on the next one and that they who will not get vaccinated will be a new risk group in society. He has some difficulty in seeing the public wearing respiratory protection all the time - at least not for the purpose of slowing down the spread, but more for the purpose of preventing an individual risk.

There are people that have to put themselves at risk, for instance due to their workplace, who could benefit from better respiratory protection. In Sweden there is no legal obligation on the caregivers to get vaccinated and it does happen that caregivers get seriously infected.


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1. Per Hagstam, biträdande smittskydsläkare i Skåne. Foto: Karin Olsson-Bendix/SR 2. Workers in asia fighting the avian flu. 3. Pandemrix, is an influenza vaccine for influenza pandemics, such as the H1N1 2009 flu pandemic called the swine flu. The vaccine was developed by GlaxoSmithKline. 4. Hospital staff, workers meet patients daily and has no legal obligation to be vaccined.

Interview with Ulf Karlsson

HEALTH CARE HYGIENE SPECIALIST

A week later I'm back at the *Skåne University Hospital* on the second floor of one of the many buildings. This is the new HQ for *Health Care Hygiene* (Vårdhygien) a sector which is also a part of *Region Skåne*. Their mission is to prevent healthcare acquired and associated infections and reducing the risk of infection by providing information, develop routines, being up to date with latest research, surveillance and mapping of infections, workshop etc.

I'm here to talk to Ulf Karlsson - a hygiene and infectious diseases specialist, whom I was referred to by Per Hagstam. We begin the conversation with me explaining what I know and done so far, conclusion and my current problem - which is the correct path? Reusable or disposable? For everyone or for the risk group? For anywhere or for a certain scenario?

Ulf shows me a newly designed poster which is intended to be placed around the hospitals. It is an informational poster about hygiene etiquette - to cough in the bend of the arm, sneezing in a paper tissue which then should be disposed and it also reminds care givers and patients the importance of washing their hands.

We continue on to talk about studies, research and what is known about the three means of transmission (droplet, aerosol and contact). Ulf provides me with four articles about transmission and respirators which are right on the money for my topic.

The routines and regulation when it comes to respirators in a health care setting are not exactly easy. Most caregivers do not come in contact with airborne infectious diseases, but still there are some facts that are not being faced. If it would be an event or routine to wear high level respirators and dispose of these after each use would mean an additional cost of billions (SEK) for the health care system. This could also highlight the fact that there might be a shortage of respirators in the event of an epidemic or pandemic.

Ulf also explains the factors that cause viruses to spread - such as humidity also the importance of preventing aerosol distribution, diseases like Tuberculosis, Smallpox, Measles which has an undisputable airborne transmission.

The dilemma of reusable versus disposable respiratory protection is another point that was raised. The risk of reusable being the exposure to viruses when changing filters and cleaning the device. Disposable ones does not come without risk either, but will contribute to a huge amount of waste and a possible shortage of them. Ulf suggested I should look further in to the survival time rate of viruses, which some say might be short or shorter depending on which material they rest on. I ask about lethal rates. In the emergence of novel viral diseases, they can at first be very deadly, but after some time the virus goes through an antigenic swift - rendering the virus to become more contagious but far less deadly.

Furthermore, we talk about risk groups and how they could potentially be a target group. People with an immune deficiency disorder (caused by treatment or disease) asthmatics, the severely obese and pregnant women. In many cases it is due to way they have to breath. Everyone in this risk group could benefit from better and safer respiratory protection in more than one scenario.

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1. Doctor checking the infusion of an E. coli patient undergoing a kidney dialysis at Asklepios Hospital in Hamburg-Altona, Germany 2. New informational posters about hygiene etiquette made for the hospitals in the southern county of Sweden; cough in the bend of the arm, sneezing in a paper tissue which then should be disposed and it also reminds care givers and patients the importance of washing their hands. 3. Aerial view of the univeristy hospital in Lund, Sweden.

Respirators

NONPHARMACOLOGICAL INTERVENTIONS

This following section about respirators and medical masks is a summery of the article *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu* by the National Research Council, Washington D.C. The aim was to investigate the possibilities of reusing the respirator N95, which is a disposable facemask. They also present a thorough investigation of the varying approved masks (in the United States only) and can give an unbiased comparison of these.

In the event of pandemic influenza, supplies of effective vaccines and antiviral medications are liable to be inadequate to treat a very large number of affected individuals. Therefore, non pharmacological interventions will be important, including the use of respiratory protection or medical masks. Currently available medical masks and disposable N95 filtering face piece respirators have a limited operational life span. Once worn, they can become damaged from moisture buildup.

Respirators sold in the United States are tested and certified by the National Institute for Occupational Safety and Health (NIOSH). They are typically composed of mats of non-woven fibrous materials, such as wool felt, fiberglass paper, or polypropylene.

Respirators can be classified as air-purifying or atmosphere-supplying. Air-purifying respirators include those that use filters to remove airborne particulate matter (such as N95 filtering face-piece respirators), those that use an adsorbent to remove hazardous vapors and gases (half face-piece with chemical cartridges or canisters), and those that combine a filter and adsorbent to remove particulate matter, gases, and vapors (cartridge or canister with particulate-removing filter). Per the NIOSH respirator selection logic, air-purifying respirators cannot be used in atmospheres that lack a normal amount of oxygen (approximately 20%) or that contain sufficiently high concentrations of contaminants to be classified as immediately dangerous to life or health (NIOSH, 2004).

Non-powered respirators can either depend on the wearer to draw in air in through the filters or cartridges, and thus there is a negative pressure inside the face piece during inhalation. Powered air-purifying respirators (PAPRs) use a blower to draw air through the filter and deliver it to the wearer. Thereby eliminating airflow resistance to the wearer. PAPRs that are tight fitting or have a hood/helmet design are expected to provide higher levels of protection because the pressure inside the respirator is likely to remain positive, and certainly less negative than a non-PAPR air-purifying respirator.

Although rarely used in health care setting, air supplying respirators can be classified into (1) self-contained breathing apparatus (SCBA) for use by emergency responders or in chemical, biological, radiological, and nuclear and oxygen-deficient environments and (2) airline respirators designed to deliver clean breathing air to hoods, helmets, and full- and half face-piece masks.

An efficient method of capturing both large and small particles from the airstream is said to be an electrostatic attraction, in which electrically charged fibers or granules are embedded in the filter to attract oppositely charged particles from the airstream. The attraction between the oppositely charged fibers and particles is strong enough to effectively remove the particles from the air.[1]

1. *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu*. National Research Council. Washington, DC: The National Academies Press, 2006.

DISPOSABLE RESPIRATOR

DISPOSABLE RESPIRATOR WITH VALVE

AIR-PURIFYING RESPIRATORS

REUSABLE HALF FACEPIECE RESPIRATOR

REUSABLE FULL FACEPIECE RESPIRATOR

Respirators

CONTINUED

The institute of medicine looked at the masking question. “Can we figure out a way since [in the USA] we will not have enough masks because we do not make them in America anymore - they are all made in China.” In the SARS epidemic, we learned in Hong Kong that many transmissions occurred because people were removing their masks improperly. When they got home and removed the mask, their hand got contaminated from touching the outside of the mask. From then rubbed their nose and face.”[2] The report’s advice for further investigation and inventions concludes as following: research should focus on the material-process-structure-property relationships of woven cloth masks through incorporation of high-elongation stretch fibers (such as spandex) into fabrics containing the base fibers; investigation of a range of base or comfort fiber (e.g. cotton, polyester, polypropylene, blends) for woven cloth masks; investigation of a range of structures of varying yarn densities, designs, plies, and manufacturing technologies (woven and knitted) for producing the woven cloth masks; and integration of disposable filtering media into multilayer cloth masks.

1. *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu*. National Research Council. Washington, DC: The National Academies Press, 2006.

2. *Lessons from the 1918 flu*, Laurie Garrett for TED, Feb 2007

REUSABLE FULL FACEPIECE POWERED RESPIRATOR

REUSABLE FULL FACEPIECE POWERED RESPIRATOR

AIR-SUPPLYING RESPIRATORS

REUSABLE FULL FACEPIECE OXYGEN-SUPPLYING RESPIRATOR

REUSABLE HALF FACEPIECE OXYGEN-SUPPLYING RESPIRATOR

A Piece of What's Out There

FROM A TO WEIRD





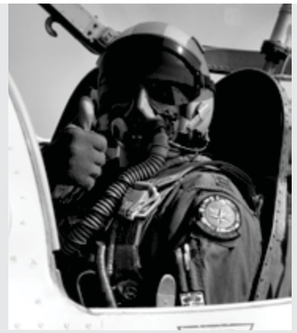


















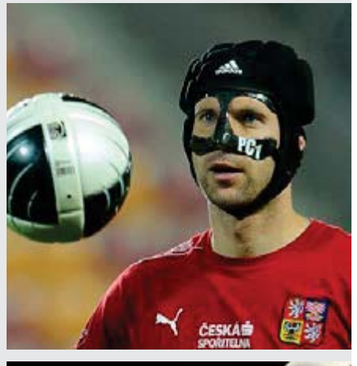
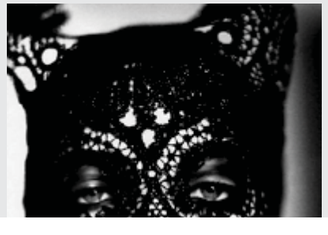
The Type B-8 winter helmet of 1944 showing attachment of the Type A-14 oxygen mask by means of snaps or studs along the front edge. (SI Photo A48555E)





















Respirator Issues

LESSONS FROM 9/11

This chapter is a summery of the article about what was learned about respirators from the terrorist attack on the World Trade Center [1] and the dust from the buildings that collapsed which caused a lot of agony for the workers.

They were supposed to be respirator masks, but as a dark post-9/11 joke, some workers at ground zero called them “neck protectors.” The masks were so cumbersome and uncomfortable that many yanked them off and left them hanging around their necks. Responders were reluctant to wear masks for long because it was too hard to speak or to be understood while wearing one. The new equipment must also meet tougher intelligibility standards for communication. “In terms of the respirators most commonly used on a day-to-day basis and most commonly used in disaster response, I don’t see any significant changes on the ground yet” said David M. Newman, an industrial hygienist with the NIOSH.

There are electronic sensors that can tell when a respirator cartridge should be changed or if it fits properly, but they are not yet required because of the added cost - about $15 to the price of a reusable respirator. A reusable respirators, with replaceable filters can cost up to $50 and are effective against an array of contaminants. The national laboratory [in USA] has also been accused of taking too long to develop new standards and lacking scientific evidence to justify the changes.

The N95 disposable mask costs a few dollars apiece and fit loosely over the nose and mouth. They are made of layers of polypropylene plastic, electrostatically charged to attract and hold contaminants like dust but not gases or oils. Self-contained breathing units offer the greatest protection but can be used only as long as the air in their tanks holds out, generally less than an hour.

Another lesson was that 3M has since 2001 developed a “smart safety” line of respirators aimed at responders who do not normally use such equipment. One feature, not yet required for government certification, is an automatic battery-powered air-purifying system. If the unit senses that a filter is impeded, a blower motor picks up speed, providing more air; if the battery starts to run low, an alarm sounds. “Down the road, we’re going to see more equipment that can be tracked by the user to ensure that it functions properly”, Mr. Weber said.

“The number of respirators that will be used in a pandemic will be astronomical, and supplies will be limited,” said Bruce E. Lippy, a safety consultant who was an industrial hygienist for the Union of Operating Engineers at ground zero. “There’s going to be this tendency to say that if there are not enough respirators available, we can rely on surgical masks.” But surgical masks are not designed to filter out viruses. [1]

1. *Improving Respirator Masks to Put Fresh Air in Reach*, by Anthony de Palma for The New York Times, 2013.

9/11 - neck protectors

Conclusions & Problems

AD HOC

>> Experience indicates we are overdue for another influenza pandemic. Immunization remains the cornerstone of our strategy, with antiviral agents as a backup, but producing and distributing a vaccine will take at least 4 to 6 months currently. In the meantime, our main defenses will be non pharmacological interventions, such as hand washing, “respiratory etiquette,” face masks, school closure, and social distancing or solation.

>> The most likely kind of pandemic will be with a virus that is highly contagious but not necessarily with a high lethality rate. This makes counter measurements such as staying at home unlikely.

>> We can not all stay home for 24 months and Telecommuting has shown not to work for all industries.

>> The ways of transmission is through Aerosol, Droplet and Contact, by preventing these to happen you could protect yourself from an airborne disease.

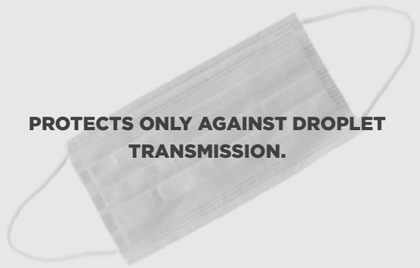
>> The places with highest risk of transmission are those where casual exposure with an infected individual can occur, such as sitting nearby in a classroom, sharing a taxi, sitting close by on an airplane.

>> It is more likely that we touch our own faces unconsciously than that we can manage to wash our hand regularly enough.

>> In Sweden, there is no plan nor a big deposit of respiratory protection, in case there is no vaccine in time.

>> Research should focus on the material-process-structure-property relationships of woven cloth masks through incorporation of high-elongation stretch fibers (such as spandex) into fabrics containing the base fibers; investigation of a range of base or comfort fiber (e.g. cotton, polyester, polypropylene, blends) for woven cloth masks; investigation of a range of structures of varying yarn densities, designs, plies, and manufacturing technologies (woven and knitted) for producing the woven cloth masks; and integration of disposable filtering media into multilayer cloth masks.

MEDICAL MASK



PROTECTS ONLY AGAINST DROPLET TRANSMISSION.

DISPOSABLE RESPIRATOR

ONLY PROTECTS AGAINST DROPLET TRANSMISSION AND AEROSOL.

AFTER TIME, HUMIDITY BUILDS UP, MAKING THEM DANGEROUS, YOU DO NOT KNOW WHEN.

DIFFICULT TO TALK AND BREATH.

PROBLEMS

REUSABLE RESPIRATOR

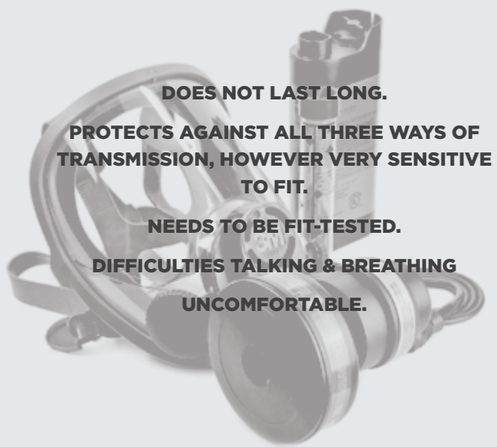
PROTECTS AGAINST ALL THREE WAYS OF TRANSMISSION, HOWEVER VERY SENSITIVE TO FIT

NEEDS TO BE FIT TESTED

DIFFICULTIES TALKING & BREATHING

UNCOMFORTABLE

POWERED OR AIR SUPPLIED RESPIRATOR



DOES NOT LAST LONG.

PROTECTS AGAINST ALL THREE WAYS OF TRANSMISSION, HOWEVER VERY SENSITIVE TO FIT.

NEEDS TO BE FIT-TESTED.

DIFFICULTIES TALKING & BREATHING

UNCOMFORTABLE.

Filtering Media

NANOFIBERS

The filtering materials of respirators and medical masks are typically nonwoven. Spundbonded polypropylene is a fabric or structure in the category of nonwoven textile materials. For filtration and trapping of aqueous particles (as in respirators and medical masks), polypropylene requires modifications to make it more hydrophilic, since it is inherently hydrophobic. One modification, the process of a droplet-attracting charge applied to the surface, has also been described, but it is not clear that such a charge could be maintained during storage of the respirator or mask, and the charge would dissipate with exposure to air with any degree of humidity. [1]

Filtration is one of the most commonly applied methods for aerosol removal because it is simple and economical. However, there are two main issues associated with filtration: (1) High aerosol removal efficiency is achieved only at the cost of high pressure drop, which is translated into high energy consumption for collective protection or high breathing resistance for individual protection. How to increase efficiency while maintaining low pressure drop is a critical challenge to filter development. (2) Collected biological agents may creep through the filter and re-aerosolize. The re-aerosolization may impose hazards to the person intended to protect. How to effectively retain the biological agents loaded on the filter, hence, is an important consideration. Nanofibrous media have the potential to solve the above issues due to their high surface area and ability to incorporate special functional groups at the nanoscale level. The nanofiber based filtering media, made up of fibers of diameter ranging from 100 to 1000 nm, can be conveniently produced by electrospinning technique. [2]

Nanofibrous media have low basis weight, high permeability and small pore size that make them appropriate for a wide range of filtration applications. In addition, nanofiber membrane offers unique properties like high specific surface area, good interconnectivity of pores and potential to incorporate active chemistry or functionality on nanoscale. Therefor, nanofibrous membranes are extensively being studied for air and liquid filtration. [3]

Theoretical predictions and preliminary investigations indicate that significant increase of the filter efficiency for the most penetrating particle size (between 0.1 and 0.5 nm) accompanied by only a slight rise of the pressure drop, can be achieved by using the nanofibrous filtering media. Some research recommended triple layer design of fibrous filters dedicated to remove the nanoparticles along with other polydispersed aerosol particles (the back support layer of densely packed microfibers, the middle nanofibrous layer for collection of most penetrating aerosol particles and front porous layer of fibers of a few micrometers diameter for collection of micrometer sized particles). [3]

1. *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu*. National Research Council. Washington, DC: The National Academies Press, 2006.

2. *Removal and retention of viral aerosols by a novel alumina nanofiber filter*, Hsing-Wang Lia et. al. Journal of Areosol Science, 2008

3. *Nanofibrous filtering media: Filtration problemsand solutions from tiny materials,* R.S. Barhate, 2007

Top: Nanofiber cloth created in the Technion-Israel Institute of Technology laboratories. Bottom: Polyacrylonitrile nanofibers - Continuous Carbon Nanofibers Templated with Double Wall Carbon Nanotubes

Let's go deeper

EXPERTS FACING RESPIRATORS & BIOAEROSOLS

An article which was right to the point on the topic, discusses two means of disrupting the transmission of the influenza virus, which are respirators and ultraviolet light. [1] The following text are excerpts from this article followed by two other articles on the same topic. The first article start off by stating that in the event of an influenza pandemic, where effective vaccine and antiviral drugs may be lacking, disrupting environmental transmission of the influenza virus will be the only viable strategy to protect the public. Respiratory protection has been largely overlooked and their potential utility is under appreciated. The effectiveness of disposable face masks may be increased by sealing the edges of the mask to the face. Reusable masks should be stockpiled, because the supply of disposable masks will likely prove inadequate.

The filtering mechanism of the respirator is the face piece. N–95 masks are so named because they are rated to block 95% of particulate aerosols from penetrating the mask. In theory, N–100 respirators (comparable with the European FFP3) are 99.999% effective in filtering particles, but has a retail price roughly ten times greater that of an N95 respirator. Respirators could be critical in mitigating a pandemic, several factors may adversely impact the feasibility of their use. Fit testing is time consuming, and in the health care setting, requires a technician. The test typically involves molding the mask until a seal is accomplished. Researchers found that most persons cannot be adequately fit tested to commercially available N–95 respirators. How long can these masks be worn and still remain effective? With time, moisture buildup causes significant breathing resistance and the risk of viruses slipping through the filter. Can these masks be resterilized? For instance, would placing the mask in a microwave kill viruses on the mask without denaturing the mask? Would bleach work? The risk of contact transmission from handling a contaminated, virus-laden mask would appear to be the same for removing the mask for disposal alone or for resterilization. There is little financial incentive, however, for respirator manufacturers to establish reusability for these products, and there is a legal disincentive, in terms of potential liability. Indications from manufacturers are that face masks are likely to degrade with attempted sterilization. Unfortunately, face masks are seen as a mundane topic and have attracted little academic interest. A solution to the problem of inadequate supply and inadequate seals could be reusable respirators. These elastomeric devices have face pieces that can be cleaned and reused, and the National Academy of Sciences has posited they might be preferable for stockpiling over N95 respirators. The retail cost is US$7.50. Their filter media, a replaceable cartridge, blocks 98% of particulate aerosols from penetrating. A practical goal would be to produce a filtering capability in the cartridge for an elastomeric frame that matches that of the N–100 respirator and devise a mechanism to resterilize that cartridge.

1. *Disrupting the Transmission of Influenza A: Face Masks and Ultraviolet Light as Control Measurs*, by Martin Meyer Weiss et. al. Health Policy and Ethics - American Journal of Public Health, 2007.

1. *Disrupting the Transmission of Influenza A: Face Masks and Ultraviolet Light as Control Measurs*, by Martin Meyer Weiss et. al. Health Policy and Ethics - American Journal of Public Health, 2007.

There are problems that limit the utility of face masks. The masks are uncomfortable, particularly in warm weather, and may be impossible to wear for people with chronic lung disease. Eating and drinking require removal of the mask. Nonetheless, competent masks could prove vital in the control of a pandemic that overwhelms our health care system and paralyzes our cities. Availability of masks might allow some measure of confidence for essential services to continue. Masks have an indefinite shelf life and could be pivotal in responding to a potential bioengineering microbial event, such as smallpox and tularemia. Ensuring an adequate, readily available supply of masks is critical.

A generally overlooked possible portal of entry is the conjunctiva (the mucous membrane that lines the inner surface of the eyelid and the exposed surface of the eyeball). Such a portal is reported for some strains of influenza and the H7N7 virus, in particular, caused many cases of conjunctivitis in humans. It is postulated that this mode of entry may also be operative in some cases of smallpox. It is unclear whether the conjunctivitis is a consequence of aerosolized viral particles landing on the ocular surface or a consequence of transfer via the hands or fomites. It is unknown whether influenza A is also transmitted by fomites, but there is supporting evidence for this premise.

UV-light can sterilize infectious aerosols. UV light is electromagnetic radiation with a wavelength shorter than that of visible light. Although the practical clinical use of UV-light as a means for disinfecting the air of respiratory viruses and bacteria is uncertain, the virucidal and bactericidal action, per se, is not in dispute. In vitro studies clearly demonstrate UV-light to inactivate 99.99% of influenza virus aerosols. Mercury vapor lamps emitting UV-C are routinely used to sterilize work areas and equipment in medica facilities and laboratories. The energy required for germicidal action, as well as adverse effects, is a product of radiation intensity and time. A few seconds of high-intensity radiation, or several hours of low-intensity radiation, may produce the same net amount of radiation and germicidal action. Flooding a room above a height of 6.5 ft with high-intensity UV radiation has been found to keep skin and eye exposure well within the safety range.

