

## High Tech in Low Vision

To Boldly Go Where No Man Has  
Gone...Wait We Did Already

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## Thank You

- Aaron Tarbett, OD for helping me build the content for this presentation.

## Disclosure

- Employee of Booz Allen Hamilton
- Contract employee and Optometric Subject Matter Expert assigned to the Vision Center of Excellence (VCE) at Walter Reed National Military Medical Center (WRNMMC)
- Views expressed in this presentation are those of Dr. Morgenstern only and do not reflect the opinion of VCE, WRNMMC, DoD, VA, DHA, BUMED or any other US Governmental agency. This is my presentation only.
- I DO NOT represent the VCE, WRNMMC, DoD, VA, DHA, BUMED, BAH or any other US Governmental or contracting agency

## Social Security Definition of Legal Blindness

- Corrected to better than 20/200 in your better eye or if your visual field is 20 degrees or less in your better eye.

## Definition of Low Vision

- Low vision is a condition caused by eye disease, in which visual acuity is 20/70 or poorer in the better-seeing eye and cannot be corrected or improved with regular eyeglasses.

[http://www.amazon.com/Low-Vision-Rehabilitation-Occupational-Therapists/dp/1556427344/ref=sr\\_1\\_3?ie=UTF8&qid=1404138080&sr=1-3](http://www.amazon.com/Low-Vision-Rehabilitation-Occupational-Therapists/dp/1556427344/ref=sr_1_3?ie=UTF8&qid=1404138080&sr=1-3)

## World Health Organization Levels of Visual Impairment

- **Moderate Visual Impairment:**
  - Snellen visual acuity = 20/70 to 20/160
- **Severe Visual Impairment:**
  - Snellen visual acuity = 20/200 to 20/400
  - **OR** visual field of 20 degrees or less
- **Profound Visual Impairment:**
  - Snellen visual acuity = 20/500 to 20/1000
  - **OR** visual field of 10 degrees or less

## No Light Perception

- **Total blindness** is the complete lack of light perception and form perception, and is recorded as "NLP," an abbreviation for "no light perception."
- 85% of all individuals with "blindness" have some remaining sight; approximately 15% are totally blind (NLP).

## Activities of Daily Living

- Difficulty seeing the height of the gas flame when [cooking](#)
- Problems [crossing streets](#) or seeing traffic
- Difficulty seeing information on a [computer screen](#)
- Problems [threading a needle](#) or making clothing repairs
- Difficulty using the telephone book or reading magazines, even with regular eyeglasses.

## Artificial Sight

- We can make the blind see
- Not science fiction anymore but still rudimentary
- Truly an international (interplanetary) community of research and development

## LCDR Geordi LaForge Star Fleet Enterprise



## Bio of LCDR Geordi LaForge, United Federation of Planets Starfleet

- 2370
  - Lieutenant, Junior Grade and Helmsman
  - Served on the USS Enterprise-D
- 2371-2372
  - Promoted to Lieutenant and Chief Engineer
  - Served on the USS Enterprise-D
- 2372-2377
  - Promoted to Lieutenant Commander and Chief Engineer
  - Served on the USS Enterprise-E

## LCDR Geordi LaForge

- Gene Rodenberry named the character after George LaForge, a quadriplegic fan of the original Star Wars series (fan died 1975)
- Blind since birth
- Uses technological devices that allow him to see
- TV Series
  - Used VISOR
- Films
  - VISOR in the first film
  - Prosthetic ocular implants in the last 3 films

## Character Description

- Lt. (J.G.) Geordi La Forge  
An away-mission regular who is racially black and birth-defect blind – although with prosthetic super-high tech artificial "eyes" which can detect electromagnetic waves from all the way from raw heat to high frequency ultra-violet, making other crewpersons seem hopelessly "blind" by comparison. His closest friend is Data, and the two of them are particularly efficient when working together on away missions. Because of his "eyes", Geordi can also perform some of the functions of a tricorder.
- [Gene Roddenberry](#), *Geordi La Forge's description, Star Trek: The Next Generation Writer/Director's Guide, March 23, 1987.*<sup>11</sup>

## VISOR

- According to the Star Trek fictional universe, a VISOR is a device that is used by the blind to artificially provide them with a sense of light
  - Visual
  - Instrument
  - Sensory
  - Organ
  - Replacement

