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„Avatar“

Recommended selection and description of scenes for teaching

This teaching aid was prepared by dialog-gentechnik as part of the project CI·SYN·BIO and funded by the Austrian genome research program GEN-AU.



www.gen-au.at



www.cisvnbio.com



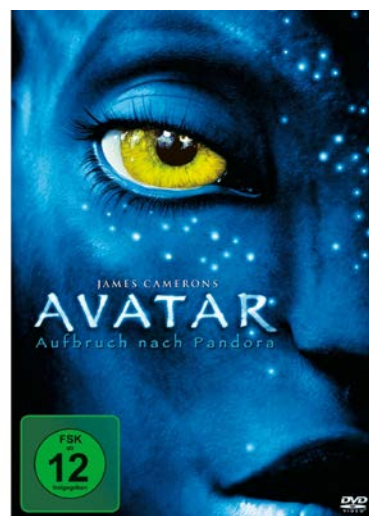
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Movie details

Genre: Action / Adventure / Fantasy
Rated: PG13
Runtime: 155 minutes
Year of production: 2009
Country: USA
Producer: Colin Wilson / Laeta Kalogridis
Director / Writer: James Cameron
Stars: Sam Worthington
Zoe Saldana
Stephen Lang
Sigourney Weaver
and many others



Technical requirements: DVD-Player, TV set

Plot

When his brother is killed in a robbery, paraplegic Marine Jake Sully decides to take his place in a mission on the distant world of Pandora. There he learns of greedy corporate figurehead Parker Selfridge's intentions of driving off the native humanoid "Na'vi" in order to mine for the precious material scattered throughout their rich woodland. In exchange for the spinal surgery that will fix his legs, Jake gathers intel for the cooperating military unit spearheaded by gung-ho Colonel Quaritch, while simultaneously attempting to infiltrate the Na'vi people with the use of an "avatar" identity. While Jake begins to bond with the native tribe and quickly falls in love with the beautiful alien Neytiri, the restless Colonel moves forward with his ruthless extermination tactics, forcing the soldier to take a stand - and fight back in an epic battle for the fate of Pandora.

Source: <http://www.imdb.com/title/tt0499549/plotsummary> on August 30th 2012

Overview of the selected sequence of scenes

On the distant moon Pandora humanoid indigenous natives (Na'vi) are living in a dangerous and unexplored environment. Humans want to conquer the planet and mine its precious resources. To facilitate communication with the Na'vi, scientists developed artificial bodies (so called avatars) through recombination of human and Na'vi genomes. Via a special device, those bodies can be connected to the brain functions of trained humans (called operators) and can thereby be controlled. The story is told by Jake, a former marine, who is on a mission to Pandora.

Start: 00:00:29
 End: 00:20:20
 Duration: about 20 minutes

Scene	Start	End	Content
1	0:00:29	0:06:36	Start of the mission – flight to Pandora – Jake is offered to take his brothers' place as an avatar operator
2	0:06:36	0:07:58	Safety instruction to newcomers
3	0:07:58	0:09:38	Norm introduces himself and shows Jake the bio lab - first view of the avatar
4	0:09:38	0:10:40	Jake explains the avatar program
5	0:10:40	0:12:15	Jake meets Grace, botanist and head of the avatar program
6	0:12:15	0:14:15	Dispute between Grace and Parker Selfridge, her boss
7	0:14:15	0:17:55	Jake links to the avatar for the first time
8	0:17:55	0:20:20	Jake goes on his first non-approved trip with his avatar

Detailed descriptions of scenes

Scene 1 (0:00:29 • 0:06:36)

Start of the mission – flight to Pandora –

Jake is offered to replace his brother as an avatar operator

The film starts with a view on the flourishing plants of the distant planet Pandora, where marine Jake Sully - bound to a wheelchair due to combat injury – tells us his story. First his eyes, then his whole face is shown. He is lying in a cryo-chamber on a spaceship on its way to Pandora, waking up from a cryo-sleep for six years. Supported by a couple of flashbacks to his former life, he talks about his twin brother Tom, a scientist who prepared for his journey to Pandora, to “find answers”. However, shortly before his departure Tom was murdered in a robbery.