The modalities discussed here, facemasks and UV-light, have been largely overlooked. They are modest and far from the cutting edge of science. Nonetheless, they offer the potential of mitigating a potentially uncontrollable pandemic. The authors hope for this article was that it would stimulates research interest and that it would draw the attention of policy makers to allow for wider implementation of their use as public health measures. Respirators are clearly an inferior strategy compared with an effective vaccine and antiviral agents for influenza A. What is offered here is a plan B, should plan A fail. [1]

Let's go deeper continued...

EXPERTS FACING RESPIRATORS & BIOAEROSOLS

Another article [1] on the topic of respiratory protection summarizes the available information on efficiency of respiratory filters against biological agents, the importance of face-fitting characteristics, maintenance and storage, and decontamination of respirators.

Microorganisms can penetrate through respirator filters, sealing surfaces, or other parts of the respirator. Penetration through filters has been studied in detail because filters are the main components involved in aerosol filtration. The performance of the facemask interface, as well as the filter material, can have a significant impact on the respirators overall protection against aerosols. Another study they refer to in this article is one by Chen and Willeke [2], they studied face seal leakage and filter penetration characteristics during inhalation and suggested that the slope if aerosol size-dependent penetration curve may differentiate face-seal leakage from filter penetration. They observed that less aerosols passed through a slit-like leak or multiple small circular leaks than a single circular size leak of equal cross-sectional area at a given pressure differential across the filter.

Further research on decontamination of pathogenic microorganisms on various respirator materials is necessary to ensure protection. Not all decontaminating agents are affective against every microorganism, at the same time a multispectrum decontaminating agent will be effective against exposure of unknown and multiple biologic materials. Care must be exercised in the use of any decontaminating agents on respirator components. The respirators manufacture's instructions should be consulted and followed to ensure agents are not used that could damage the respirator components or compromise performance. Respirator damage or compromised performance may not be detectable by the user, thereby reducing protection when reused.

In decontaminating respirator materials, the postdecontamination effect on the environment needs to be considered. Some of the decontaminating agents are known for their toxic, corrosive, and environmentally hazardous effects. Also, the environmental contamination caused by disposable masks.

Reaerosolization or reentrainment is described as the process by which any aerially deposited material can become resuspended. Reaerosolization of particles from filters is possible when particles previously captured may penetrate and reach the respiratory tract of the wearer at high inhalation rates. Alternatively, the captured particles may be released in the air during a violent coughing or sneezing. Coughing and sneezing may allow aerosol particles generated by the wearer to pass through the filter and contaminate the environment. The percentage of particles reentrained from filters was not altered by the thickness of filtering media, suggesting deposition of particles on the uppermost fibers of the filter.

Reaerosolization of particles was also performed with different filter media and type of aerosol particles.

1. *Guidance on the use of respiratory and facial protection equipment*, J.E. Coia et al for the Journal of Hospital Infection, 2013.

2. *Characteristics of Face Seal Leakage in Filtering Facepieces*, Chen et al, American Industrial Hygiene Association Journal, 1992.

1. *Guidance on the use of respiratory and facial protection equipment*, J.E. Coia et al for the Journal of Hospital Infection, 2013.

Reaerosolization was observed with fiberglass, HEPA, and polypropylene filters, but not with polypropylene/ Modacrylic filters; the reasons for the difference were unclear.

Another article which has looked close at respiratory protection, in a healthcare setting states that it is apparent from recent experiences with SARS and H1N1 pandemic influenza (2009) that healthcare workers may have a difficulty in choosing the correct type of facial and respiratory protection in any given clinical situation. Their aim was to develop some guidance based on literature and expert consensus.

The European standard for filtering face masks lists three classes of filtering face piece (FFP): FFP1, FFP2 (approximately equivalent to N95) and FFP3 - which offers the highest level of protection. These are classified by inward leakage in laboratory tests and simulated real-life use. Inward leakage can result from penetration through the material matrix of the face piece or through any gap between the face piece and the wearer's face.

Just as the previous articles mentions, an element of facial protection that is often forgotten, eye protection, which creates a barrier to droplets, splashes (and contact - mostly outside of a health care setting, by touching a contaminated object and then rubbing your eyes) impacting on the wearer's conjunctivae (the mucous membrane that lines the inner surface of the eyelid and the exposed surface of the eyeball). The most common available items are safety spectacles, full-face visors or an integral transparent panel on top of a surgical face mask. Disposable, single-use eye protection is recommended; however, if this is reusable, appropriate decontamination between uses is required.

Another recommendation in this article for future research is the development of transparent respiratory protection that does not obscure the face, which is required to reduce patient anxiety and aid communication. To have visible faces are important and applies for other scenarios - such as traveling, identification, communication together with the emotions which are already running high during an epidemic or pandemic. [1]

Conclusions & Problems II

AD HOC

>> Nanofibrous membranes are extensively being studied for air and liquid filtration. Nanofibrous media have low basis weight, high permeability and small pore size that make them appropriate for a wide range of filtration applications

>> Microorganisms can penetrate through respirator filters, sealing surfaces, or other parts of the respirator. A solution to the problem of inadequate supply and inadequate seals could be reusable respirators. Or new solutions for disposable ones, that address these problems

>> Availability of masks might allow some measure of confidence for essential services to continue. Masks have an indefinite shelf life and could be pivotal in responding to a potential bioengineering microbial event, such as smallpox and tularemia. Ensuring an adequate, readily available supply of masks is critical.

>> A generally overlooked possible portal of entry is the conjunctiva (the mucous membrane that lines the inner surface of the eyelid and the exposed surface of the eyeball). Disposable, single-use eye protection is recommended; however, if this is reusable, appropriate decontamination between uses is required.

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>> In decontaminating respirator materials, the postdecontamination effect on the environment needs to be considered.

>> Face masks have been largely overlooked. They are modest and far from the cutting edge of science.

>> Disrupting environmental transmission of the influenza virus will be the only viable strategy to protect the public. Respiratory protection has been largely overlooked and their potential utility is under appreciated. The effectiveness of disposable face masks may be increased by sealing the edges of the mask to the face.

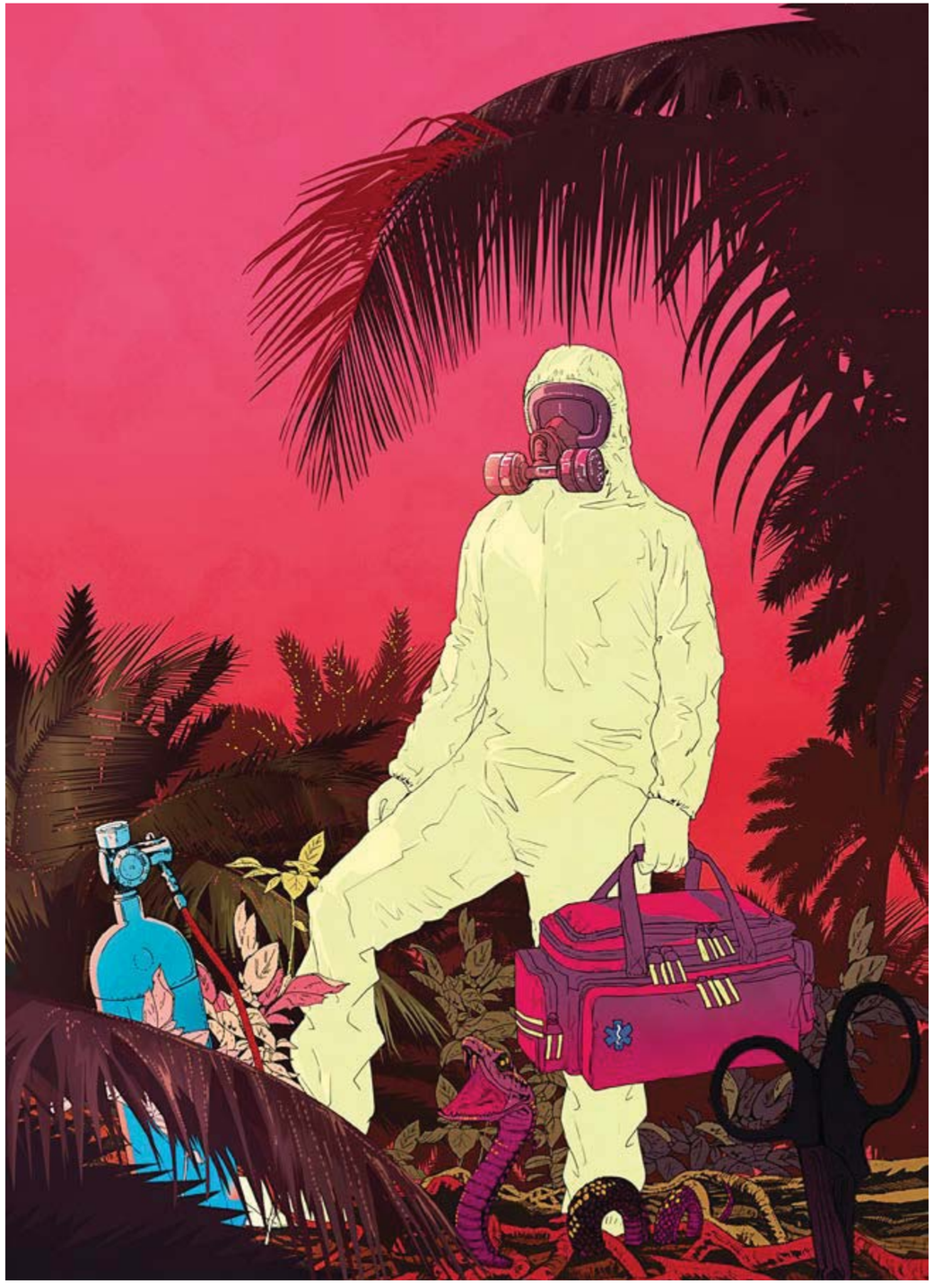


Illustration for Wired uk: How to shut down a epidemic. Credit: Shotopop

DEVELOPMENT

Water virology started about half a century ago when scientists attempted to detect the polio virus in water samples. Since then, other pathogenic viruses that are responsible for gastroenteritis, hepatitis, and many other virus strains have replaced enteroviruses as the main aim for detection in the water environment.

But What's the Right Path?

DISPOSABLE VS REUSABLE

HANDLING
> Reusable - There are risks with surrounding the behavior of taking the mask on and off. Proper hygiene of hands and device is critical and must be encouraged. A reusable product could potentially have a higher cost and therefor be better produced.

> Disposable - Could be safer but there still need to be a hygiene ritual surrounding it use and safe disposable bins.

FIT
> Reusable - Needs to be sealed somewhere and somehow, but still comfortable. With the reusable ones on the market they are sealed on the face and held with straps. Other possibilities if not the face would be the neck, which could either be claustrophobic or uncomfortable.

> Disposable - Today's masks needs to be molded around the face, and the few studies done on the subject, shows that most do not know how to do this properly and that there is still a significant amount of leakage. A new and more effective solution is needed.

MATERIAL
> Reusable - Could be made with higher performing materials. Filters still needs to be disposable

> Disposable - The amount of waste will be a problem. Stockpiling will be another one. The cost could be higher. It all comes down to how the product solves varying problems. Maybe it's wort the waste? Maybe there is a solution in between.

Other points that are just general considerations for both that cannot be comparable with out concepts are the following.

EASY TO STORE AND BRING
A resuable product would need to be protected from contamination and scratches when not in use. A protective case you can put in your handbag, briefcase or backpack could be an interesting solution. A product with similar problems one can compare with is eyewear. However, when it comes to a disposable product, you should be able to pack them as efficiently and with as little packaging as possible.

BREATH AND HUMIDITY
Breath does not only cause condensation but also builds up humidity which is a problem for the filter's ability to fight off viruses and bacteria. Layers of absorbent material could be interesting.

EYEWEAR, HEADPHONES, HAIR
A solution which allows the use of eyewear and headphones is desirable. Some will risk their lives by not wearing bicycle helmets due to the fact that it messes up their hair. Staying away from trapping hair is a bonus.

THE DONNING AND DOFFING
This action, I've concluded (only by imagining the scenarios) needs to be a ritual and preferably close to a sink so one can wash the hands. I don't wish to invoke a behavior of casually taking the mask on and off, since the risk of mishandling and contracting diseases from the mask itself is too great.

EATING AND DRINKING
Minimum requirement could be drinking. Consuming food or beverages is a behavior which, depending on how and where, could be a risk factor. If it is deemed to be permissible it should be solved by other means than actually removing the mask completely.

Pandemic Alert Phase

BEFORE, DURING OR IN BETWEEN

The following text is excerpts from the WHO web page concerning pandemics and their phases. [1] In the 2009 revision of the phase descriptions, WHO has retained the use of a six-phased approach for easy incorporation of new recommendations and approaches into existing national preparedness and response plans. The grouping and description of pandemic phases have been revised to make them easier to understand, be more precise and be based upon observable phenomena. Phases 1–3 correlate with preparedness, including capacity development and response planning activities, while Phases 4–6 clearly signal the need for response and mitigation efforts. [1]

PHASE 1. In nature, influenza viruses circulate continuously among animals, especially birds. Even though such viruses might theoretically develop into pandemic viruses, in Phase 1 no viruses circulating among animals have been reported to cause infections in humans.

PHASE 2. An animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans, and is therefore considered a potential pandemic threat.

PHASE 3. An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks. Limited human-to-human transmission may occur under some circumstances, for example, when there is close contact between an infected person and an unprotected caregiver. However, limited transmission under such restricted circumstances does not indicate that the virus has gained the level of transmissibility among humans necessary to cause a pandemic.

PHASE 4. Is characterized by verified human-to-human transmission of an animal or human-animal influenza reassortant virus able to cause "community-level outbreaks." The ability to cause sustained disease outbreaks in a community marks a significant upwards shift in the risk for a pandemic. Any country that suspects or has verified such an event should urgently consult with WHO so that the situation can be jointly assessed and a decision made by the affected country if implementation of a rapid pandemic containment operation is warranted. Phase 4 indicates a significant increase in risk of a pandemic but does not necessarily mean that a pandemic is a forgone conclusion.

PHASE 5. Is characterized by human-to-human spread of the virus into at least two countries in one WHO region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short.

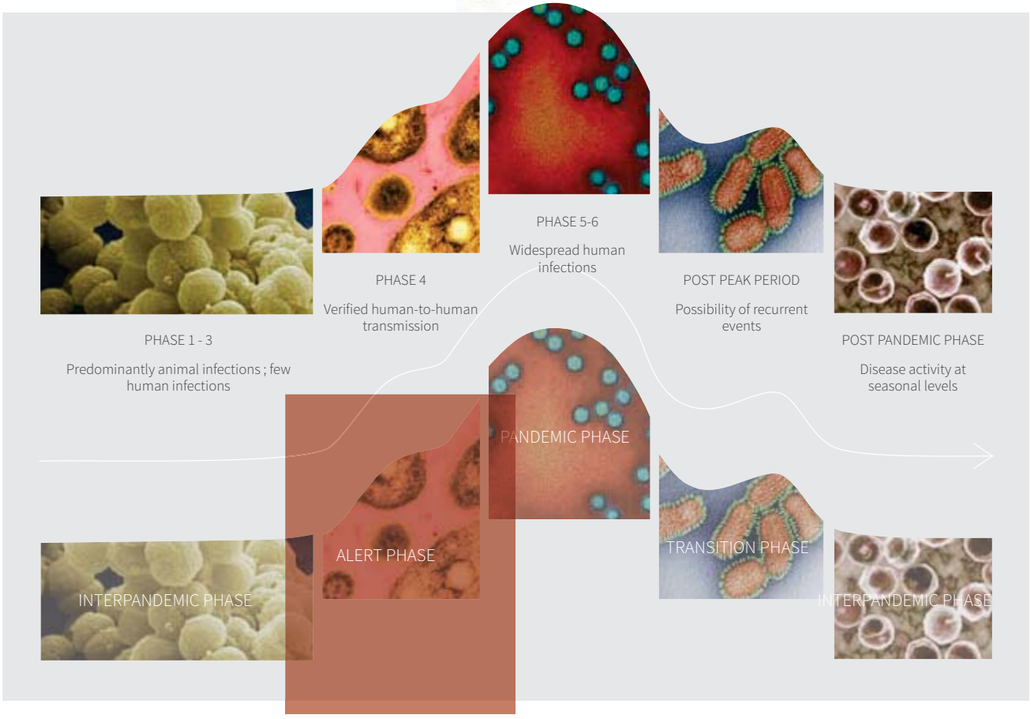
PHASE 6. The pandemic phase, is characterized by community level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is under way.

1. *Current WHO phase of pandemic alert for Pandemic (H1N1) 2009*, Global Alert and Response, WHO

WHO PANDEMIC PHASE DESCRIPTIONS AND MAIN ACTIONS BY PHASE

PHASE	DESCRIPTION	MAIN ACTIONS				
		PLANNING AND COORDINATION	SITUATION MONITORING AND ASSESSMENT	COMMUNICATIONS	REDUCING THE SPREAD OF DISEASE	CONTINUITY OF HEALTH CARE PROVISION
PHASE 1	No animal influenza virus circulating among animals have been reported to cause infection in humans.	Develop, exercise, and periodically revise national influenza pandemic preparedness and response plans.	Develop robust national surveillance systems in collaboration with national animal health authorities, and other relevant sectors.	Complete communications planning and initiate communications activities to communicate real and potential risks.	Promote beneficial behaviours in individuals for self protection. Plan for use of pharmaceuticals and vaccines.	Prepare the health system to scale up.
PHASE 2	An animal influenza virus circulating in domesticated or wild animals is known to have caused infection in humans and is therefore considered a specific potential pandemic threat.					
PHASE 3	An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks.					
PHASE 4	Human to human transmission of an animal or human-animal influenza reassortant virus able to sustain community-level outbreaks has been verified.	Direct and coordinate rapid pandemic containment activities in collaboration with WHO to limit or delay the spread of infection.	Increase surveillance. Monitor containment operations. Share findings with WHO and the international community.	Promote and communicate recommended interventions to prevent and reduce population and individual risk.	Implement rapid pandemic containment operations and other activities; collaborate with WHO and the international community as necessary.	Activate contingency plans.
PHASE 5	The same identified virus has caused sustained community level outbreaks in two or more countries in one WHO region.	Provide leadership and coordination to multisectoral resources to mitigate the societal and economic impacts.	Actively monitor and assess the evolving pandemic and its impacts and mitigation measures.	Continue providing updates to general public and all stakeholders on the state of pandemic and measures to mitigate risk.	Implement individual, societal, and pharmaceutical measures.	Implement contingency plans for health systems at all levels.
PHASE 6	In addition to the criteria defined in Phase 5, the same virus has caused sustained community level outbreaks in at least one other country in another WHO region.					
POST PEAK PERIOD	Levels of pandemic influenza in most countries with adequate surveillance have dropped below peak levels.	Plan and coordinate for additional resources and capacities during possible future waves.	Continue surveillance to detect subsequent waves.	Regularly update the public and other stakeholders on any changes to the status of the pandemic.	Evaluate the effectiveness of the measures used to update guidelines, protocols, and algorithms.	Rest, restock resources, revise plans, and rebuild essential services.
POST PANDEMIC PERIOD	Levels of influenza activity have returned to the levels seen for seasonal influenza in most countries with adequate surveillance.	Review lessons learned and share experiences with the international community. Replenish resources.	Evaluate the pandemic characteristics and situation monitoring and assessment tools for the next pandemic and other public health emergencies.	Publicly acknowledge contributions of all communities and sectors and communicate the lessons learned; incorporate lessons learned into communications activities and planning for the next major public health crisis.	Conduct a thorough evaluation of all interventions implemented.	Evaluate the response of the health system to the pandemic and share the lessons learned.

World Health Organization



Closing in on the Target

IMMUNOCOMPROMISED VS RISK EXPOSURE

Immunodeficiency (or immune deficiency) is a state in which the immune system's ability to fight infectious disease is compromised or entirely absent. Those very likely to be immunocompromised are individuals who has had an organ transplantation and they have to protect themselves, very generally speaking, against infectious diseases. In order for their body to not reject the transplant they need to take immunosuppressant drugs. A common side-effect of many immunosuppressive drugs is immunodeficiency.[1] In Europe there are 30.000 transplantations of heart, kidney and liver every year.[2] Additionally, they who suffer from and advanced HIV infection and the loss of the thymus at an early age both result in severe immunodeficiency.[1]

Risk group 2 with varying levels of immunodeficiency are those with a genetic predisposition for it or undergoing chemotherapy for cancer treatment. 1 Pregnant women has a level of immunodeficiency, since it keeps your body from fighting off the baby, but even the seasonal flu can be more dangerous in pregnant women.[3] Other common causes of poor immune function in developed countries are obesity, alcoholism, and drug use.[1] The two other risk groups consist of those who either have or choose to expose themselves to risk by being in situations where they are in confined spaces with others for extended periods in a day.

Therefor is risk group 3, during a pandemic alert phase, those that through their occupation are exposed to many individuals in a confined environment. Such as flight attendants, hospital and clinic staff, receptionists working close to the waiting room, medical outreach services, nurses, cleaning staff, certain groups in the Public sector - e.g. teachers. Fatigue and stress in these group also effects their immune system's ability to fight off diseases.

The impact of air travel on the spread of infectious diseases has led to considerable concern but limited study. More than 1 billion people travel by air each year.[4] We all of course face risks during a pandemic alert phase in public and confined places. Risk group 4 could be anyone who are a frequent flyer or travellers. If the alert should move into phase 6 there could be many more situations this group should protect themselves in.