## VISOR

- Caused persistent pain which could not be treated without interfering with the device
- Does not replace normal human vision but allows character to “see” energy phenomena (Thermo and night vision camera/goggles)
- Expands normal human vision from 1Hz to 100PHz
  - Able to see human vital signs (heart-rate and temperature) (FitBit)

## Back to Reality, for Real

- New Scientist magazine reported on a “similar device to VISOR that installs a retinal implant”
- NASA developed a device named JORDY (Joint Optical Reflective Display) named after LCDR LaForge
- 2012, National Academy of Sciences publishing an article stating the code that sends signal to the retina has been cracked
  - <http://www.the-scientist.com/?articles.view/articleNo/41052/title/The-Bionic-Eye/>
  - <http://www.nasa.gov/vision/earth/technologies/jordy.html>
  - <http://www.bloomberg.com/news/articles/2012-08-13/blind-mice-given-sight-after-device-cracks-retinal-code>

### Different Diseases Require Different Technological Solutions

- Anterior segment vs. posterior segment
- Different anatomical layers of the retina
- Bypass problem vs. restore vision

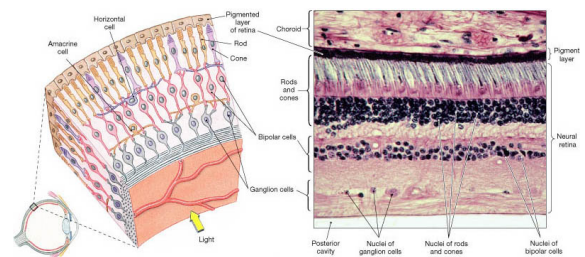
### Argus II Retinal Prosthesis System

- Second Sight Medical Products, Inc.; USA
- Received clearance from the United States Food and Drug Administration (US FDA)
- Intended for patients aged 25 years and older with bare or no light perception vision caused by advanced retinitis pigmentosa with a history of previous functional vision
- Reimbursed by Centers for Medicare and Medicaid Services (CMS)
- Cost per unit is approximately \$115,000
- Over 125 devices implanted already

### Argus II Retinal Prosthesis System

**VIDEO**

### Retinal Anatomy



## Retinitis Pigmentosa

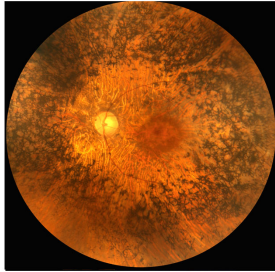


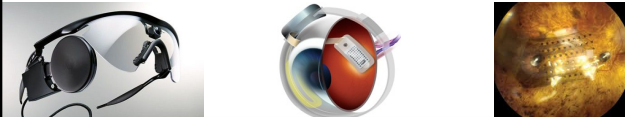
Fig. 12b. Fundus photo of a patient with retinitis pigmentosa.

## Argus FDA Indication

- *Intended for patients aged 25 years and older with bare or no light perception vision caused by advanced Retinitis Pigmentosa (RP) with a history of previous functional vision*
- Designed to improve the visual function of patients and may produce the sensation of light.
- Results of the clinical study showed that the System helped subjects:
  - Identify the location or movement of objects and people;
  - Recognize large letters, words, or sentences;
  - Other activities of daily life, such as detecting street curbs and walking on a sidewalk without stepping off.

## Argus Components

- 3 Parts
  - Miniature video camera (housed in bridge of glasses)
  - Video processing unit (VPU)
  - Retinal implant



## Argus Processing System

- Video camera transmits images via a cable to the VPU
- VPU processes image
- Processes to a 6X10 pixelated grid
- Sends back to glasses
- Transmitted to the retinal implant via radio frequency

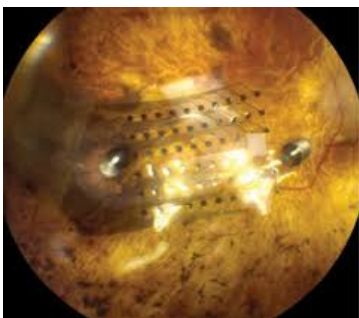
## Argus Contraindications

- Ocular diseases or conditions that could prevent the Argus II System from working, including optic nerve disease, central retinal artery or vein occlusion, history of retinal detachment, trauma, or severe strabismus;
- Ocular structures or conditions that could prevent the successful implantation of the Argus II implant or adequate healing from surgery, including an extremely thin conjunctiva, axial length less than 20.5 mm or greater than 26 mm, or corneal ulcers;
- Ocular diseases or conditions, other than cataracts, that prevent adequate ability to visualize the inner structures of the eye, including corneal opacity;