Meanwhile, the spaceship is approaching Pandora and the cryo-chambers open to release the awakened passengers. Jake states that unlike his brother Tom, the scientist, he is only another “dumb grunt going some place he’s gonna regret”. While we see the surface of the spaceship, Jake talks about Pandora, an unimaginable world. In another flashback the cremation of his brother’s corpse is shown: Two business men offer Jake a continuation of his brother’s contract, “who represented a significant investment”. Because of their identical genome as twin siblings Jake could theoretically follow in Tom’s footsteps. We hear the voice of one of the business men saying, “It would be a fresh start on a new world. And the pay is good. Very good.” The flashback ends with the cremation of Tom’s body.

Except of Jake, there are only active soldiers in the shuttle approaching Pandora. The order “Exo-packs on!” points to the toxic atmosphere on Pandora, which would lead to death of humans within four minutes of exposure. During the landing approach a mine of sheer enormity can be seen. The shuttle lands and soldiers leave at the double. Due to his physical restrictions Jake comes last, but mentally he still defines himself as a marine. With his veteran soldier’s aid and due to the general economic situation he cannot afford a costly operation to fix his spinal column.

A huge man-operated robot crosses his path. A vehicle passes by; long and colourful arrows protrude from the wheels. We hear that back on earth soldiers were marines, but on Pandora they are mercenaries working for the company.

Scene 2 (0:06:36 • 0:07:58)

Safety instruction to newcomers

A safety commissioner points out to the newcomers that the environment on Pandora is extremely hostile and dangerous for humans, even worse than hell. Every living thing that crawls, flies or squats in the mud beyond the fence wants to kill them. There is an indigenous population of humanoids called the Na'vi. Their skeleton is reinforced with naturally occurring carbon fibre, which renders them nearly impossible to be killed. They use arrows dipped in a neurotoxin for hunting that stops a human heart from beating within a minute.

The safety commissioner declares that in order to survive in this hostile environment, one need to have strong willpower and obey the "Pandora rules" which he then begins to state.

Scene 3 (0:07:58 • 0:09:38)

Norm introduces himself and shows Jake the bio lab - first view at the avatar

Dr. Norm Spellman is another avatar operator who completed the avatar training together with Tom, Jake's brother. Astonished at their resemblance, he welcomes Jake and is looking forward to their collaboration. In the bio-lab Norm shows Jake the link chamber, where connections to the avatars take place.

We can hear the voice of Jake explaining that he and Norm are on Pandora to operate these remote controlled bodies called avatars. Avatars are grown from the DNA of the human operator combined with the natives' DNA. In the background we can see incubators sustaining one avatar each. The scientist Dr. Max Patel welcomes them. Jake and Norm are amazed by the size of the avatars and Norm states that they mature to their full size just on the flight to Pandora. Dr. Patel is satisfied with the avatars' muscle tone and proposes a first trip for the next day. Seeing his avatar for the first time, Jake is strongly reminded of his brother's face. Norm emphasizes that the avatar is looking exactly like Jake and that it is his avatar now.

Scene 4 (0:09:38 • 0:10:40)

Jake explains the avatar program

For documentation purposes Jake keeps a video log. He explains that every operator is matched to his own avatar to make sure their nervous systems are in tune. So, Jake was offered his brother's assignment because he can link to Tommy's avatar due to their identical genetic makeup. When Jake asks Norm and Max, if his video

record is fine, Norm explains the importance of good observation and documentation in science and also the benefit of keeping him sane during their six year long mission.