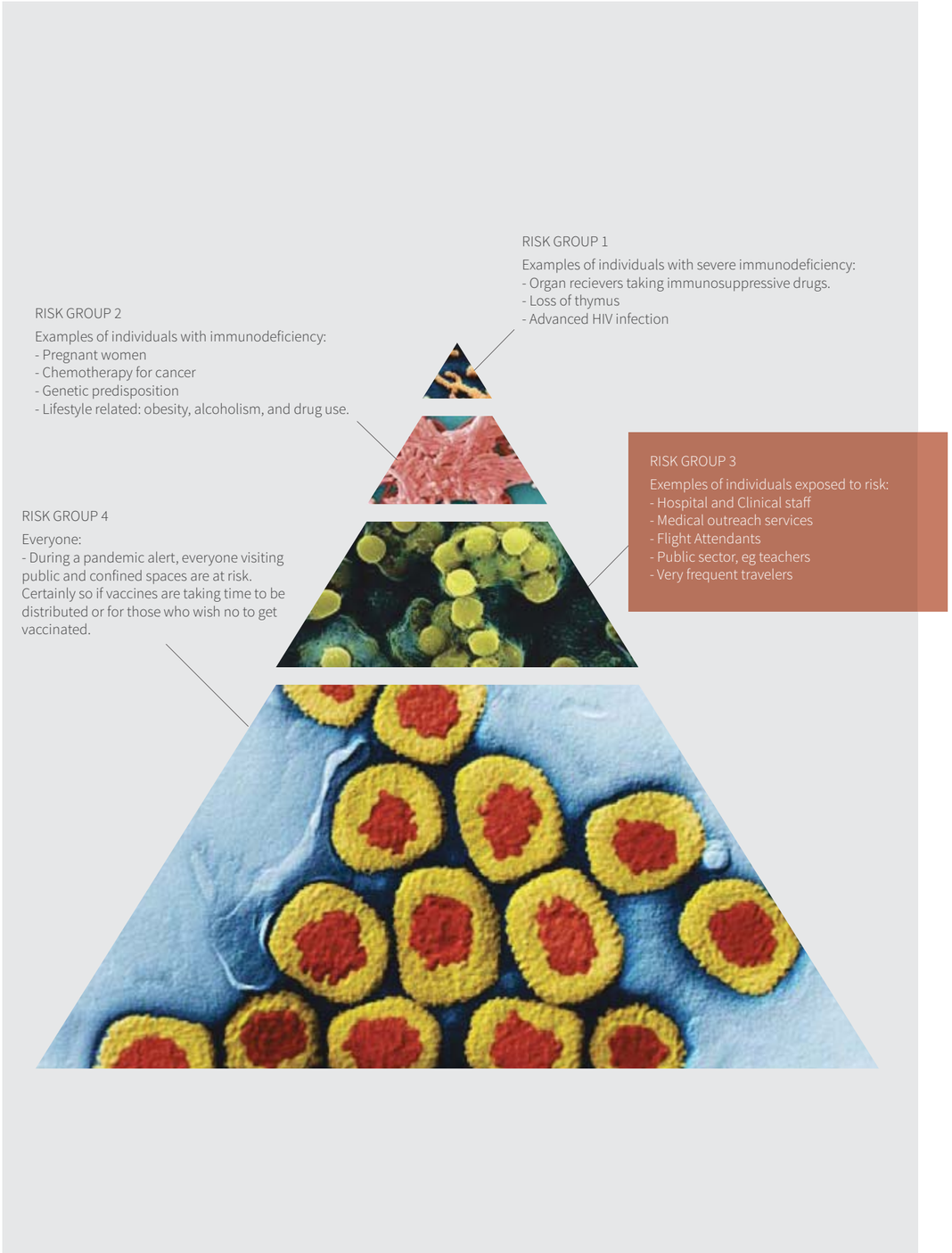
1. *Immunodeficiency*, Wikipedia, 2014

2. *Organ donation and transplantation*, NHS Confederation

3. *Infections in Pregnancy*, by the Healthline Editorial Team, 2012

4. *Germs on a Plane: Aircraft, International Travel, and the Global Spread of Disease*, Division of Pediatric Infectious Diseases, Departments of Pediatrics and Medicine, University of Utah, Andrew T. Pavia, 2006.

5. *Research studies spread of infectious disease on aircraft*, Georgia Institute of Technology, Research Communications for ScienceDaily, 2012.



The Art of Flight

HOW AN ALERT PHASE TURNS FOR THE WORSE

Airborne infectious diseases transmitted during commercial air travel are of concern to public health officials. In 2002, 20 people on an international flight were infected by a single SARS patient, which showed how air travel could serve as a conduit for the rapid spread of both emerging infections and pandemics of known diseases.

Researchers know that bacteria and viruses can be transmitted in all three ways on aircraft: inhalation of small droplets coughed or sneezed by infected persons and carried significant distances in cabin air; inhalation of larger droplets that tend to fall within a meter of their sources, and transfer of droplets from surfaces into the eyes or noses of susceptible individuals. The latter which may account for as much as 80 percent of the disease transmission can occur when passengers touch contaminated surfaces; surfaces such as seat tray tables, lavatory door knobs or sink handles. [2] The same scenario and risks can be seen in waiting rooms, classrooms, buses, etc.

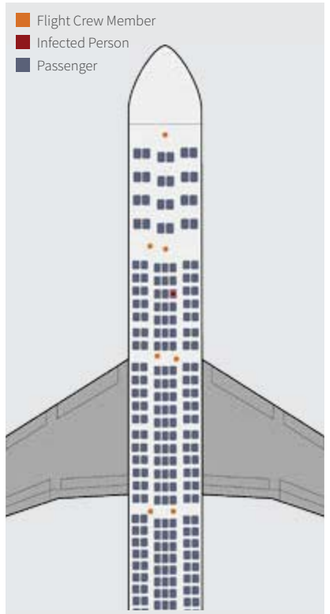
The reasons for me to focus on Risk Group 3 (see previous page) is that they are exposed by working among many other individuals in a confined space for a certain amount of time. They could also be a threat to others if they should become infectious themselves. . Risk Group 1 and 2 already live with a risk of contracting many kinds of infections; infections which are usually non-lethal but could be for them. It is not difficult to argue that Group 1 and 2 should stay away from travelling by air during a pandemic alert phase.

Risk Group 4: “Everyone Else” consists of those who wish or need to travel during an alert phase. This group could be difficult to persuade to wear such a protection unless conditions are really bad. There is a lot of behavior we know to be dangerous, but that we still continue to do, no matter how aware we are of them. In the scenario for this concept one could argue that a way to reach them is for this group to be around professionals who are protecting themselves. Maybe that could ease the acceptance of such a protection. “If they are wearing it, maybe I should too...”

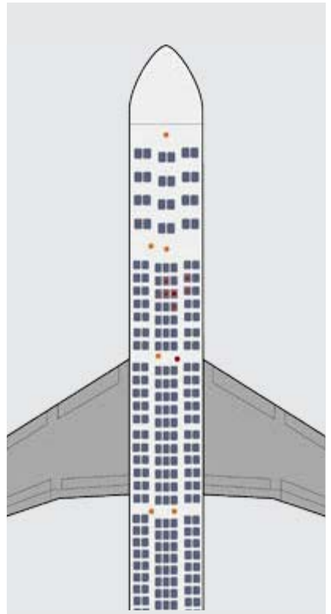
Air travel and the scenario described on the following page is just an reminder and example of how and why things can go wrong rapidly. The same scenario is applicable in a health care setting and many other public spaces and professions.

1. *Germs on a Plane: Aircraft, International Travel, and the Global Spread of Disease*, Division of Pediatric Infectious Diseases, Departments of Pediatrics and Medicine, University of Utah, Andrew T. Pavia, 2006.

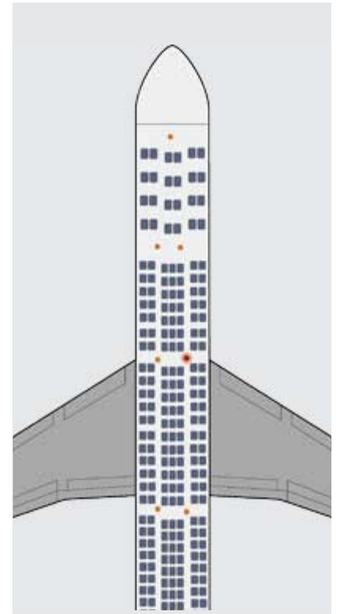
2. *Research studies spread of infectious disease on aircraft*, Georgia Institute of Technology, Research Communications for ScienceDaily, 2012.



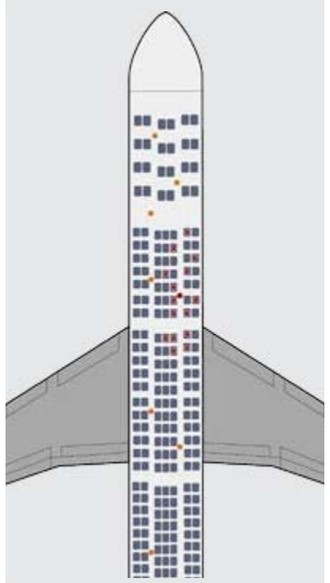
1. One of the passengers is unawarely sick, but not symptomatic when he boards the plane.



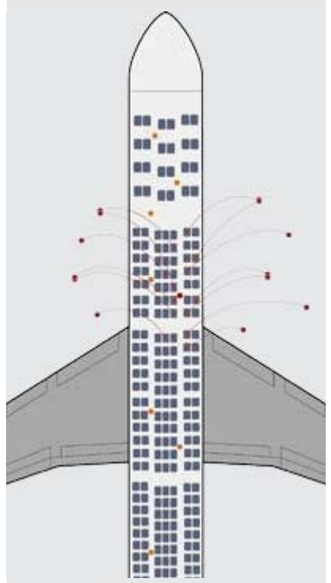
2. During the flight the disease is transmitted to the passengers surrounding him, but also one of the crew members.



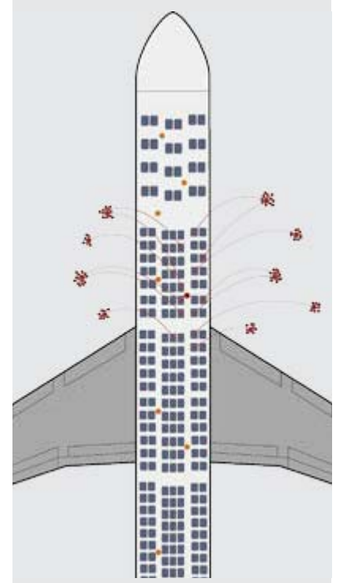
3. The second day, the flight is returning and the crew member doesn’t feel ill enough to pay much attention to it.



4. During the return flight the ill crew member developes a few symptoms, nothing she pays attention too, but is contagious and spreads the disease to 15 of the passengers.



5. Unbeknownst to them, the contagious passengers travel on to their destinations.

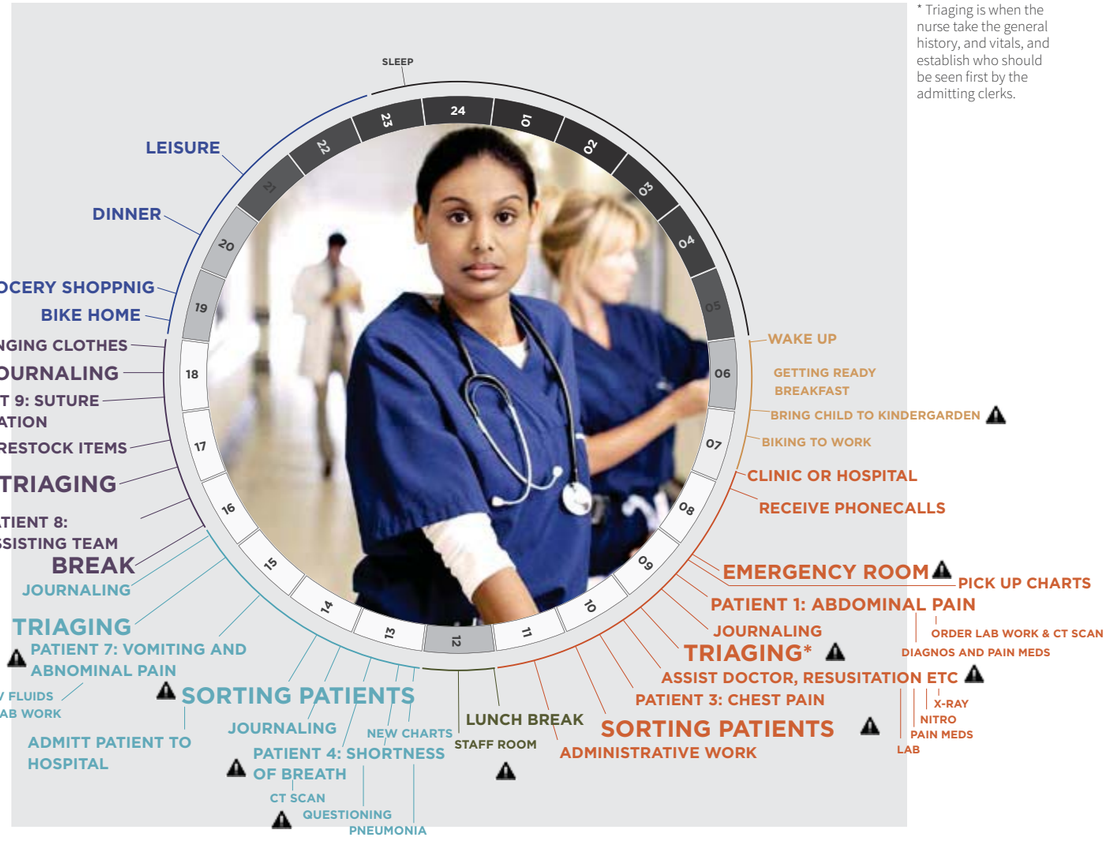


6. Spreading the disease to fellow travellers on the way and/or family.

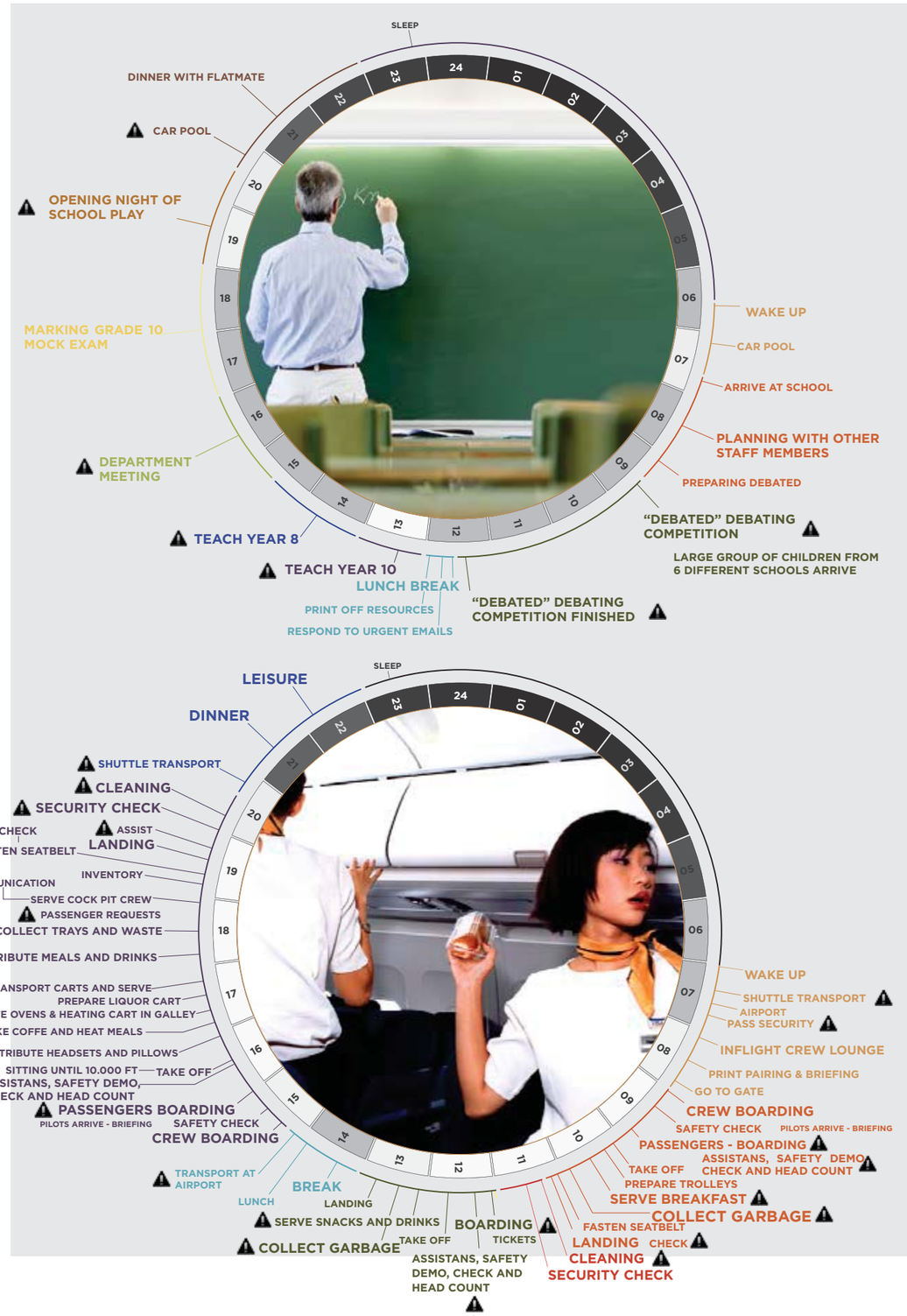
That’s how a pandemic could start.

360

AN ER NURSE, A FLIGHT ATTENDANT AND A TEACHER



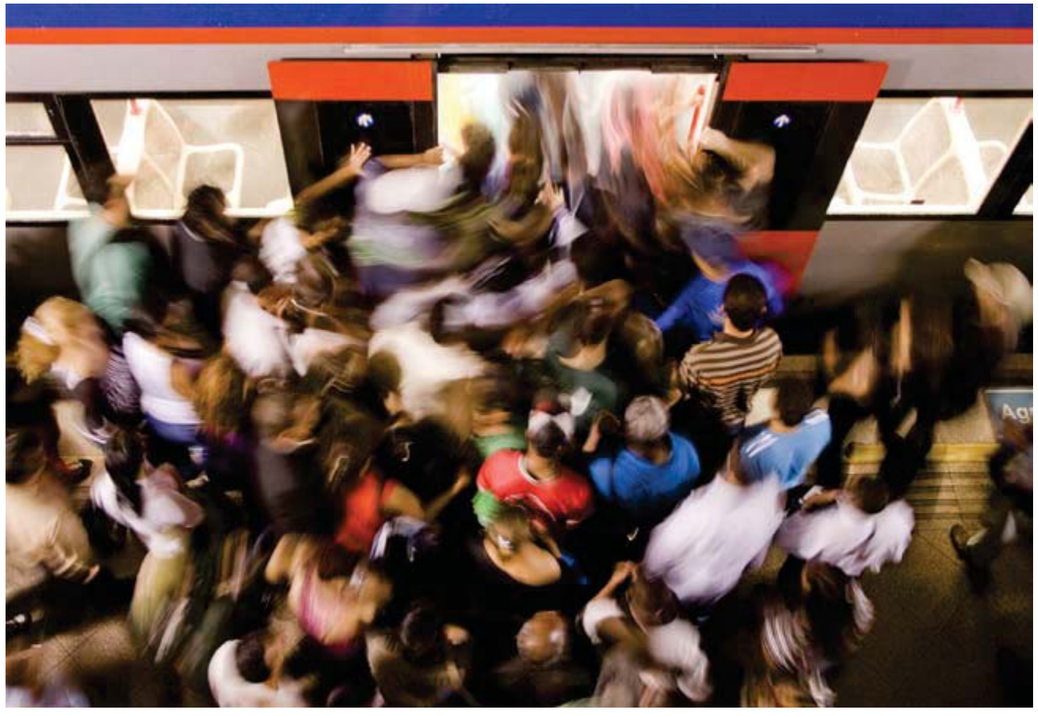
* Triaging is when the nurse take the general history, and vitals, and establish who should be seen first by the admitting clerks.

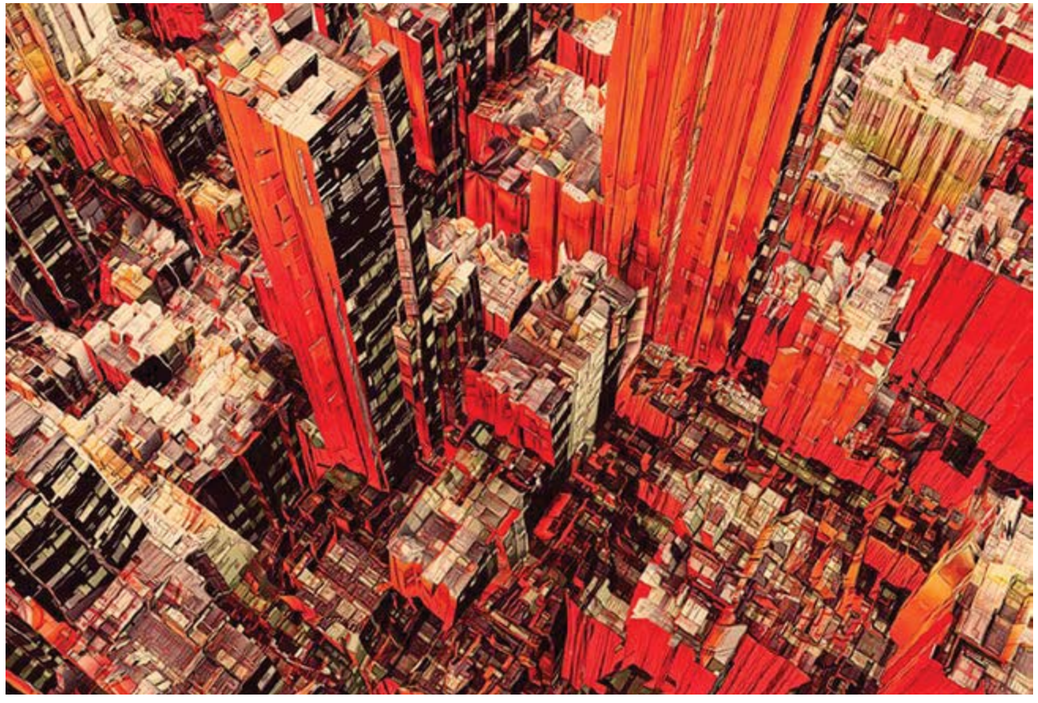


Brief 2

WHEN, WHERE, WHY, HOW

Delaying the entry of a virus into the population by protecting those who work with a higher risk of exposure and transmission, which is especially important during a pandemic alert phase. How? By using existing materials and technologies the aim is to improve the efficiency and lessen the risks which today's respirators has. Main focus on the emotional response, leakage, face-touching and communication.





Questionnaire

AESTHETICS OF WEARABLE DEVICES

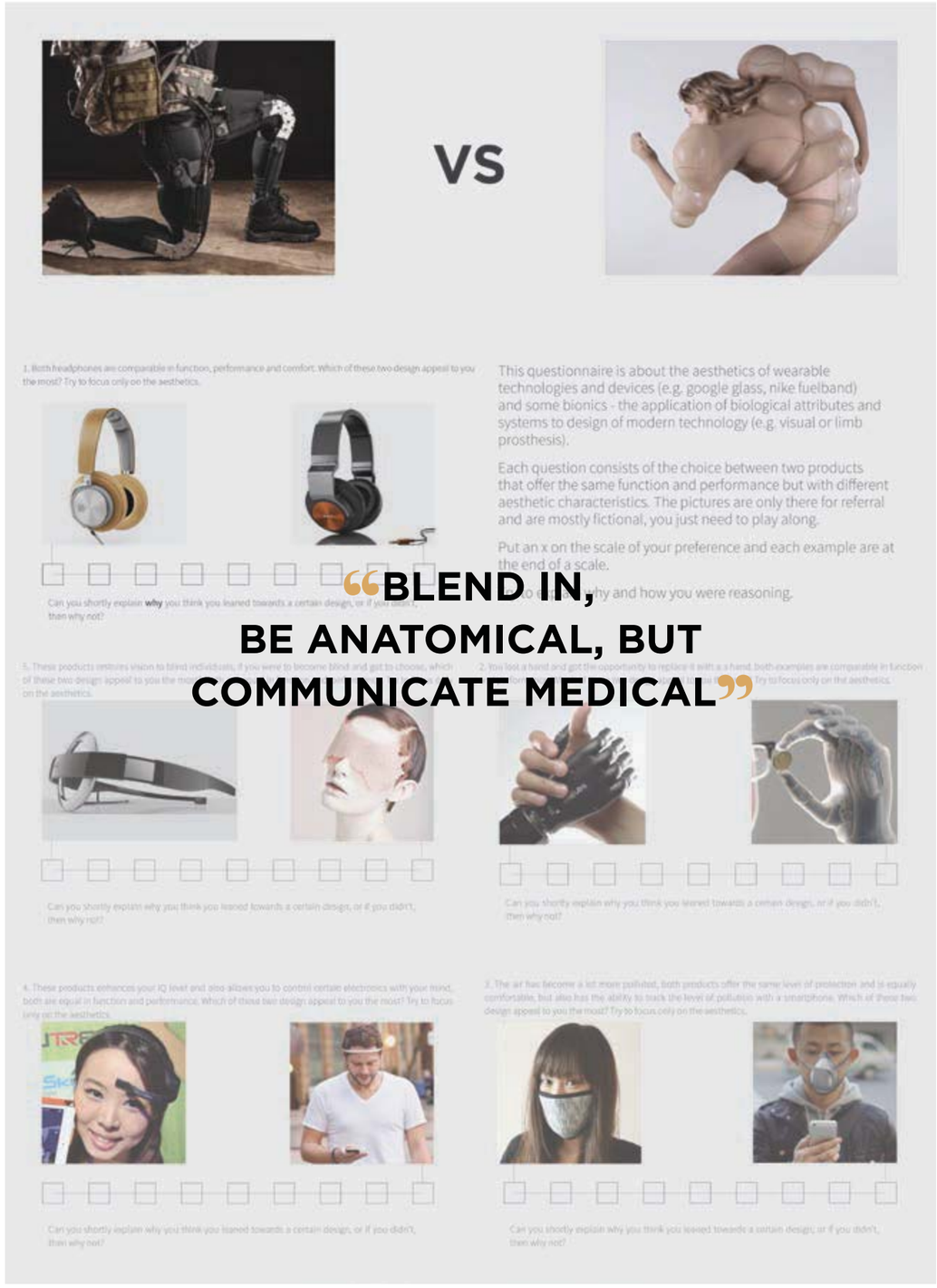
This research was done as assignments for the in course *Design Research*, prior to this project. What I learnt from that research is very much applicable to this project since the topic was consciously chosen - aesthetics of wearable devices. A recent report defines wearable technology as 'being worn for an extended period of time, with the user experience significantly enhanced as a result. [1] The initial topic started as the user and other's perception and feelings towards wearable devices. This was based on the theory, or hypothesis, that when applying technology on the human as an idly constant wearer compared to as temporarily user, that the design (shapes, colors, materials, textures, haptics) has to merge slightly more with the human appearance in order to be a more accepted product. Or as Armağan Kuru and Çiğdem Erbug put it: ...These types of products hold different meanings and intentions for users than off-body products, which may lead to new interpretations... [they reviewed] perceptions of product qualities as early determinants of the experience and response to product appearance. [1]

There were four categories within my research question: 1. Leisure 2. Medical. 3. Utilitarian-Leisure 4. Utilitarian-Medical. The research question got reformulated to: The two main and opposite aesthetic trends of wearable technologies and bionics seem to be tech-looking or anatomically-looking, which is preferred? Does this change depending on which category the product belongs to?

Even though this was a test questionnaire and in a very small scale, there were still very interesting findings and insights which could easily be overseen without this questionnaire. The general conclusion of the result is that the acceptance of leisure products will be harder to predict due to differing and stronger opinions which are much based on personal preferences or experiences. Medical products might have a better reception, if the design has an appearance towards the anatomical, but clearly communicates its purpose and function. Discretion however is valued in both leisure and medical products, extra attention from bystanders makes people uncomfortable with wearing devices.

Users perceive two principal qualities of products throughout their experience: pragmatic [Dealing or concerned with facts or practicality] and hedonic [characterized by pleasure]. While pragmatic qualities are related to product functionality, hedonic attributes measure the user's well-being and psychological goals. In this approach, hedonic qualities are considered as 'motivators' for a positive experience, whereas pragmatic qualities are 'hygienic factors' that remove certain barriers by fulfilling user needs, but are not a direct source of a positive experience. Products can also lead to negative hedonic and pragmatic experiences; poorly designed functions can lead to a negative pragmatic experience and poorly designed emotion-related qualities can lead to a negative hedonic experience. The aesthetics, emotions and meanings assigned to a product are strong contributors to a positive experience. [1] Meaning that no matter how practical a product is it always needs to fulfill the emotional needs such as the aesthetic point of view in order for the user to have a positive experience. Figuring out what a face worn medical device functions, emotional response and aesthetics should be in order to fulfil these hedonic needs will be the future steps.

1. *Explorations of perceived qualities of on-body interactive products*, Armağan Kuru and Çiğdem Erbug, 3 Aug 2012.



* *Organic* – the definition of organic in this context is by looking human, biological, anatomical, and blending in with the human appearance.

Product Function Analysis

MF - Main Function
NF - Necessary Function
DF - Desired Function

BASIC FUNCTION

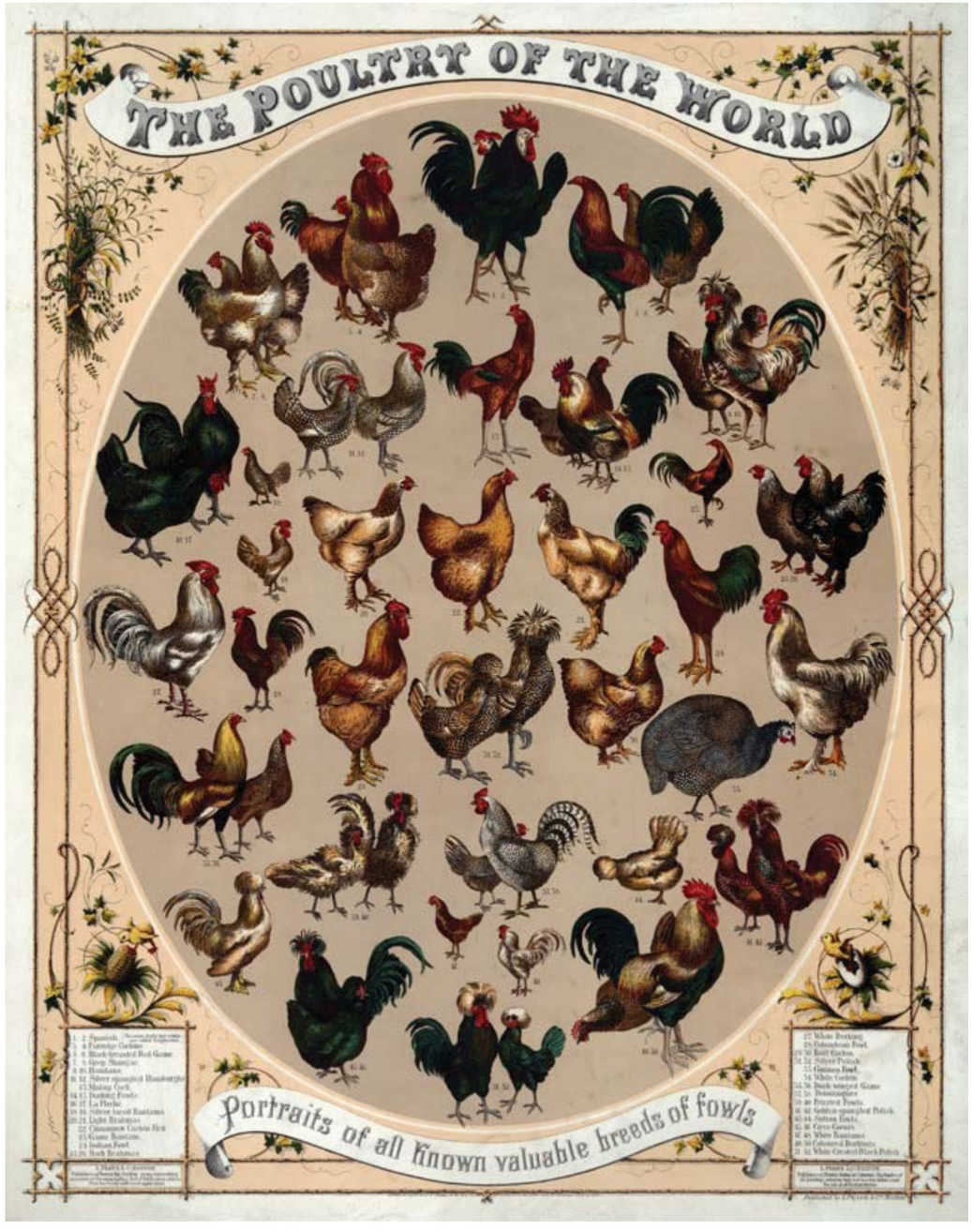
MF	Protect against airborne diseases
NF	Prevent aerosol transmission
NF	Prevent droplet transmission
NF	Prevent contact through secondary transmission through eyes, mouth, nose
NF	Disposable filters
NF	Reusable main mask
NF	Easy to disinfect and dry
NF	Offer absorption of humidity
DF	Be user friendly and prevent mishandling
DF	Invoke a routine of disinfection while donning and doffing
DF	Offer self explanatory use

FEEL

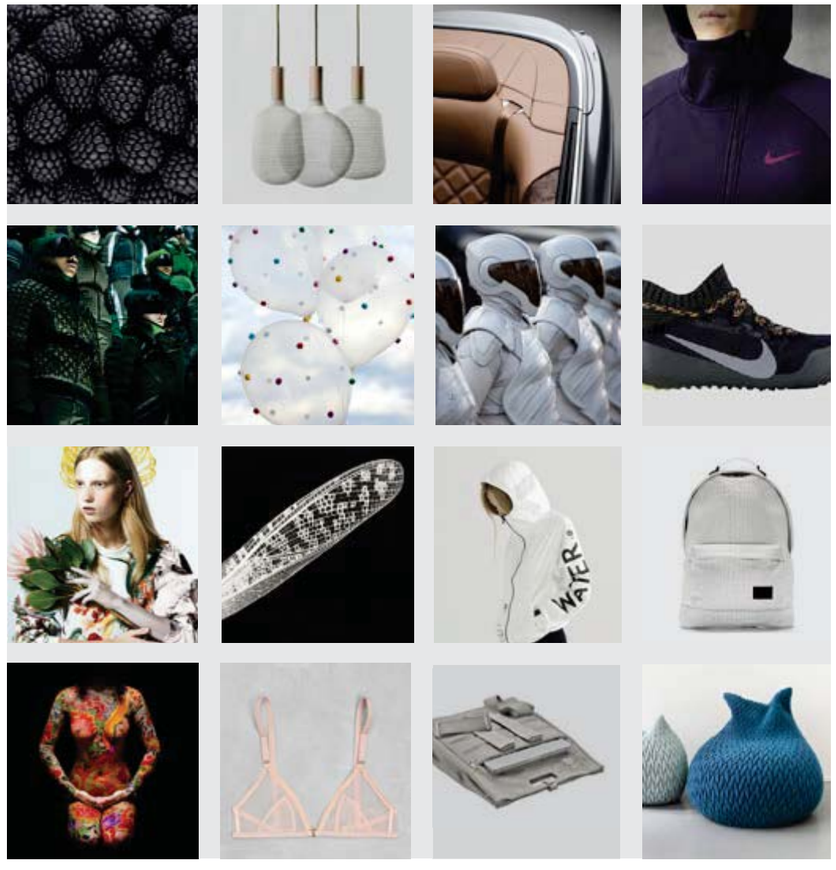
NF	Give a feeling of being anatomical but still slightly medical
NF	Give a feeling to the wearer of safety and comfort
NF	Look hygienic
DF	Offer observers an immediate understanding of its function
DF	Offer some customization
DF	Avoid any negative-hospital feelings
DF	Offer a solution that does not obstruct the entire face, aids communication and prevents anxiety

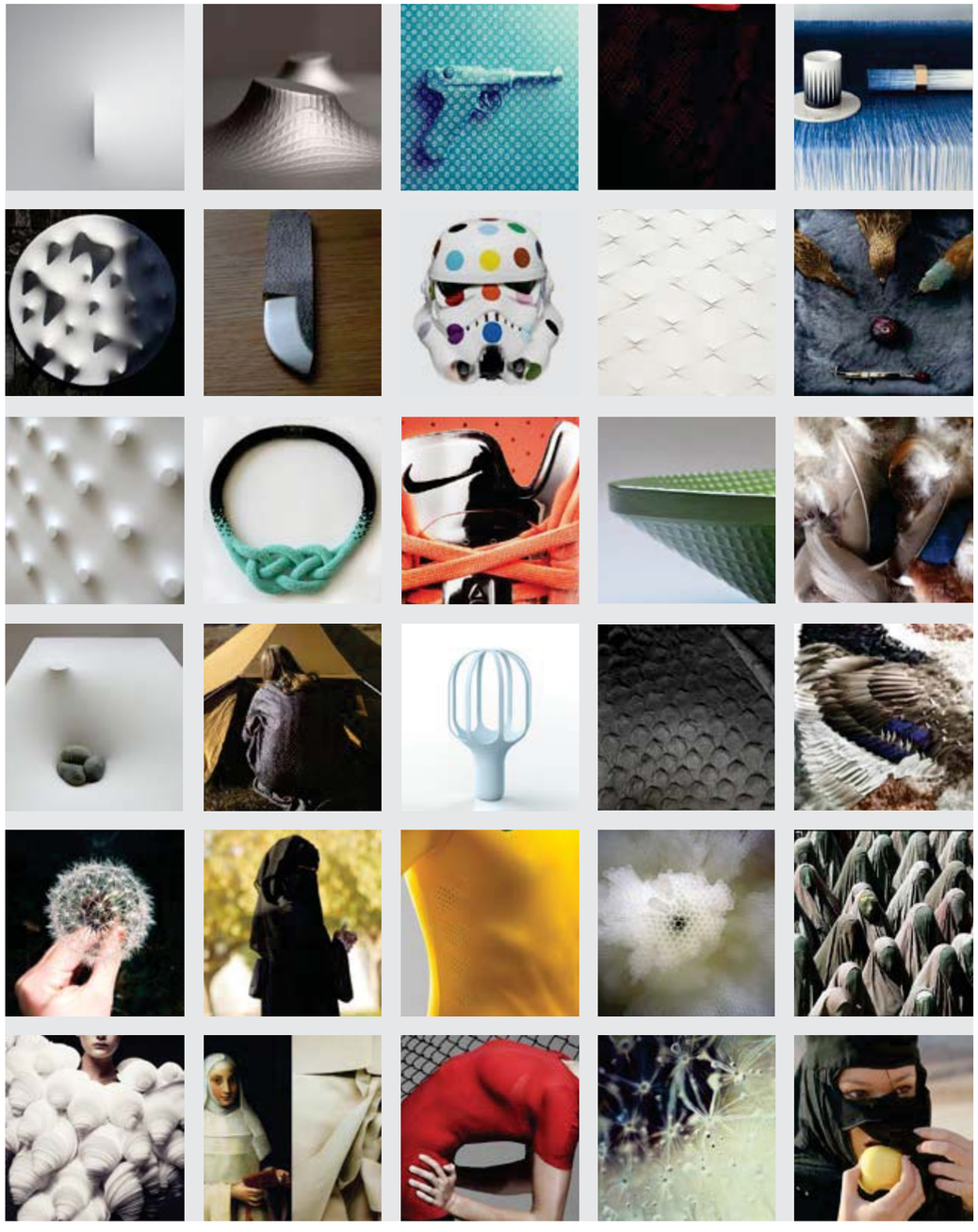
FIT

NF	Comfortable and ergonomic
NF	Adjustable fit
NF	Completely sealed edges
NF	Prevent fog on visor
DF	Enable users to wear eyewear, headphones and headgear



Initial Inspiration





Inspirational Products & Functions

ON THE BORDERS OF MEDICAL

I found inspiration in the materials and some of the functions of a colostomy bag. A colostomy is a surgical procedure that brings one end of the large intestine out through an opening (stoma) made in the abdominal wall. Stools moving through the intestine drain through the stoma into a bag attached to the abdomen. [1]

Colostomy bags are a medical product and for some a product they use for the rest of their lives. They are worn close to the body and attached by adhesive silicone. The colostomy bags also uses tiny filters to let gas pass, both a particle filter and also a carbon filter. Everything well integrated inside of the very discreet bag. A lot of work has put in the adhesive part, since it is indispensable for the wearer that it will not fall off.

SenSura Mio is a new colostomy appliance from *Coloplast* designed with a unique adhesive that is formulated to enhance elasticity and fitting performance: elastic adhesive, pliable to individual body contours and maintains a secure fit thanks to its ability to respond to natural body movement. [2] Other products which are, borderline medical are feminine hygiene products, bandages and plasters. Because they are day-to-day products, used outside of a hospital setting. These kinds of products are designed to be used close to the body or plastered onto it by using some sort of adhesive, are absorbent or filtering. I was interested in finding inspiration for the innovative part in designing a new and more effective respirator.

Some excerpt from *Coloplast's* patches' descriptions. *Biatain Silicone* is a patch which contains soft and conformable polyurethane foam dressing with a semi-permeable, water- and bacteria proof top film and a soft silicone adhesive. *Biatain Super* consists of a super absorbent hydrocapillary pad with a semi-permeable, water- and bacteria proof top film, a hydrocolloid component for the adhesion and a non-adhesive wound contact layer. The semi-permeable topfilm is both bacteria- and shower proof.

From *Hansaplast* we can find similar promising product descriptions. The flexible fabric material stretches with the skin's movements and dries quickly. The waterproof and breathable membrane can help to keep the wound dry. The strong adhesion ensures that the plaster stays in place. These plasters are available as strips in different sizes which can seal around the wound. [4]

In another *Hansaplast* products, the *Therapeutic Heat Pads*, make use of minerals for its extra function. The pads contain iron powder, salt and charcoal. The iron reacts with the oxygen in the air when the pouch is opened and energy and warmth is then released. Salt and charcoal act as modulators and accelerate the chemical reaction. The heating effect lasts for 8 hours at a constant temperature of 40°C. [5] The heat effect might not be something usable for a respiratory protection, but its the use of minerals which is, perhaps for future research, something like this can be applied to solve the problem of humidity within the filters.

Another product category which greatly inspired me when it comes to the user scenario of the respirator were contact lenses. My aim was to prevent casual donning and doffing. Just as with contact lenses, where hygiene is an important step in its usage, I was looking for a scenario which required the use of a mirror and sink and therefor encourages and enabled a routine of adequate hand and mask hygiene. This was another reason I was leaning towards the use of adhesive silicone.

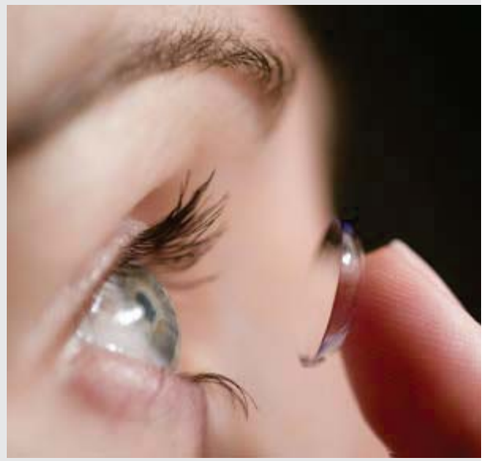
1. *Colostomy*, MedlinePlus, last updated 2014.