Scene 5 (0:10:40 – 0:12:15)

Jake meets Grace, botanist and head of the avatar program

A link chamber is opening. Inside lies the botanist Grace Augustine, head of the avatar program and author of the book “Pandoran Botany”. Released from the chamber she already demands a cigarette, which is promptly brought. Meeting Jake and Norm for the first time, she asks Norm about his language skills in Na’vi and is uninterested and dismissive, when Jake is introduced. Grace was looking forward to meet Jake’s brother Tom, who went through 3 years of special training for this project and had a lot of lab experience, both features Jake is lacking. After a short conversation Grace rushes out in rage to see Parker Selfridge. Max advises Jake to come back at 8 o’ clock the next morning and “try to use big words”.

Scene 6 (0:12:15 – 0:14:15)

Dispute between Grace and Parker Selfridge, her boss

Parker Selfridge, the man in charge of the mining efforts on Pandora, is playing golf between the staff members of a busy command centre. Grace, complaining about being sent a jarhead dropout instead of a researcher, does not get Selfridge’s attention. Only after kicking his putting cup, he responds. Parker is convinced she should feel lucky, as Tom had a twin brother and on top of that, one that was trained as a marine. He can therefore be used as security escort. Grace is not thrilled by the prospect of having another trigger-happy marine in her vicinity. Parker contemplates about her program’s goal to win the hearts and the minds of the natives. “If you look like them and talk like them, they will start trusting us. We build them a school, we teach them English and after how many years – relation with the indigenous are only getting worse.” Grace counters that this tends to happen, when machine guns are used on them. Parker loses his patience and reminds Grace, that it is their mission on Pandora to mine the valuable Unoptanium which is also what pays for her science. He declares that the savages are threatening the whole operation and that they are on the brink of war. Grace is supposed to find a diplomatic solution.

Scene 7 (0:14:15 – 0:17:55)

Jake links to the avatar for the first time

The incubators are being cleaned. We see “sleeping” avatars in hospital gown lying on gurneys. Grace asks Norm about the amount of time he was already linked and Norm answers “520 hours”. Grace also asks Jake and his answer is, “Zip. But I read the manual”. Grace is shocked. She asks him what he was thinking to come to the most hostile environment known to man, with no training of any kind. He answers that he was sick of doctors telling him what he could not do.

Jake gets last instructions – relax and let your mind go blank – before the chamber closes and a link is initiated. On a screen a scientist notices first congruence between Jake and his avatar. Max detects high brain activity with Jake which makes his brain a “gorgeous” one. Grace also enters a chamber in order to link to her avatar.

A scientist states, “Phase-lock at 99%; Link is stable.” Jake is now connected to his avatar. We see a moving pattern of multicoloured, energetic circles and hear intense breathing. An advisor says, “He is in.” Jake’s perspective from within the avatar shows a blurry vision. Two advisors lean over and check his reflexes, asking him about his well-being. Jake sits up and the advisors record his vital signs. Jake is impatient and before they can check his sensory motor reflexes, he is standing up. They ask him to sit down, because he is not used to his new body yet. Before they can sedate him, Jake roughly pulls out all control wires and hurries to get out. Norm tries to stop him but fails.

Scene 8 (0:17:55 – 0:20:20)

Jake goes on his first non-approved trip with his avatar

Jake’s first steps are clumsy, but he starts running and is soon getting faster and more skilled. He is enjoying his fully functional body, enabling a life without wheel chair. After a short sprint he stops and digs his toes into the loose soil of a vegetable patch. He takes a deep breath and for the first time notices the environment on Pandora with full awareness. When Grace shows up in her avatar body he barely recognises her. She tosses him a pandoran fruit which he catches and eats. At sundown all avatars go to sleep in a secured shelter and Grace locks the door. On shutting his eyes, Jake awakes in the link chamber. Max welcomes him and asks about his well-being, while Jake pulls his body back into the wheel chair.

Potential topics for discussion

- Is it possible to combine the complete genomes of different life forms – like humans and Na'vi? Can science and technology already do that?
- A mind-game – if it was possible: how could an avatar made from human and Na'vi genomes be generated by methods of synthetic biology?
- What ethical status would humanoid life forms like Na'vi or artificial avatars have?
- Is it possible to control a brain from outside the body?
- Is it possible to grow artificial bodies in the lab?
- May humans be used as test objects under certain circumstances?