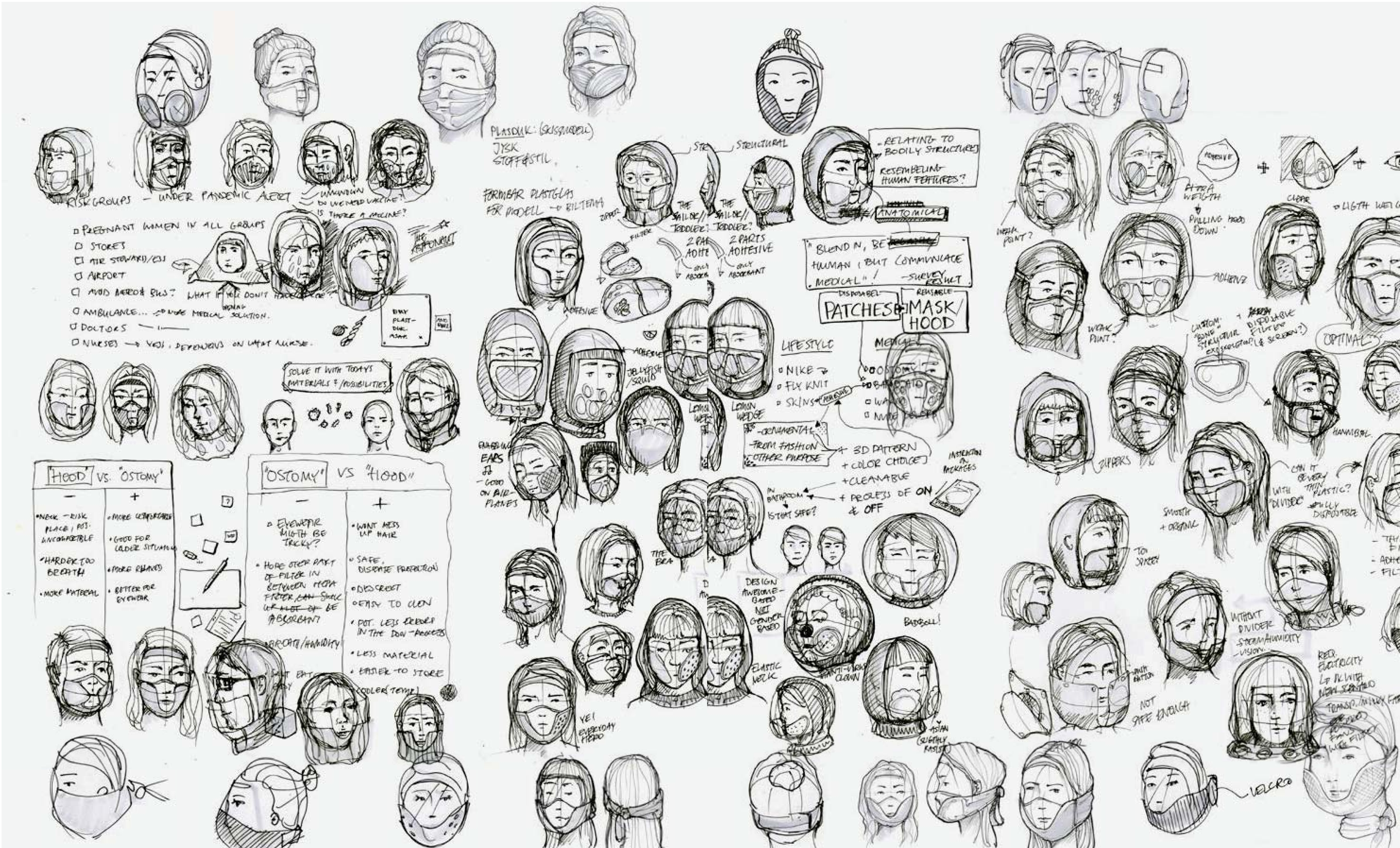
2. *SenSura® Mio 1-piece closed pouch*, Coloplast

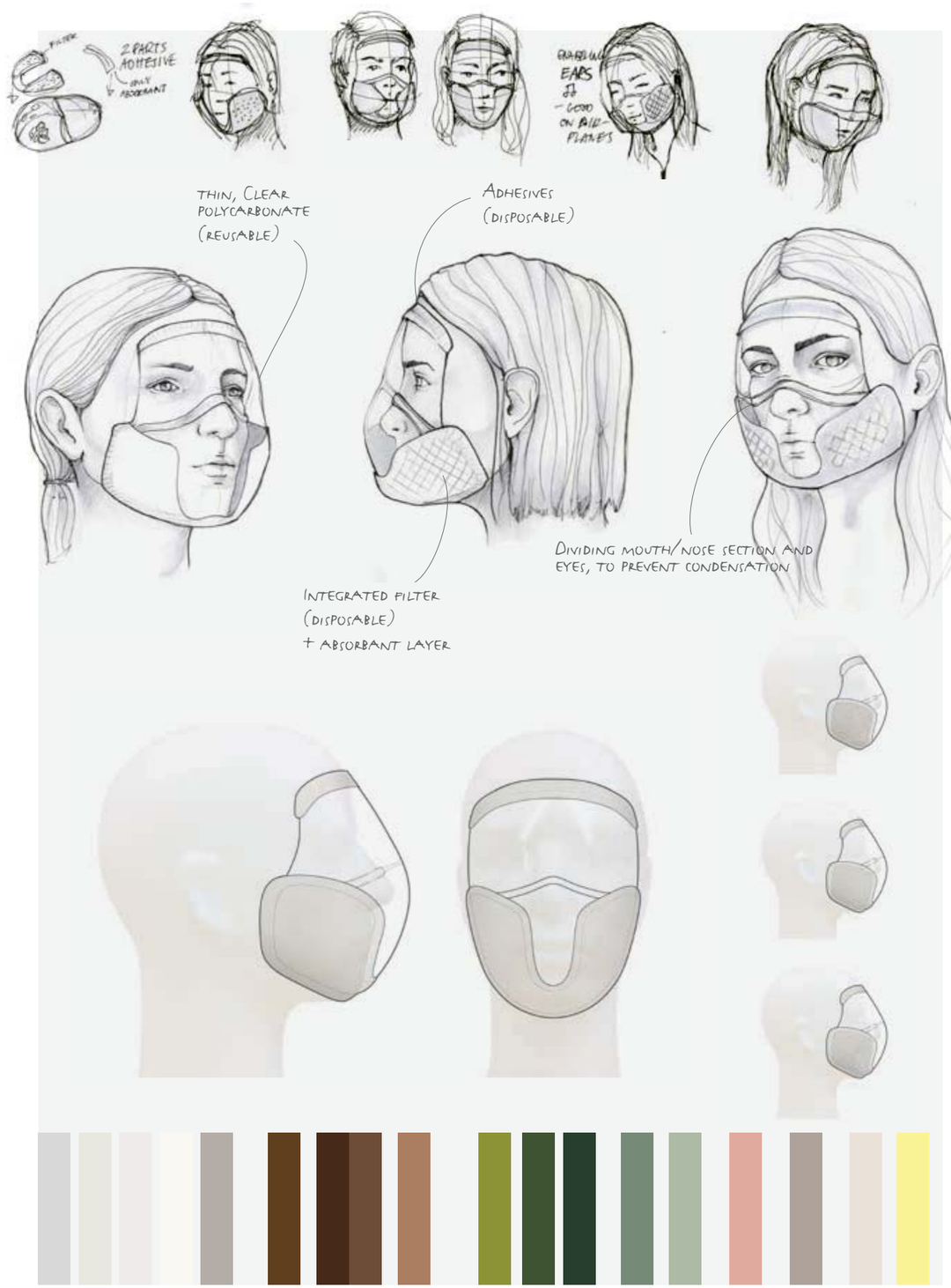
3. *Biatain® Super*, Coloplast

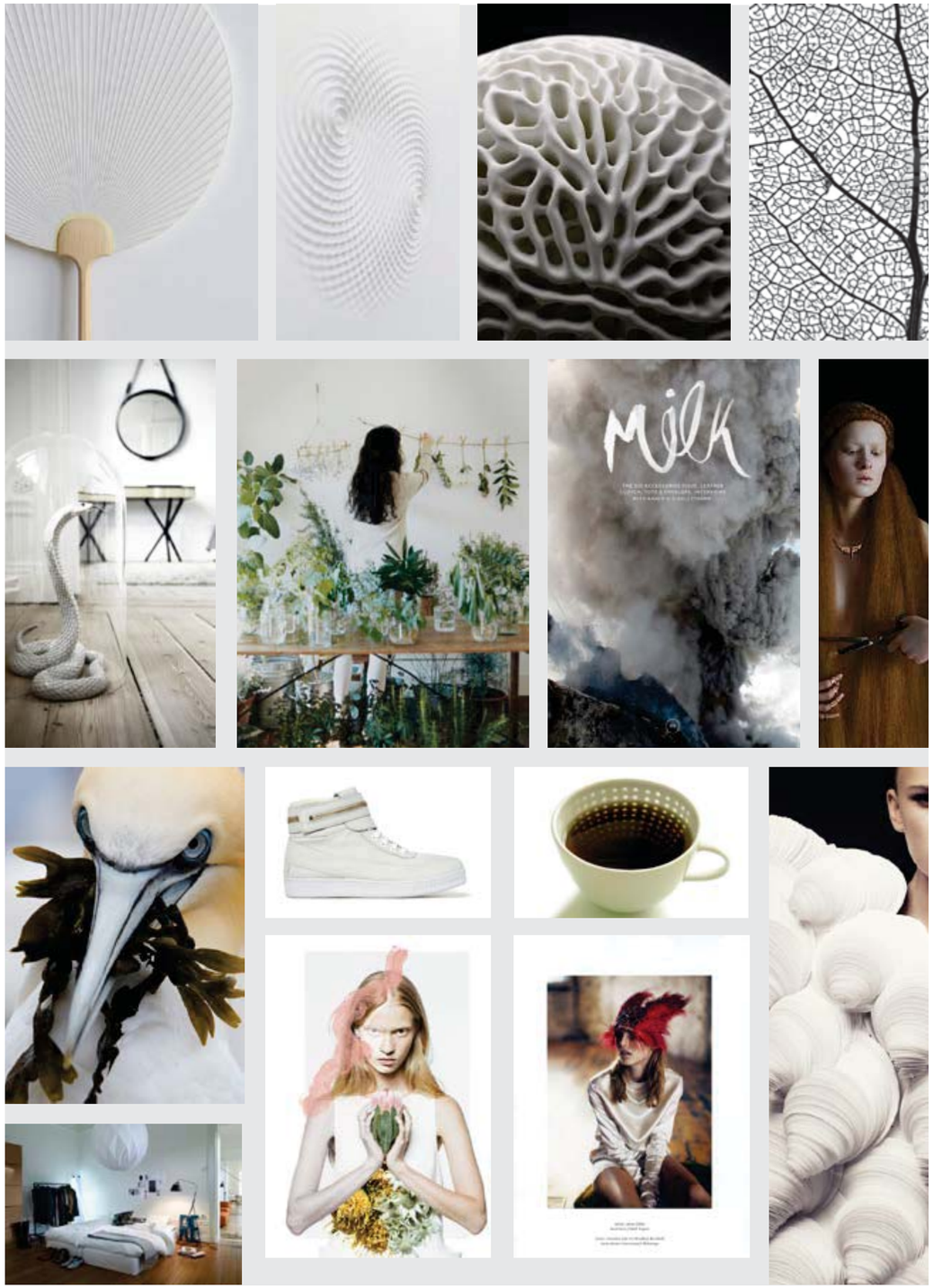
4. *ELASTIC+ WATERPROOF Flexible and Waterproof plaster*, Hansaplast.com

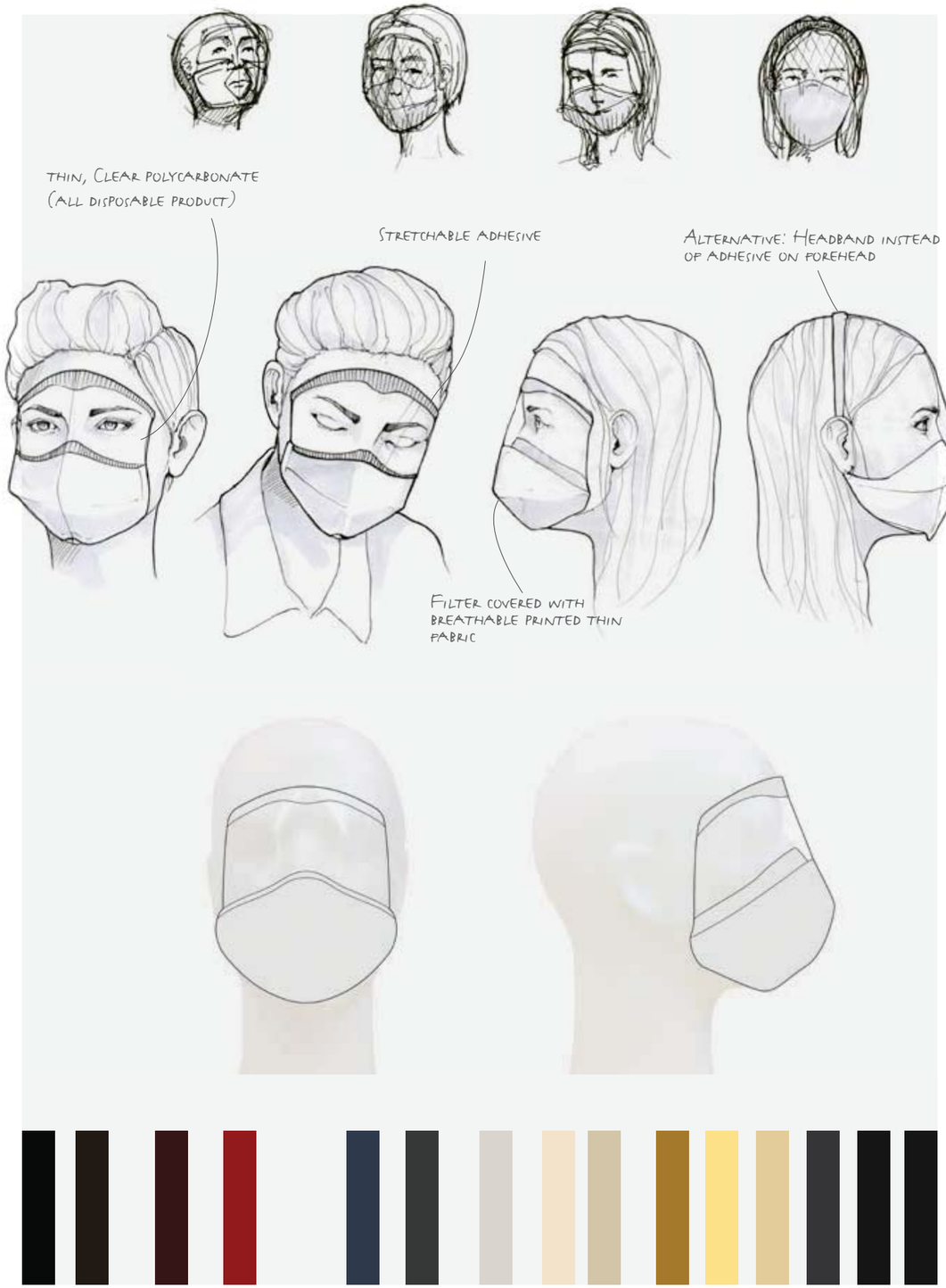
4. *Theraputic Heat Pads*, Hansaplast.com

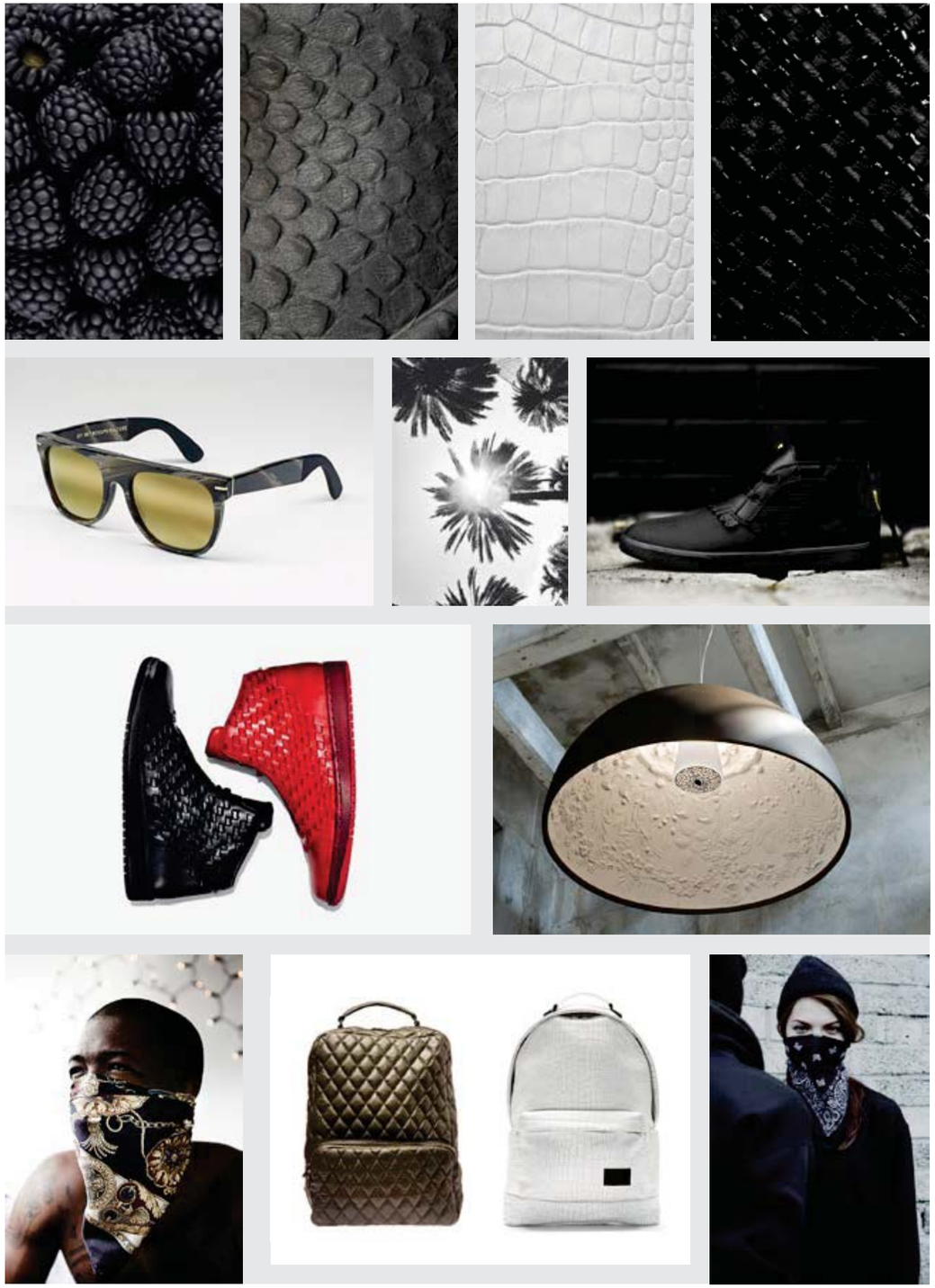



RISK GROUPS - UNDER PANDEMIC ALERT
PREGNANT WOMEN IN ALL GROUPS
STORES
AIRPORT
AMBULANCE...
DOCTORS
NURSES
SOLVE IT WITH TODAYS MATERIALS ? /POSSIBILITIES
"HOOD" VS. "OSTOMY"
"OSTOMY" VS "HOOD"
LESS MATERIAL
EASIER TO STORE
JYSK
STRUCTURAL
RELATING TO BODILY STRUCTURES
RESEMBELING HUMAN FEATURES?
ANATOMICAL
"BLEND IN, BE HUMAN, BUT COMMUNICATE MEDICAL" ! -SURVEY RESULT
DISPOSABEL
REUSABLE
PATCHES
MASK/ HOOD
LIFESTYLE
NIKE
FLY KNIT
3D PATTERN
+ COLOR CHOICE
+CLEANABLE
+ PROCESS OF ON & OFF
IS THAT SAFE?
BABY DOLL!
ELASTIC NECK
YE! EVERYDAY HERO
LIGTH WEIGTH
OPTIMAL
ADHESIVE
ZIPPERS
HANNIBAL
SMOOTH + ORGANIC
THIN PLASTIC FILM.
ADHESIVE TEJP
FILTER
WITHOUT DIVIDER
NOT SAFE ENOUGH
VELCRO

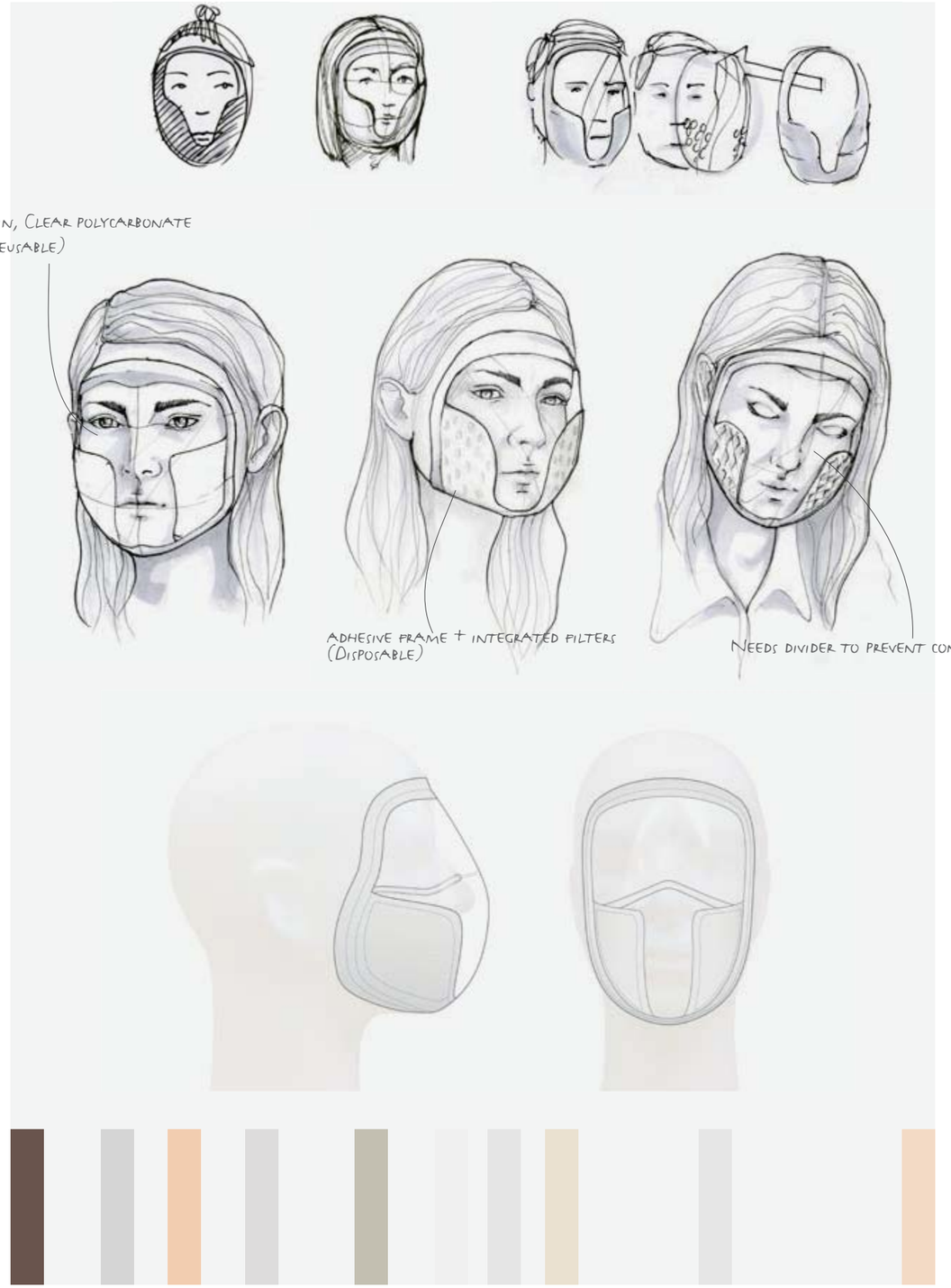

FILTER
2 PARTS ADHESIVE
ONLY ADHERANT
EARS
- GOOD ON AIR-PLANES
THIN, CLEAR POLYCARBONATE (REUSABLE)
ADHESIVES (DISPOSABLE)
DIVIDING MOUTH/NOSE SECTION AND EYES, TO PREVENT CONDENSATION
INTEGRATED FILTER (DISPOSABLE) + ABSORBANT LAYER


Milk

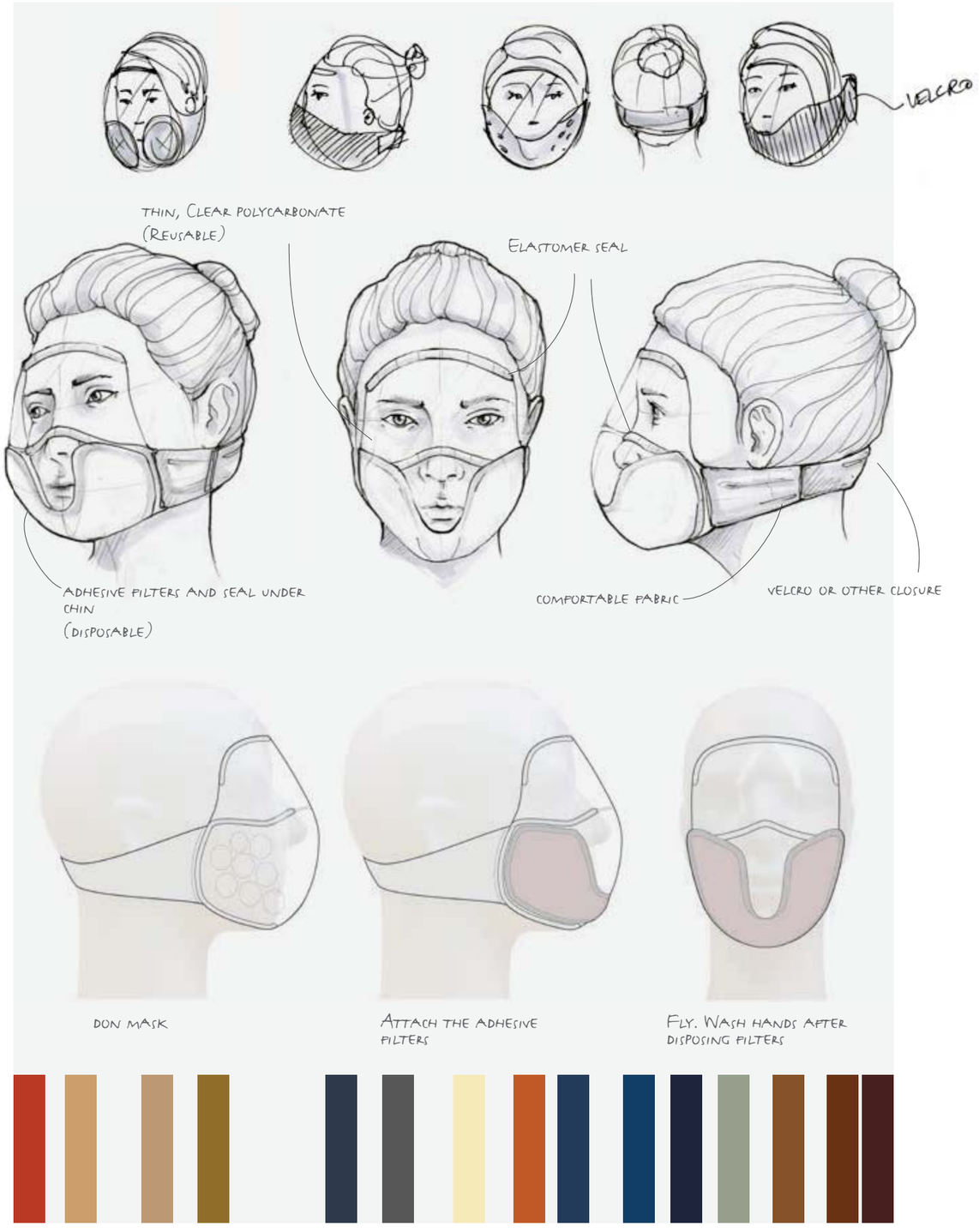




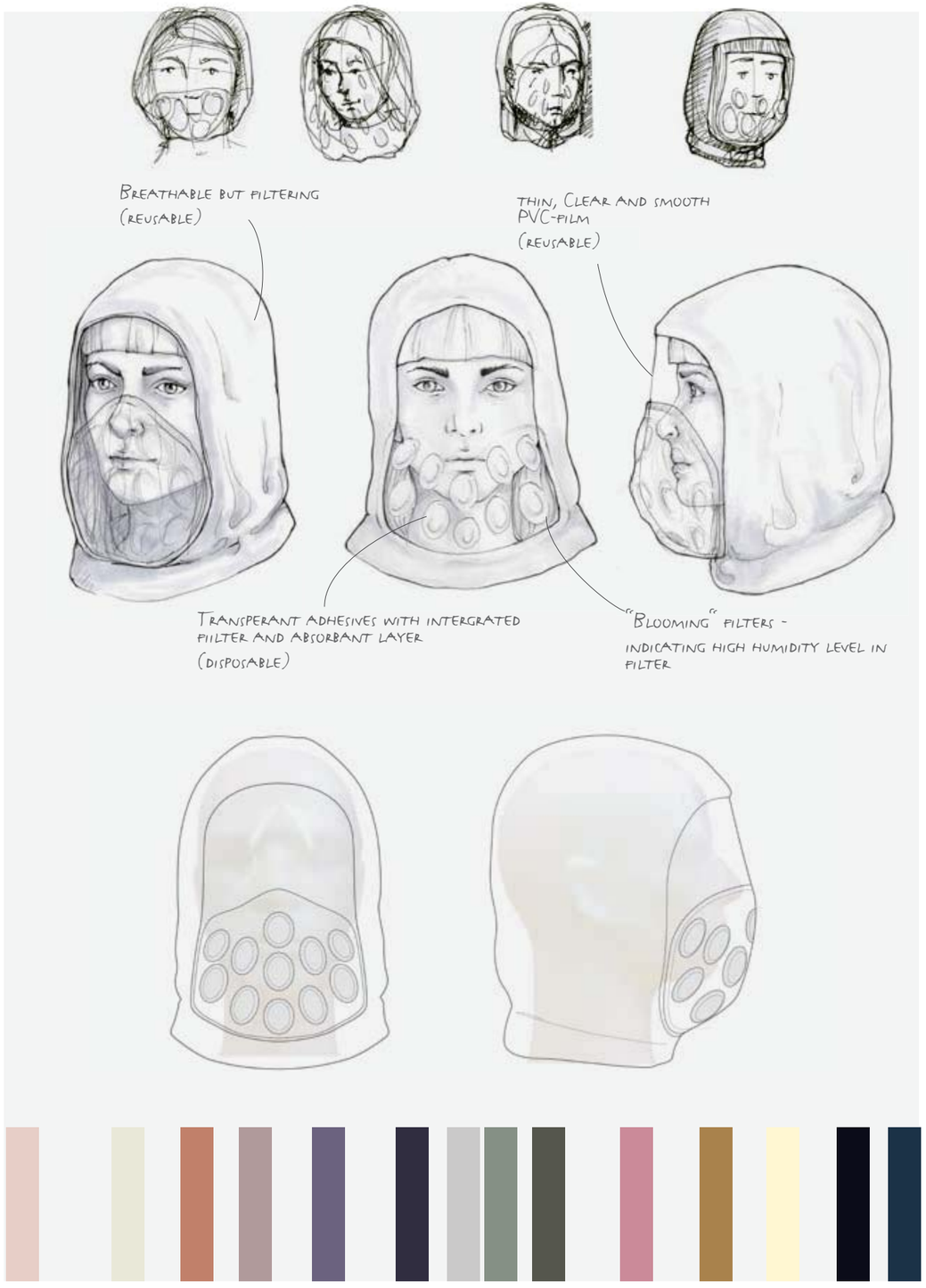
TEXTURED SHADES

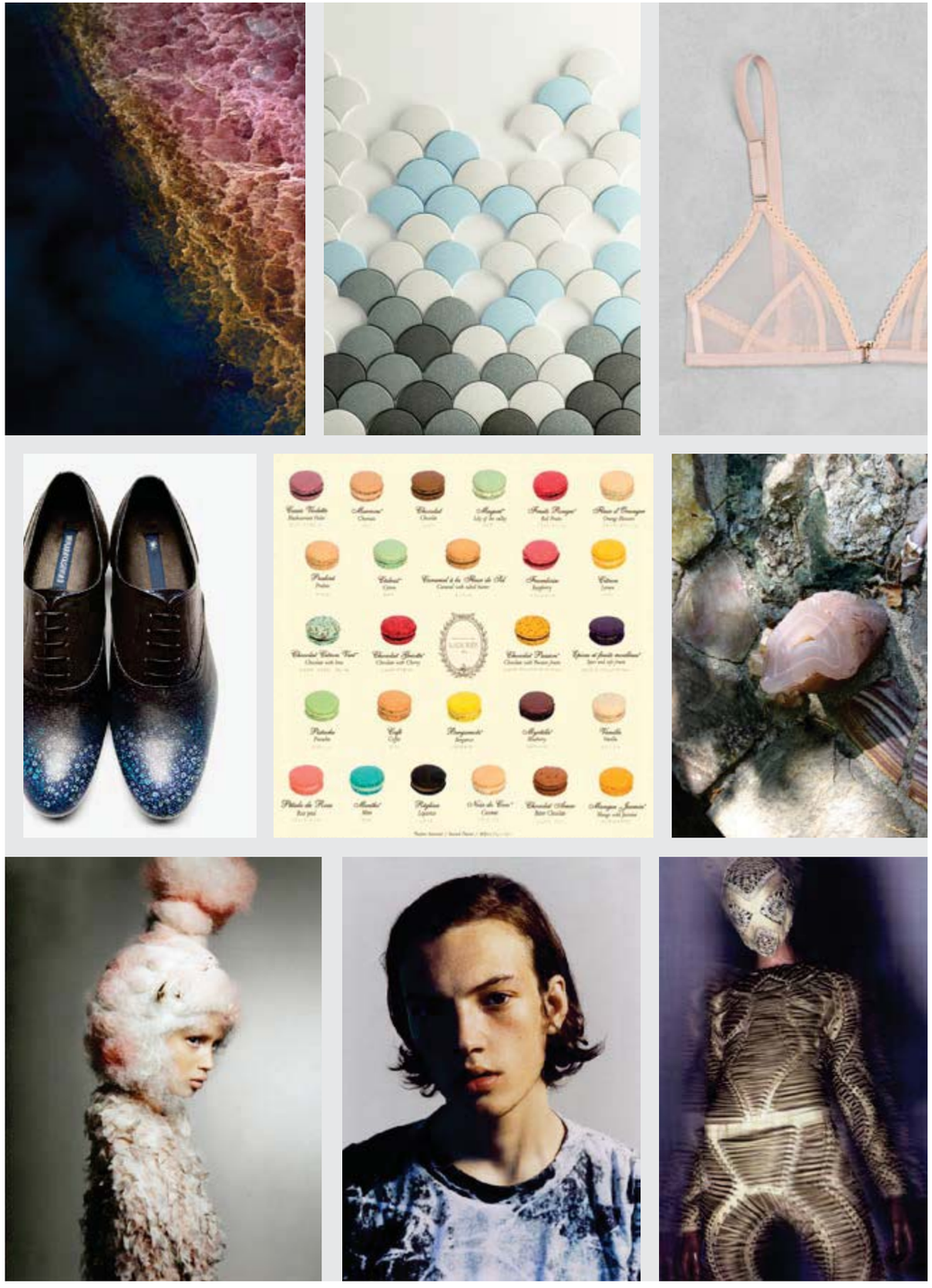


MACHINED WHITE

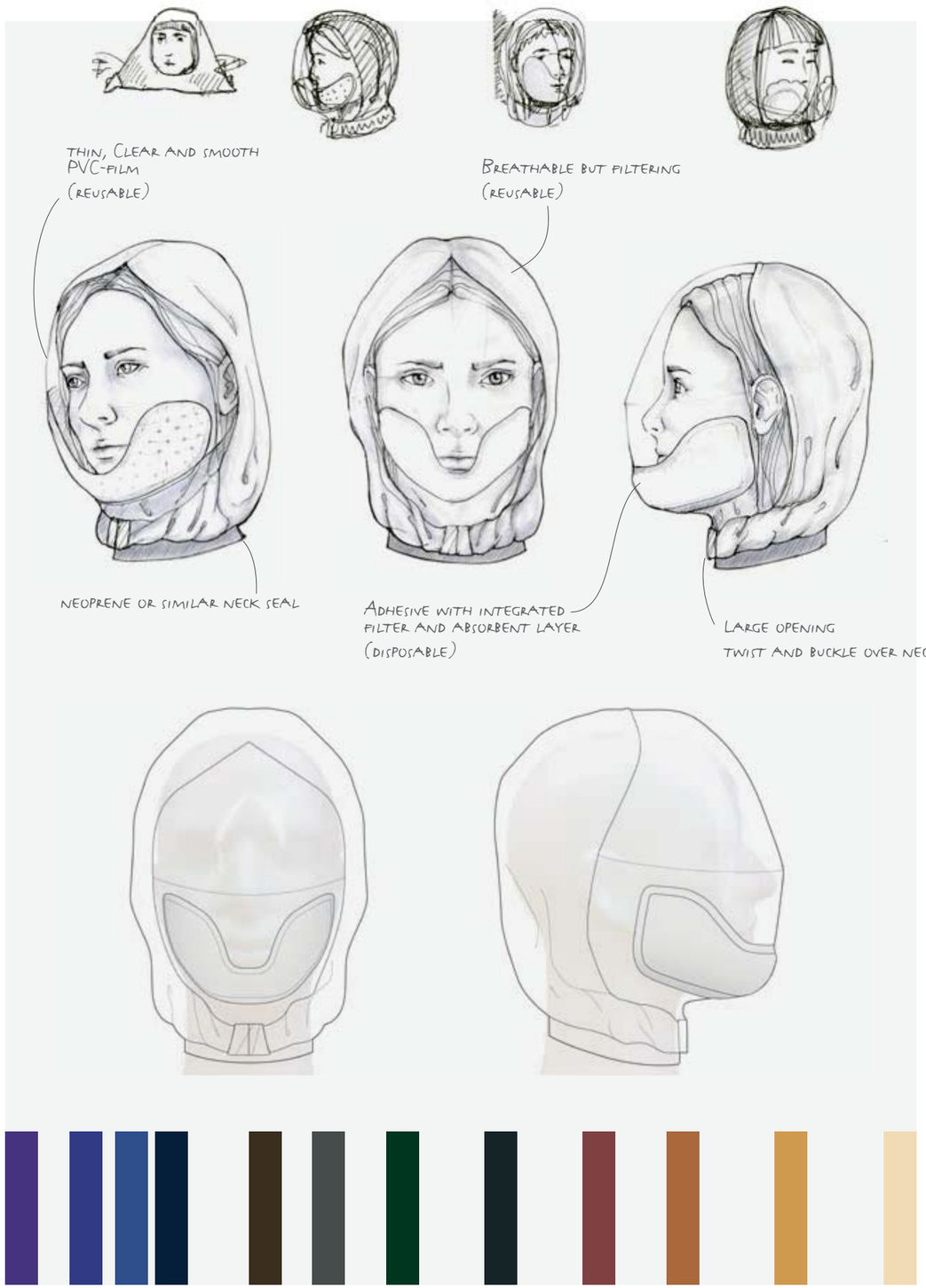


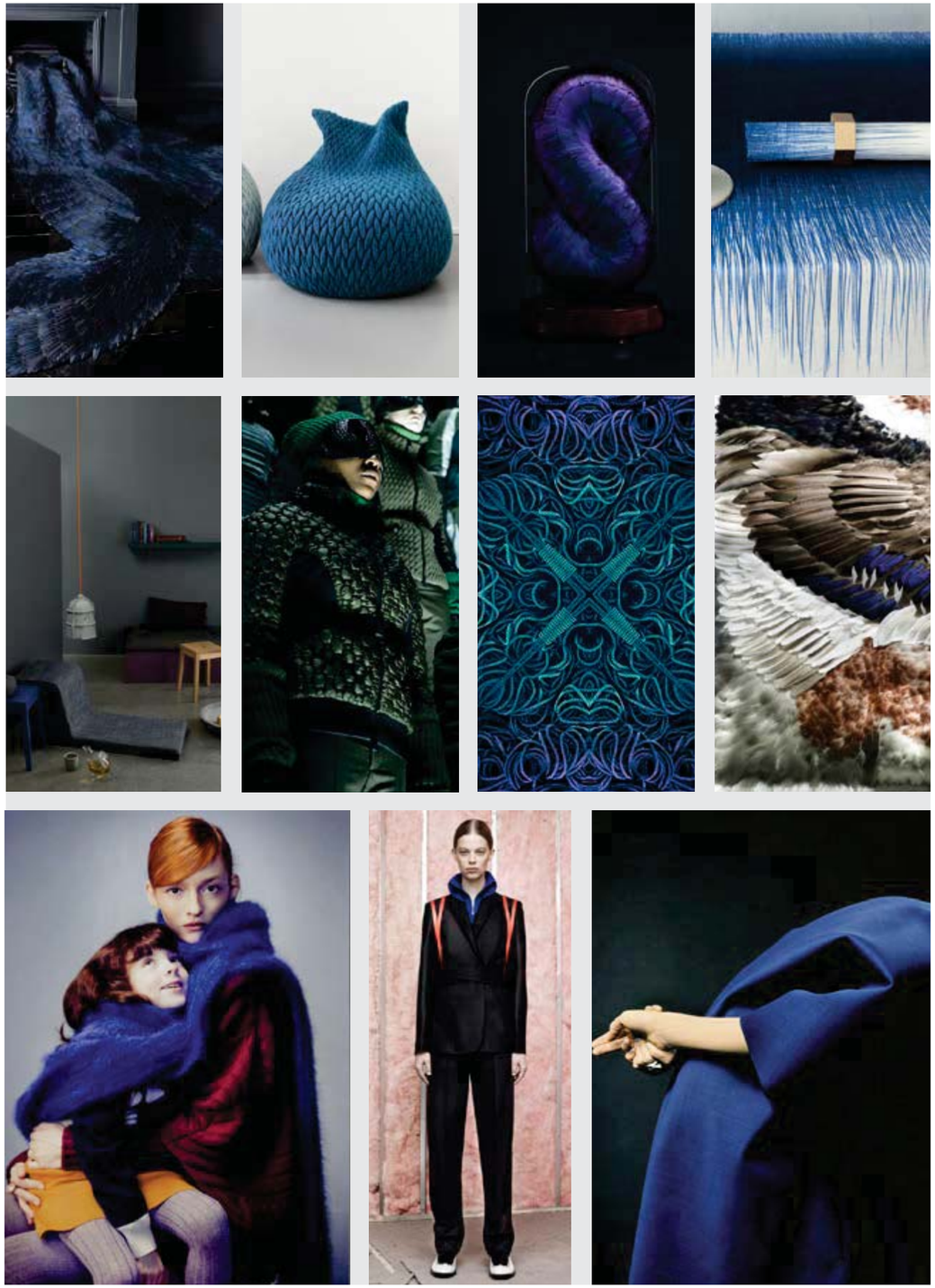
KING OF HOTEL LOBBIES





PORCELAIN DOLLS





ROPE OF FEATHERS

REFINEMENT

...Ebola outbreaks typically occur after “unusual downpours or droughts in central Africa—a likely result of climate change.” Climate change would in turn amplify food insecurity, and prompt even more remote West African communities to eat virus-carrying animals like bats.

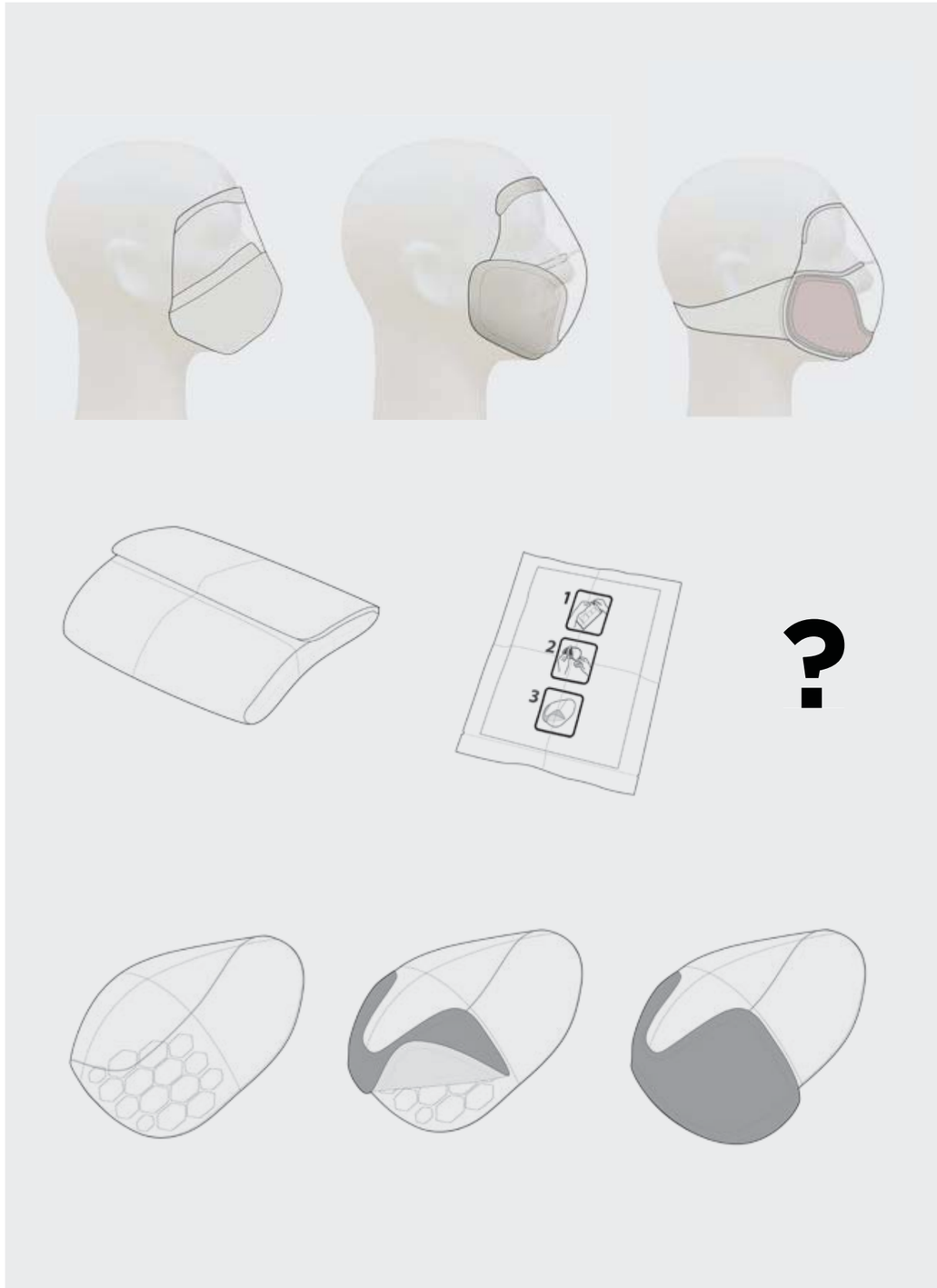
The Final Question

REUSABLE OR DISPOSABLE

Every decision usually has two sides to it and so was the case with the ultimate dilemma regarding the respirator. Either it is disposable - lighter, simpler and fewer concerns regarding user errors. Throw it away, wash your hands and a new clean one comes out of its sealed packaging. However, the other side of the disposable respirator, is the amount of waste it would be responsible for. Surely a negligible amount if compared to other industries, such as the food- or packaging industry. However, that is not a sustainable argument; that is an excuse. In the Swedish hospitals, the disposable ones are used several times, the reason being the cost. Cost is tricky to calculate, but would be a factor that could matter for the intended target group. If the disposable one means that you have to take it off and throw it away every time you have a break in your schedule the cost would be high and we learnt from before that the casual donning and doffing is creating more risks than protection.