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Background information and topics for discussion

This teaching aid was prepared by dialog-gentechnik as part of the project CI·SYN·BIO and funded by the Austrian genome research program GEN-AU.



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Is it possible to combine complete genomes of different life forms – like humans and Na’vi? Can science and technology already do that?

In nature, a so called hybrid is an organism with a naturally occurring combined genome. The term “hybrid” indicates a build-up of heterogeneous parts or mixed ancestry. Formation of natural hybrids is important for both evolutionary processes and the establishment of genetic variety within a species. Well-known examples are mule (crossbreed of female horse and male donkey), hinny (crossbreed of female donkey and male horse), pizzly (female polar bear and male grizzly), diverse fresh water snails etc. In addition, hybrids between closely related species can also be generated by human efforts in targeted plant and animal breeding.

Recombination of whole genomes of various organisms in the laboratory is not possible. Only single genes or DNA fragments of limited size can be introduced to defined target sites in the genomes of certain model organisms and humans (keyword gene therapy). For this transfer certain "transport vehicles" such as viral vectors are employed. A prerequisite for the development of a fertilized egg into a viable foetus is the concerted control of gene activity (i.e. the time and extent of transcription of a gene into a functional RNA). This is a highly complex mechanism and requires precise coordination of a variety of molecular signals. Random integration of DNA into the human genome would severely disrupt this fine tuned cascade leading to the death of the respective zygote or foetus.

In the context of synthetic biology minimal bacterial genomes were already artificially created by chemical synthesis and transplanted into other bacterial cells (see slides "Synthetic Biology). However, also this approach can currently not be used to combine whole genomes of different bacterial strains to create a new recombined bacterial cell. Besides, genomes of higher organisms are much larger and more complex than those of microorganisms. Although genomes of several higher organisms have already been sequenced, the sequences' functions remain elusive in large part. Technically, chemical synthesis of such large genomes is currently not feasible anyhow. Even if this was possible, a scheme for “mixing” two genomes at the molecular and structural level remains fiction.

A mind-game – if it was possible: how could an avatar made from human and Na’vi genomes be generated by methods of synthetic biology?

Theoretically, this would be done by manipulation of an oocyte. For a start, a functional genome constructed from a mixture of the two organisms’ DNA sequence would have to be designed in a computer based approach, which also is the key reason preventing this idea from being realized. To work out a combined genome, gene functions, genome structure and regulation of gene expression in both human and Na’vi would have to be characterized in great detail. Provided this could be sufficiently elucidated, epigenetic phenomena would have to be taken into account, still!

The following text gives an overview on epigenetics:

"Epigenetics is one of the central themes in genetics in the first decade of the 21st century. The term epigenetics describes mechanisms and consequences of heritable chromosomal modifications that are not based on changes in DNA sequence. The main epigenetic modifications include subsequent modifications of certain DNA bases (DNA methylation), changes of the chromatin (histone modifications) and RNAi-mediated mechanisms. Epigenetics provides conceptually new approaches for the understanding of genetic regulation processes in development and disease. Epigenetic modifications play an essential role in the control of developmental processes in plants, animals and humans. Genomes of multicellular organisms are "covered" with cell-specific, development-driven, epigenetic codes. These epigenetic modifications structure chromosomes, control gene activity on a cell- and tissue specific level and provide for silencing of large genomic regions. Epigenetic modifications, however, are potentially reversible and may change during life due to changes in developmental or environmental conditions. Epigenetics offer new approaches to study the influence of environmental changes on the genome and to improve our understanding of their long-term effects on the individual."

(source: <http://epigenetics.uni-saarland.de/de/home/>, translated)

After complete chemical synthesis of the virtually designed DNA molecule, it would have to be packed correctly (coated with nuclear proteins and structured into specific chromosomes), introduced into an oocyte, and implanted into a surrogate mother (artificial incubators for developing the fertilized egg into viable organism as often seen in movies do currently not exist).

Are there any artificial body parts already produced/used?