A reusable one, would with today's technologies and materials still require disposable filters and some caring and cleaning of the mask. However, it leaves some more room for over-all quality and comfort when it comes to its reusable parts.

I saw the potential in finding an in-between solution. The respirator could either be a partly disposable and reusable product or have a limited life cycle just like contact lenses.



Concept tryouts

FORM AND LOGIC

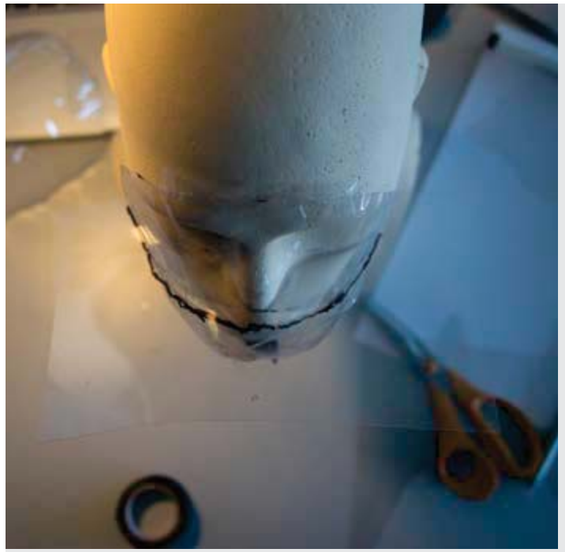
After some exploration and a lot of time for thinking, I knew what main elements and materials the respirator should consist of so I started there. I referred to the main clear part as the visor. At first when I was leaning towards a purely disposable product the visor was thought to be only for preventing the transmission through the eyes. As I was drifting towards the semi-disposable path and started making full face visors and grew fond of the idea. Thin, clear, flexible and light weight, similar to the plastic used for blister packaging. I researched about what polymers are used for products of a similar range, all from goggles to varying thermoplastics.

At the same time I was exploring the overall shape of the visor, first by the help of cutting and tape, and found the mostly organic and smooth shapes to both more functional (less visual distortion) and a better (at this point) aesthetic fit to the human anatomy. To better achieve this shape, I made clay molds which I could use to form plastic sheets with a heat gun. It made it easy to make copies with the same result and I could then proceeded with the next steps and compare the results.

Condensation

COMPARTING THE MASK

A predicted requirement was to separate the mouth and nose section from the eye section. Otherwise condensation from your breath could create fog on the inside of the visor. The idea was to treat the inside of the mask with an anti-fog agent, however these are not 100% reliable and there were other reasons for sectioning the mask in two part. A nose bridge across the cheek and to the end of the mask could prevent obtrusive condensation if properly sealed. It would also make it easier to position the respirator on your face and help it being held up. I created a gap between the two sections to prevent heat transmission and therefore fog. This gap would later also help solving an additional problem. I made some tests to try out how it felt to wear it, how much condensation is a problem and if the gap will work. Another thing noted from testing the sketch models is that wearing something fitted very closely over the mouth caused a slight claustrophobic sensation. The space between the mouth and the worn mask caused this more than the thickness or density of the material I tried to breath through. Disposable respiratory masks such as 3M's Aura™ (level FFP3) is an improvement when it comes to this claustrophobic sensation because of the way it is constructed. 3M's Aura's™ other problems is the overall humidity and the edges which are creating gaps and therefore leakage.



Process of finding the ideal size and placement of gap and 3M's Disposable respiratory masks Aura™

Flexibility

AND YAWNING

I could try out and compare the perception of breathing difficulties with sketchmodels and their varying shapes. Filters were attached to the sketchmodels and the edges sealed with tape. What I found is that it is the distance from the mask to the mouth that matters when it comes to the perceived level of difficulty in breathing. Creating a larger distance helped this perception, which is opposite to what I assumed. Purely physiologically it does not make sense to create a dead space inside the mask. It could be because the dead space in the conceptual mask is a wide area rather than a too long tube. If this works or not will highly depend on the perforation as well. Interestingly, benefits do accure to a seemingly wasteful design for ventilation that includes dead space.[1] (1) Carbon dioxide is retained, making a bicarbonate-buffered blood and interstitium possible.[2] (2) Inspired air is brought to body temperature, increasing the affinity of hemoglobin for oxygen, improving O2 uptake. [3] (3) Particulate matter is trapped on the mucus that lines the conducting airways, allowing its removal by mucociliary transport.[2] (4) Inspired air is humidified, improving the quality of airway mucus. [3]

Another important step was to allow the mask to move along with the movements of the jaw; this is where the gap with very defined creases helped the most.

1. *Respiratory physiology : the essentials (9th ed. ed.)* West, John B. 2011.

2. *Dead space (physiology),* Wikipedia, september 2014.

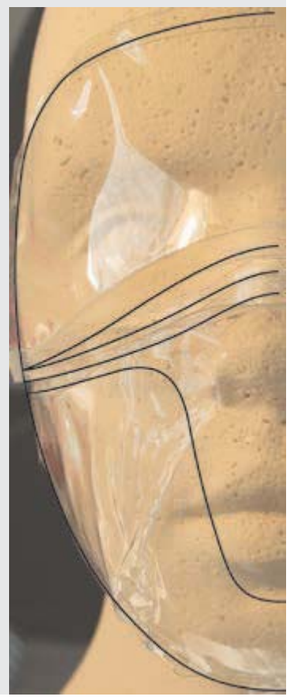
3. *Relationship between the humidity and temperature of inspired gas and the function of the airway mucosa*, Williams et al. Critical Care Medicine 24 (11): 1920–9. November 1996

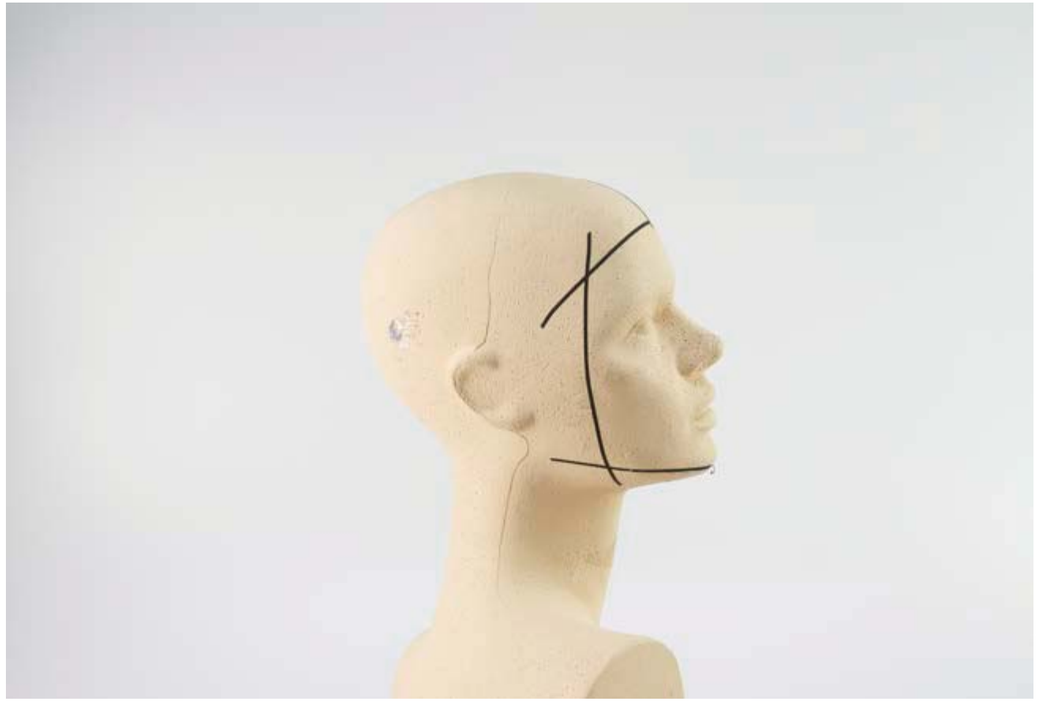
CAD preparation

ANATOMY AND LINEWORK

Creating a physical model with the desired quality and detailing was not realistic in this project. For me to build a real model would require a CAD model as well anyway. I therefor gave Alias Autodesk and rendering software all my attention. My aim was to reach a higher level of Computer Aided Design (CAD) skill. My level was not time efficient enough and was lacking confidence. I began with all lecture notes, online tutorials, assignments and videos I could find.

The main shape was surprisingly difficult build and shape perfectly correct, however it was the most important step. A couple of 3D prints were needed to get the shape right. The sketch models came handy when it came to making curves to build from. I enjoyed working with Alias eventually, even though every step was redone a minimum of three times.

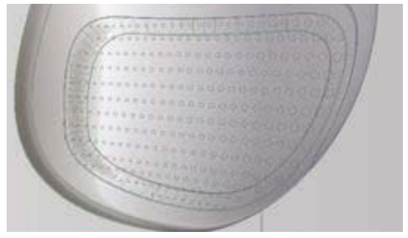




Pattern Refinement

INSPIRATION AND REASONING

Initially I envisioned the perforation as being in a pattern. After some experimentation and consideration this changed. By having the perforation as small holes close together yet gradually - there were endless more possibilities by having a pattern onto the filter beneath. Any graphical pattern could be printed on to a layer of the filter and would be visible through the perforation. A possibility like this one could make the mask more customizable, fashionable and even more fun for the user to wear. I continued with a pattern close to the one on the upper left corner. Orderly, calm, condensed yet gradual (see image on the right of the red car). Another reason for going with a perforation which was more relatable, was that I had to keep the research regarding wearable aesthetics in mind. Keeping it discrete, anatomical yet needed in order to communicate its function.

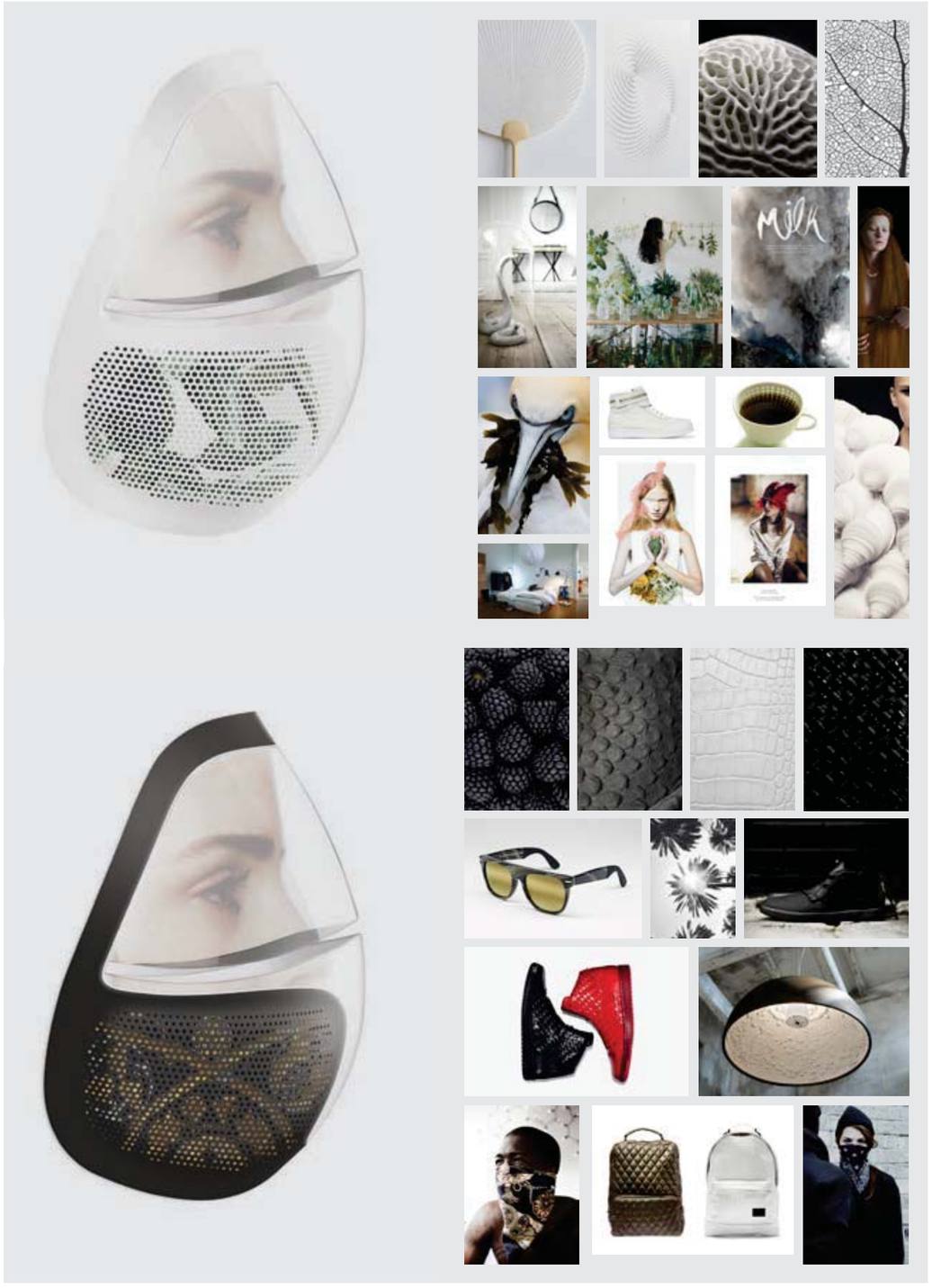



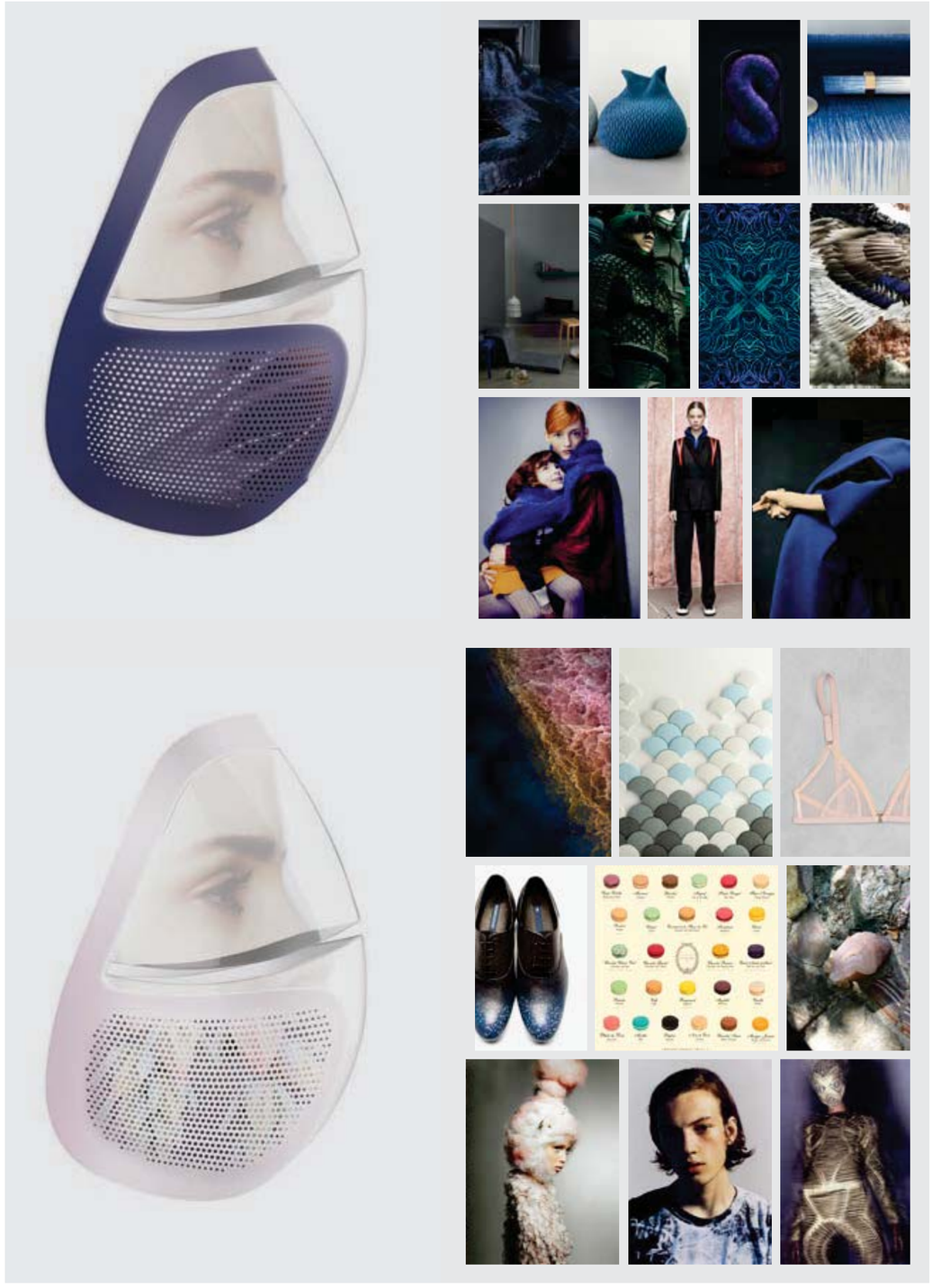










Milk



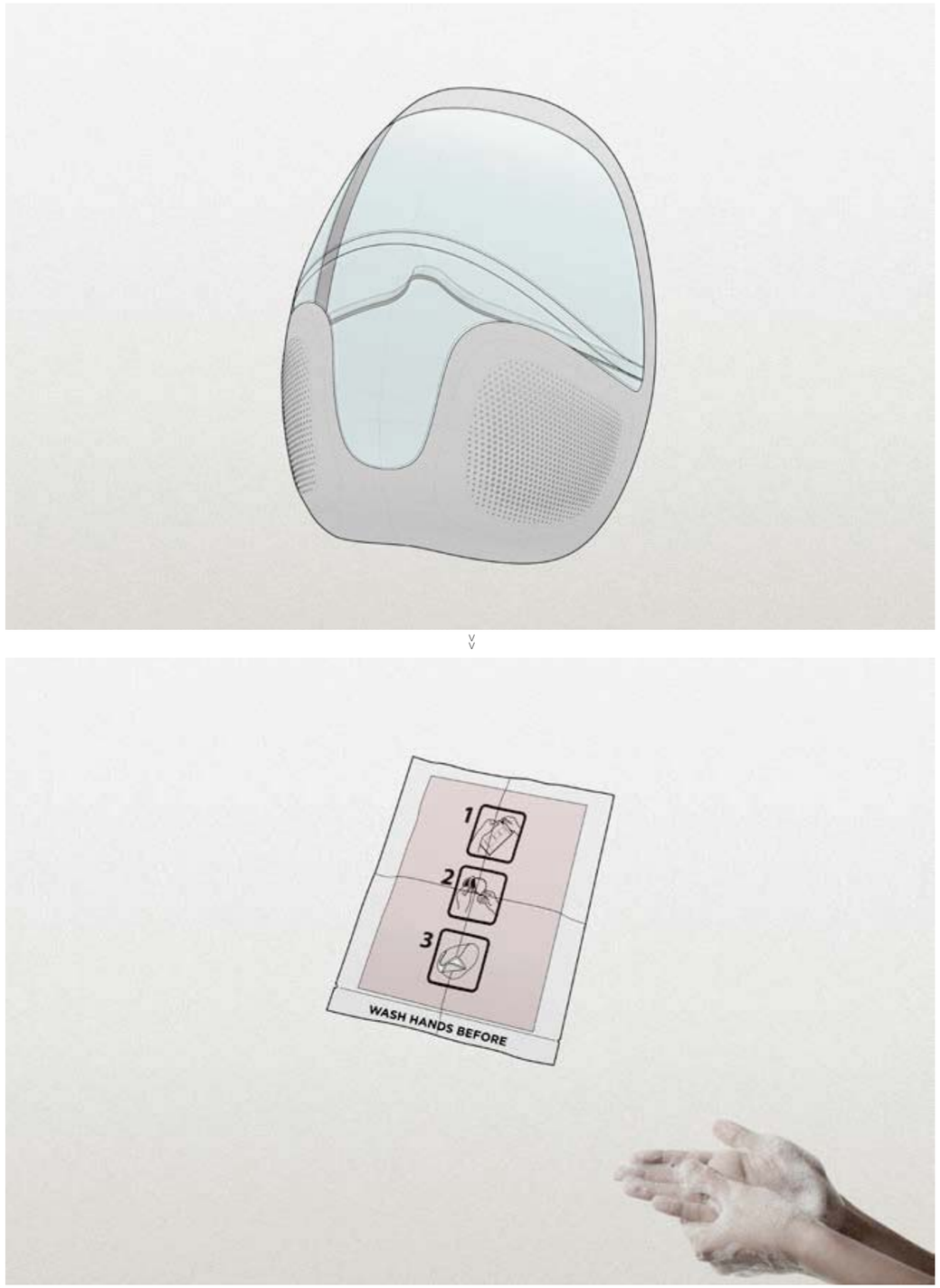
Filters & Branding

AIRLINES, INVESTMENTS AND SPONSORING

When it comes to introducing a new kind of respirator like this concept, a strategy is needed. If we use the airline business as an example, it would be both in the airline's as its staff's interest to stay healthy and avoid risks, especially during the event of a possible emerging pandemic. If a case of viral disease could be traced back to an airline's staff, it would be tragic for the one affected, but it could also mean bad publicity for the affected airline.

In this case I imagine that every individual in the staff would be investing in a couple of reusable masks for themselves. Enough masks to not run out and with the understanding that one mask could be used for weeks. The airline would sponsor or provide its staff with enough filters that they can change them as often as needed. In return the filters could be branded with the airline logo. One reason for this would be the case that the respirator could be regarded by both staff and their customers as something professional and as a part of their uniform. Another aspect would be the positive publicity the branded respirators could create. The signal would hopefully be one of responsibility and safety. In its very first introduction, this news of a novel product also could be spread through varying media. Unavoidably, this would also result in publicity for the Airline or Hospital.

Simple means of communication between WHO and authorities in each domain (e.g. CDC and Airlines) for when an emerging threat is upon us would also be an advantageous aspect.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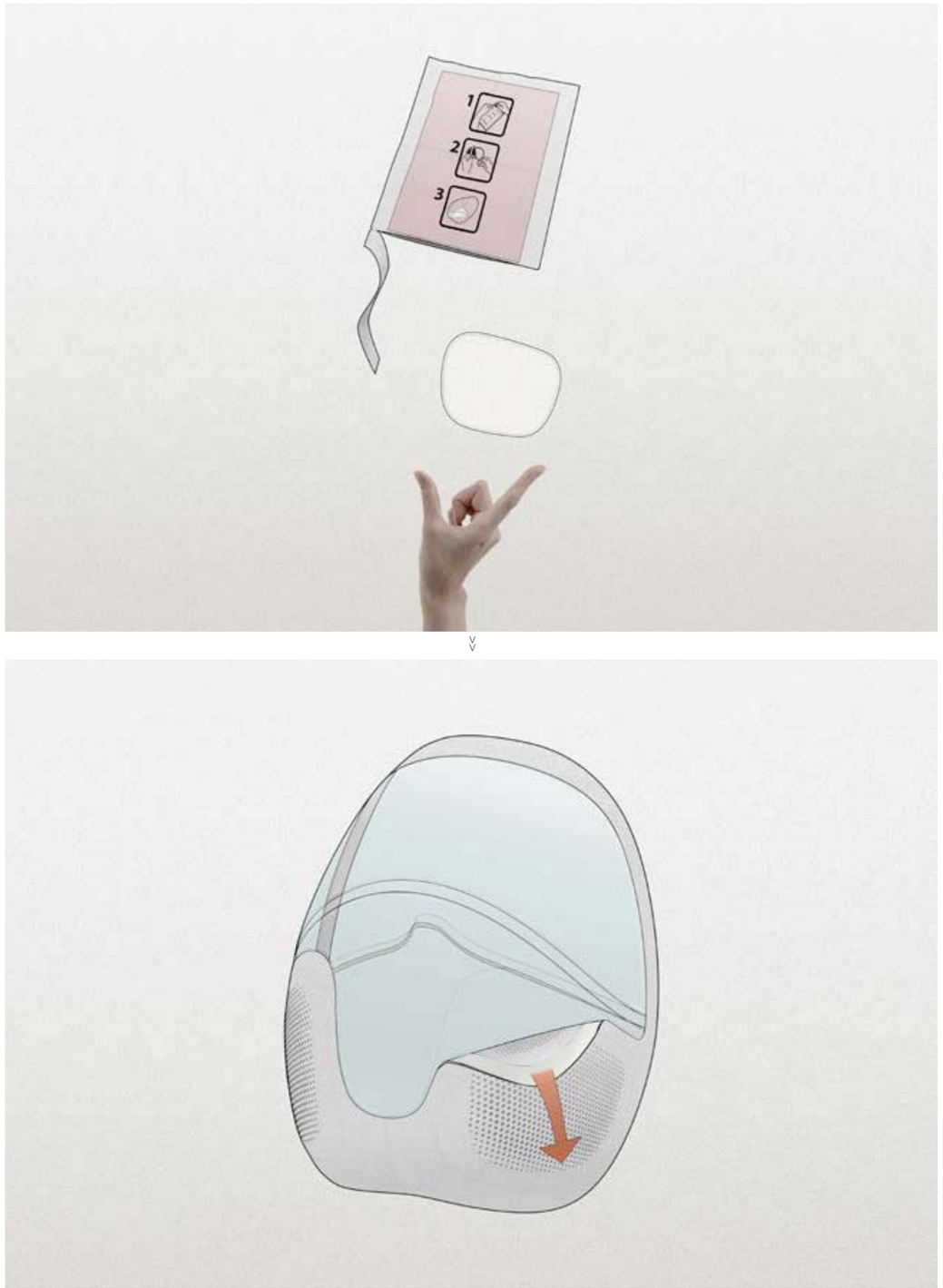
WASH HANDS BEFORE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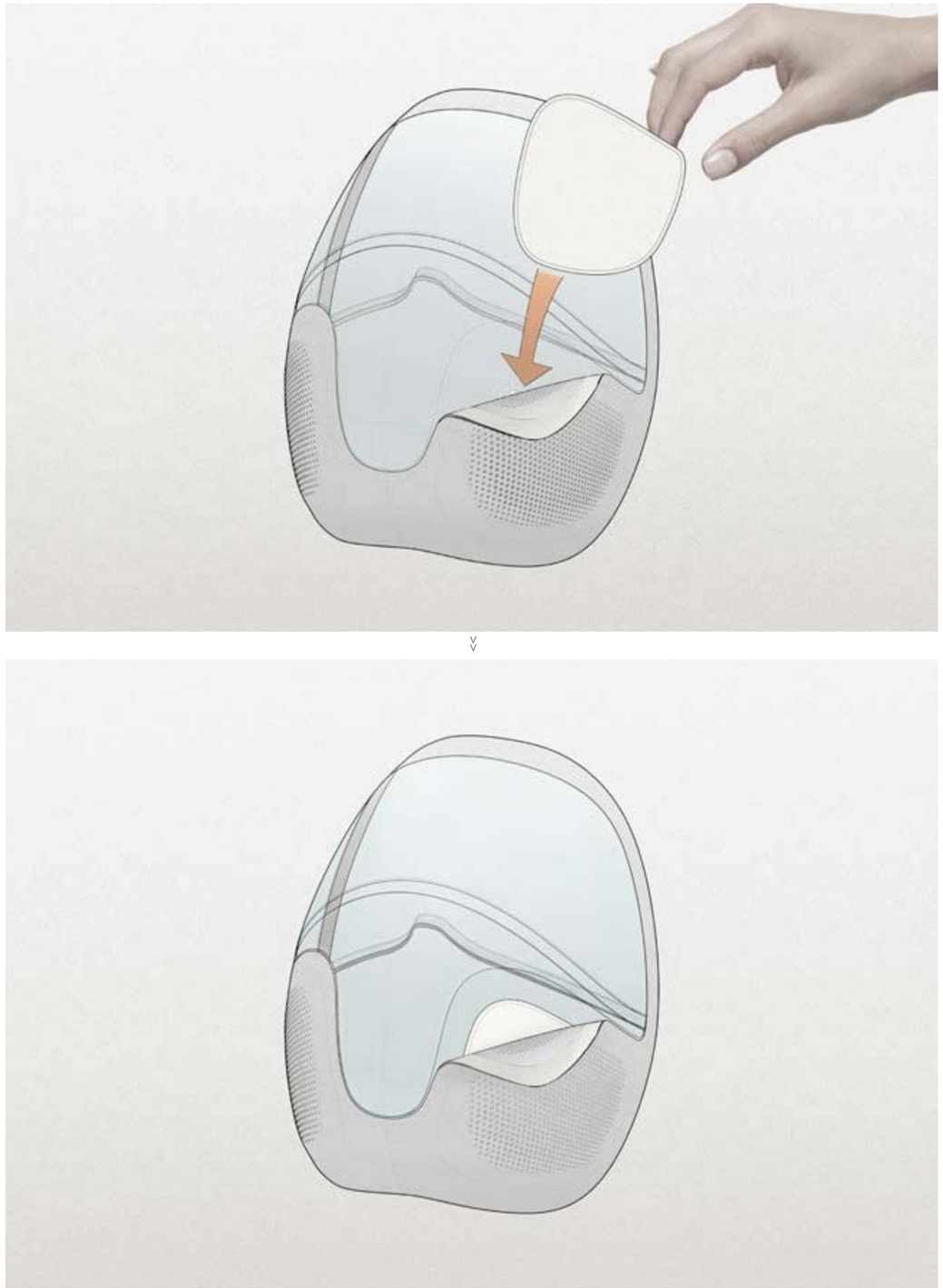
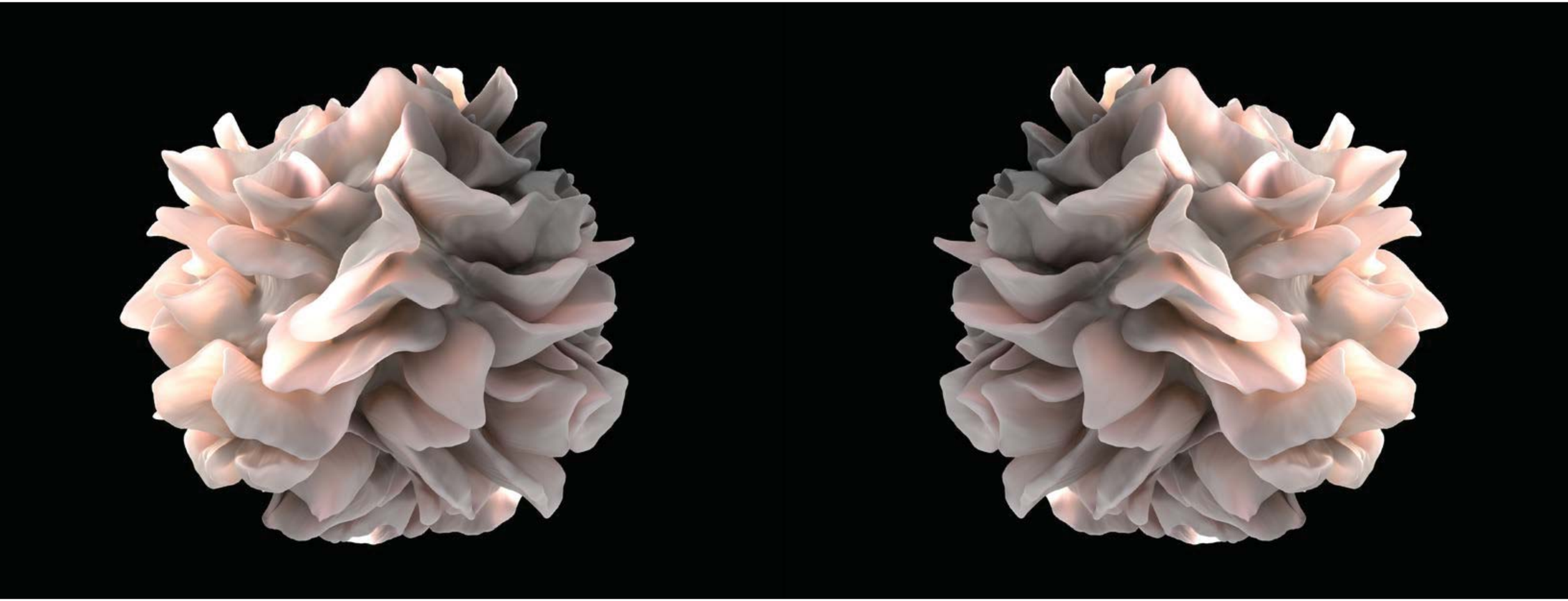
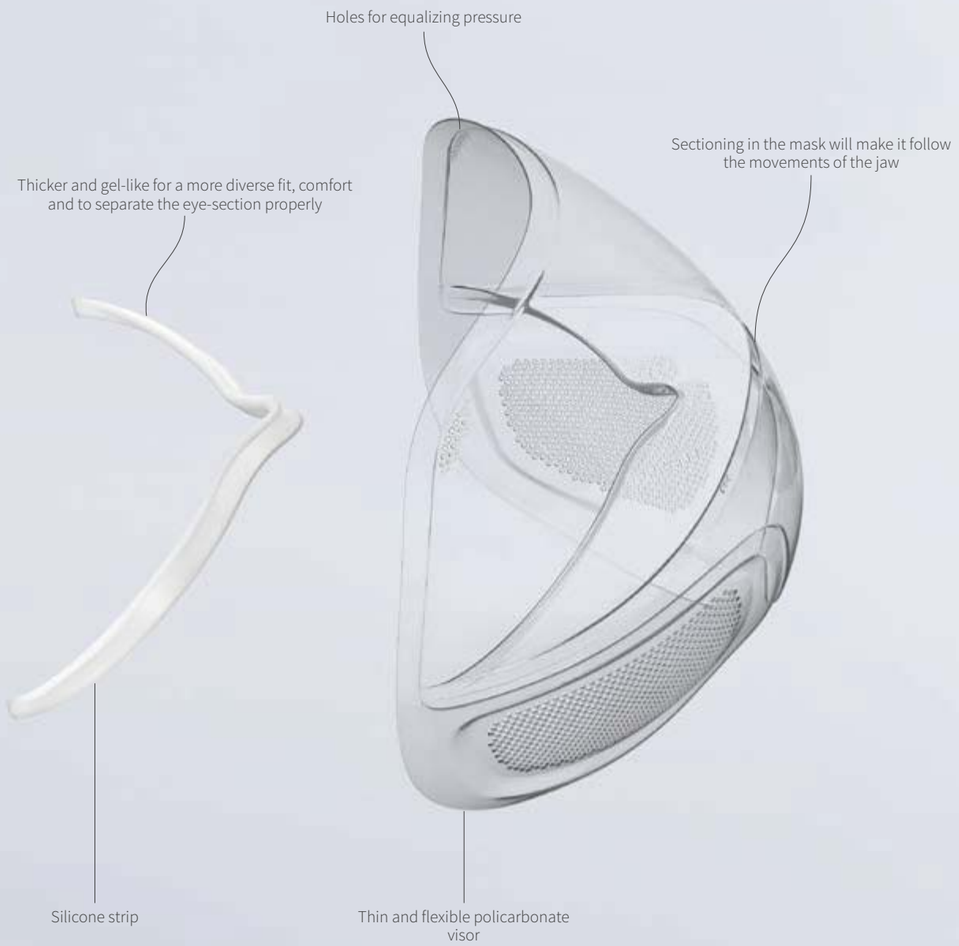




RESULT

Artistic rendering of the surface of a human dendritic cell illustrating the unexpected discovery of sheet-like processes that fold back onto the membrane surface. When exposed to HIV, these sheets entrap viruses in the vicinity and focus them to contact zones with T-cells targeted for infection. Wikipedia 2014.


Holes for equalizing pressure
Thicker and gel-like for a more diverse fit, comfort and to separate the eye-section properly
Sectioning in the mask will make it follow the movements of the jaw
Silicone strip
Thin and flexible policarbonate visor


Adhesive silicone can be reattached and can remain its adhesive properties after cleaning
Layered with printed patterns. Super absorbent layers inside could make the filters more effective and longer lasting
Disposable filters
Stretchable silicone with adhesive edges

Conclusions

AND AFTERTHOUGHTS

The most difficult aspect of this project was the decision whether the main mask should be reusable or disposable, or in between. However, this decision did not need to have any impact on its design. A fully disposable version would indeed have a much safer user handling. A disposable version of the same mask could have the same design, but instead having the silicon and filters fused together. This is also an indicator of a safer product and also a possibility to easy integrate super absorbent layers. This could make the filters work better for a longer time since humidity is what makes them lose efficiency. However, having it disposable would mean that you throw it away every time it is taken of which could mean every time the intended user would go on a break. The amount of waste is not negligible either. Neither is the cost. In order to properly compare this a much more accurate price point would have to be determined than what I could estimate and a much more developed product and an exact plan of how it would be produced as well as of material required. In the end, this dilemma would be a matter of risk vs. cost.

Before I began this project I knew the prospect that the final concept could be something worn on or close to the face. I knew it would be very challenging. It was. Consider how awkward it can be to choose eyewear. The face is a very sensitive and challenging part of us to integrate design for. To know that it would be challenging combined with a general interest for wearables helped a bit. I would make several versions of the respirator if I had another month to this project, but with the same materials and ideas.

However, it was unexpectedly intriguing to work with a medical product. It was more motivating to a certain point to design with so many constraints. It also needed to incorporate the aesthetic of a wearable medical product should communicate and what feelings they should evoke.

From the articles I read I was hoping I would get an official answer to why respiratory protection has been over looked. I understand it is because today's protection is not efficient enough and that there are a lot of monetary benefits from investing in pharmaceuticals when there is one. However, I'm still very curious about what will be the case where there is not any pharmaceutical aid to turn to? It is unfortunate that not enough research is being invested in respiratory protection and UV-light.

It was not always easy to efficiently understand the whole subject of the problems we are facing when it comes to future pandemics, how viruses work outside of the body and filtering media. Especially when the conclusions of the majority of the articles were; more research is needed.

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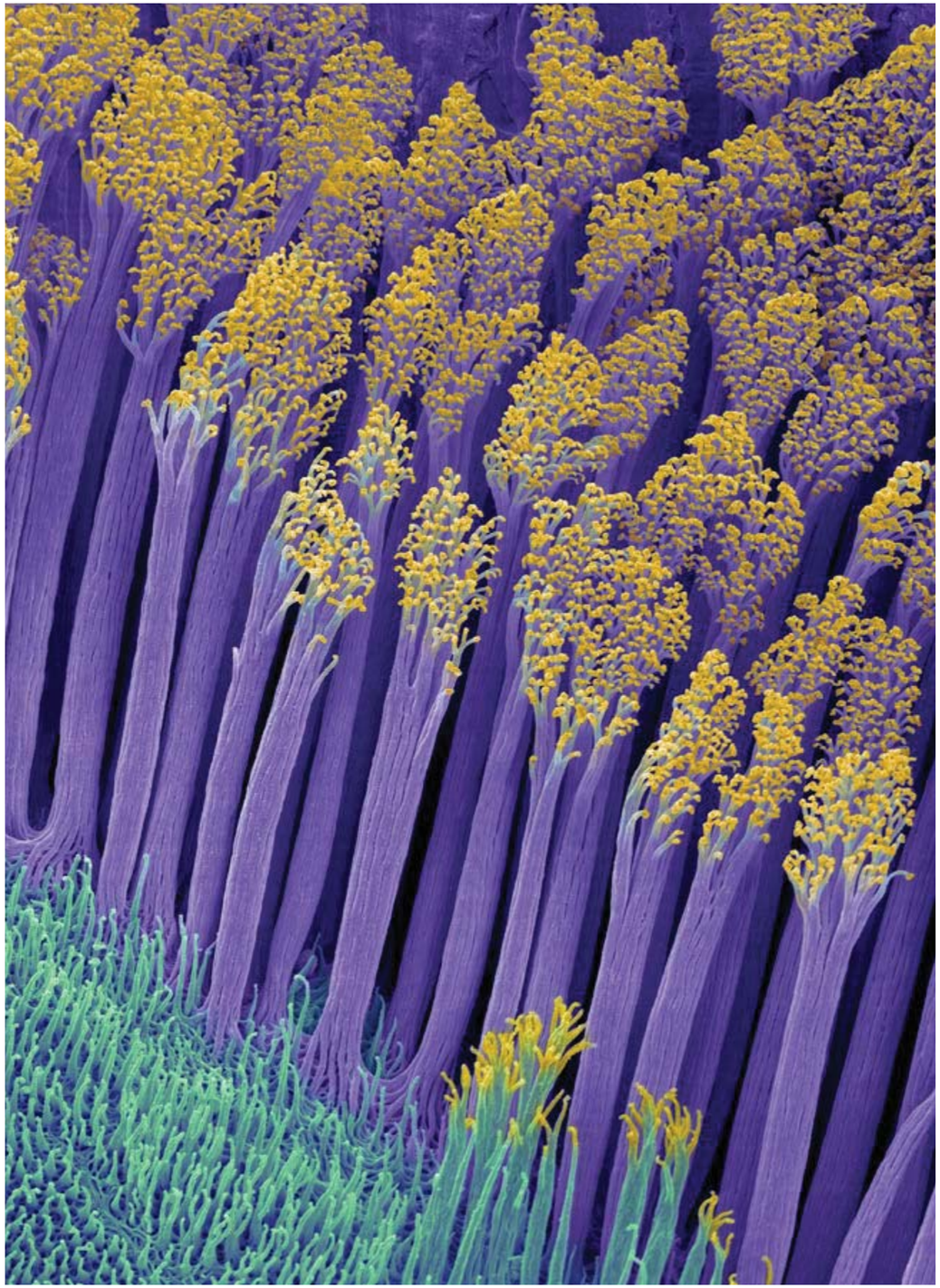

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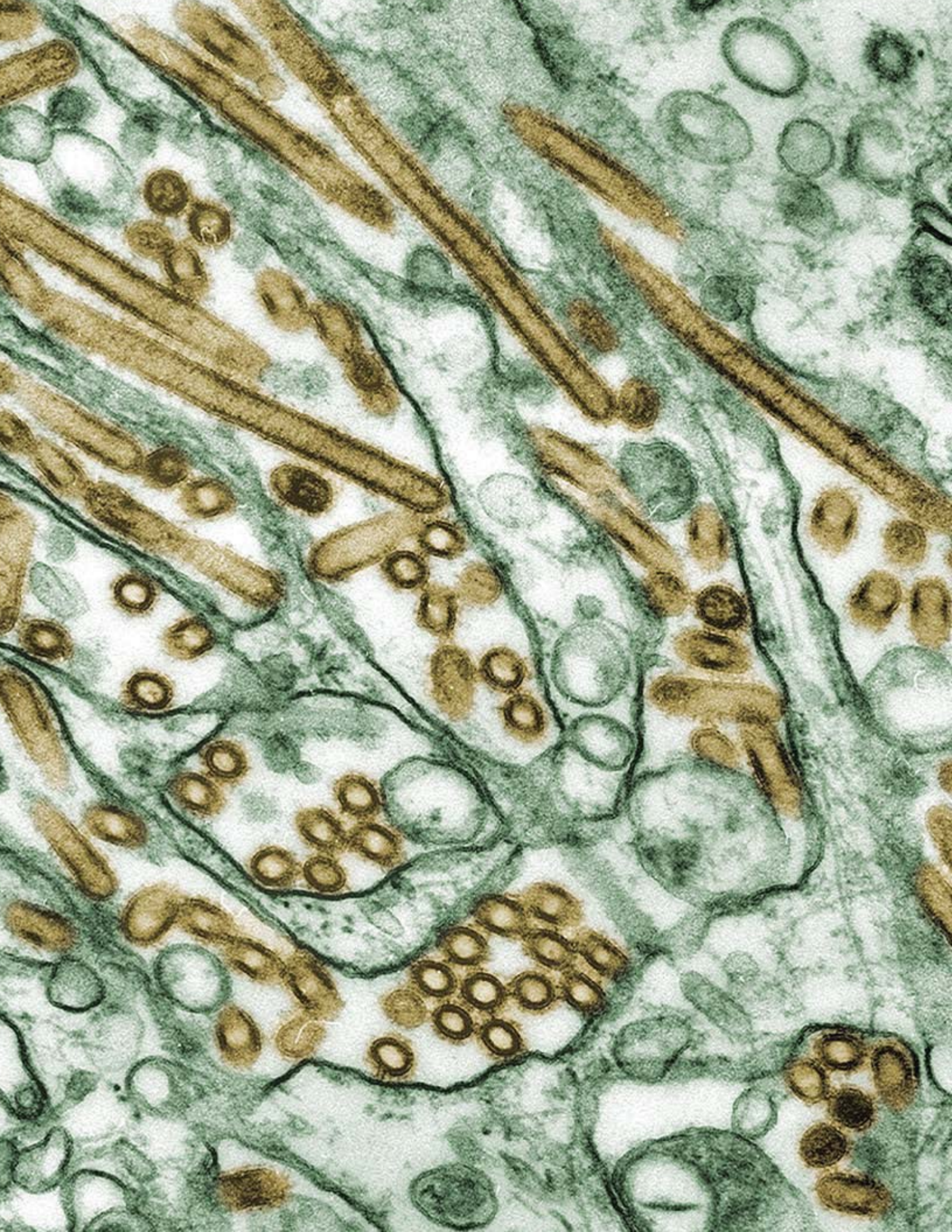


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