Yes, many. Artificial hip joints, pacemakers, kidneys, arm and leg prosthesis etc. are already routinely used. Artificial skin is even already produced on an industrial scale! "In the sterile factory everything is fully automated: First, the skin sample is cut into small pieces. Then, the different cell types of the skin are isolated and stimulated to growth. Subsequently, cells are reassembled in two layers in a three dimensional gel matrix. The artificial skin is finished." For further information see i.e.

<http://www.fraunhofer.de/de/fraunhofer-forschungsthemen/gesundheit-ernaehrung-umwelt/Regenerative-Medizin/hautfabrik.html>. Based on this approach it is envisaged to generate artificial tracheae and oesophagi, too.

Is it possible to control a brain from outside the body?

This is hardly conceivable, since the human nervous system is extremely complex. It is subdivided into peripheral and central nervous system according to its position.

The peripheral nervous system (PNS) comprises all nerves, which pass through the body in a three dimensional net, like telephone cables in a city. Nerves transmit information coded in electric pulses between spinal cord or brain and the rest of the body.

The central nervous system (CNS) is the vital control centre. In concertation with the endocrine system, it regulates all body functions - from aspiration, motion and reproduction to digestion. Sensory organs allow the central nervous system to process perceptions and to connect humans to their environment. Overall it is the base for all "higher" functions like awareness, sensation, thinking and learning.

The human brain has an estimated number of 100 billion neurons, cells specialised in the conduction of excitation, which are connected by around 100 trillion synapses. Synapses are the contact points of neurons where neurotransmitters (endogenous biochemical messengers) transfer information from one cell to another. When electric pulses (action potential) arrive at a synapse messengers are released from their storage location (= synaptic vesicles).

One neuron is connected with around 1000 other neurons. The billions of those cells are the basis for our thinking, acting, feeling and communication. Each neuron has a lot of branches to transmit pulses to other cells. Like a news service, they pass all information from inside and outside of the body on to the brain. A typical mammalian neuron is composed of dendrites, a cell body and an axon (filamentary cell extension). An axon may be 1 metre long and allows conduction of excitation over long distances. For this purpose, certain ions are transferred through the cell membrane of a neuron producing an electrical signal that runs along the axon.

As it is shown in the movie, our nervous system is controllable by electric stimuli – only to a limited extent however. The application of electric pulses to the nervous system is called neurostimulation. Stimulation can happen indirectly via electrodes attached to the skin or directly on a nerve by means of an implant. Therapeutic applications of neurostimulation aim at restoring motor functions disturbed by brain or spine injuries. The method is used for muscle stimulation (i.e. in rehabilitation after stroke or paraplegia) and pain relief. Also innovative applications in medical engineering, such as thought-controlled arm prostheses are already in use:

http://www.ottobock.at/cps/rde/xchg/ob_at_de/hs.xsl/32040.html (in German).

In May 2012, the journal “Nature” published a remarkable study showing that external brain control is a hot research topic. Following is a translation of a summary of this study as published in the Austrian newspaper “Der Standard” on June 18th, 2012.

“Thanks to a novel brain sensor developed by US researchers, a paralyzed woman is able to drink coffee without assistance

London/Vienna – It sounds like science fiction but it is real: a woman paralyzed from the neck downwards, is able to bring a bottle to her mouth without assistance – thanks to a robotic arm and a brain-implanted sensor developed by US-based researchers. “For the first time in almost 15 years she was able to lift an object by her own will.” US neurologist Leigh Hochberg, who was engaged in this spectacular progress of brain-machine interface, enthusiastically states. The study published in “Nature” centres on a brain-computer interface called BrainGate2 and the 58 year old Cathy Hutchinson. Fifteen years ago, she suffered a stroke which severely injured her brain stem. Since then, she is paraplegic and unable to speak. Shortly after the stroke, she only was able to use eye movements to communicate with her environment and suffered from the so-called locked-in syndrome. Meanwhile she can slightly move her head again and occasional trembling motion of her arms occurs.

Hutchinson, together with a fellow sufferer, was supplied with a sensor implanted into the brain cortex. The four times four millimetres sized device consists of 96 thin electrodes which record the electric activity of the involved nerve cells and was placed at the exact location where electric pulses to trigger arm movement are generated in a healthy brain. Via delicate gold wire this information is conveyed from the interface to the skullcap and from there via a computer further to the robotic arm.

The successful trial which was carried out in April of the previous year was part of a continuing study about the robotic arm. Six years earlier, John Donoghue (Brown University in Providence) and his colleagues let patients paralyzed from the neck downwards move a cursor on a computer screen merely by their thoughts.

The new application goes far beyond that because control of a robotic arm is much more complicated than moving a computer cursor. In addition, movement of the arm takes place not only on a plane but in three-dimensional space. According to the researchers, the successful experiments using BrainGate2 – Hutchinson succeeded in four out of six studies – show the potential of brain-computer interfaces. Still, they would need considerable improvement: A technician had to always accompany the patients to adjust the system in a half hour procedure before use. Ideally, BrainGate should be ready for the market within ten years. Till then, the system should also be able to take over more complex routine tasks from the patients such as brushing their teeth.”

Due to the complexity of the central and peripheral nervous system it seems unthinkable to electrically control a whole body as shown in the movie.

What ethical status would humanoid lifeforms like Na’vi or artificial avatars have?

Bioethics describes the ethical reflection of humans dealing with their living environment, especially with other humans’ lives, nature as well as medical and biotechnical applications. One of the goals is to find consent of society about these questions and discussions to provide a (moral) fundament for normative rules (like laws, conventions, basics for decision-making in ethics commissions) for a responsible handling with life. Bioethics is a branch of ethics. Source: wikipedia

Therefore it seems to be important to deal with the definition of life itself. From this concludes the value of life and questions concerning the treatment of other organisms. The empirically and epistemologically justified definition of life states three obligatory qualities of an entity to be called “alive” in a basic biological sense: reproduction, metabolism and capability to evolve.

Methodologically, these criteria make clear what life is but still do not help in pinpointing the character or developmental capabilities of the life form. This would need extended observation. The above definition lacks the aspect of the uncontrollable which is based on the potential of development of organisms. The value a life has or could have remains unclear.

The value of the life form / the organism for the ecosystem as a whole could also be important. Minimizing the definition of life bears the risk of generating a reductionistic technologically deterministic view on life.

For the ethical assessment of avatars and Na'vi (representing humanoid life forms), the validity of categorizing them as “novel” is of some relevance and up to discussion. They possess some properties which do not occur naturally in terrestrial organisms and some which closely resemble (or even equal) human characteristics.

Are they ethically equal to humans? What consequences would that have?

To what extent would avatars as products of synthetic biology be results of not only a generating process but also creation? Does man become the creator? Which consequences would such an altered self-image have for the human perception of the world?

These ethical considerations are based on a text by Joachim Boldt, Oliver Müller und Giovanni Maio (Synthetische Biologie, eine ethisch-philosophische Analyse).

May humans be used as test objects under certain circumstances?

Experiments on human beings can be allowed, but only if they volunteer. These experiments play an important role in market authorization of novel drugs. They constitute the last stage in the course of a clinical research study to approve a novel drug. They are even mandatory in this case, as knowledge gained from animal experiments is only partially applicable to humans.

Clinical trials for pharmaceuticals are carried out in four stages. During the first stage of a trial, aimed at determining the risks of the treatment, the drug is administered to 20-80 healthy people who are paid for taking part in the study.

In order for a clinical trial to be approved, an ethical commission of the medical association in charge has to investigate all judicial and ethical issues and make sure that all international medical guidelines are complied with. More details about clinical trials can be found here: http://en.wikipedia.org/wiki/Clinical_trial

Questions raised in the film that may serve as topics for discussion:

- Philosophical questions around the topic of body – soul differentiation?
- Is there a body without mind?
- Which responsibilities arise from creating/altering an organism?

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