## Argus Contraindications (Cont)

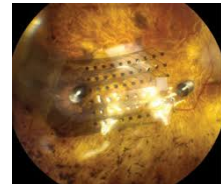
- An inability to tolerate general anesthesia or the recommended antibiotic and steroid regimen associated with the implant surgery;
- Any metallic or active implanted device in the head including a [cochlear implant](#).
- Any disease or condition including significant cognitive decline that prevents understanding or communicating informed consent, fitting procedure of the Argus II System, or postoperative follow-up. A confirmatory pre-operative psychological evaluation may be recommended;
- A tendency for rubbing their eyes.

## Argus Retinal Implant



## Implant Design

- Antennae
- Case which houses a inductive coil link
- Coil link transmits data to 60 channel microelectrode array



### Retinal Implantation Procedure

- 4 hour surgery
- Inserted into vitreous cavity
- Tacked to retinal face
- Includes phaco-emulsification and vitrectomy
- 1 day inpatient stay usually required

### FDA Reported Visual Outcome

- Improvement from light perception to hand motion and counting fingers
- One recipient achieved 20/1260 vision
- Minimal side effects

### FDA Reported Complications

- Conjunctival erosion or dehiscence over the extraocular implant (antennae and housing)
- All successfully treated
- One patient had to have the device removed

### Alpha IMS Retinal Implant

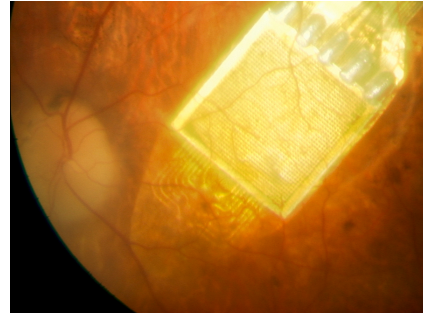
- Retinal Implant AG; Germany
- Not FDA Approved
- Received CE mark and available in Europe
- Placed between the Retinal Pigmented Epithelium (RPE) and Neurosensory retina
- Sub-retinal implants are a more difficult implantation
- Unknown if it will be available in the US



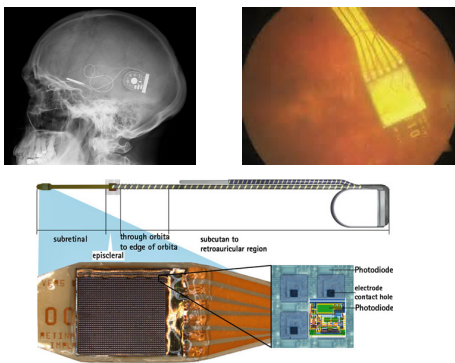
## Alpha IMS Retinal Implant

**VIDEO**

## Subretinal Implant Note: Retinal Vasculature



## Alpha IMS



## Alpha IMS Features

- 3X3mm silicon chip
- 70 microns thick
- 1500 pixel cells contain a
  - Light-sensitive photodiode
  - Logarithmic differential amplifier
  - 50X50 micron iridium electrode
  - Electrode is where electrical stimuli to the retina are guided

## Bio Retina

- Nano-Retina; Israel
- Not FDA Approved
- Bionic retinal implant
- No battery and no antennae required
- Effective on RP and AMD as well as other retinal degenerative diseases

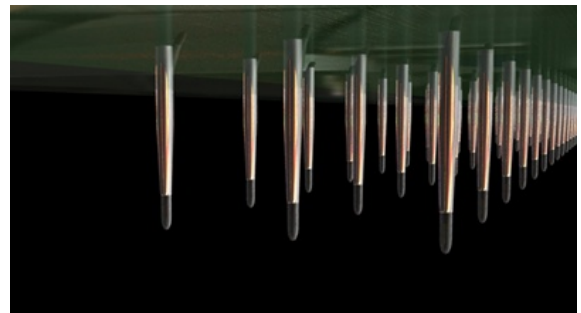
## Bio Retina

**VIDEO**

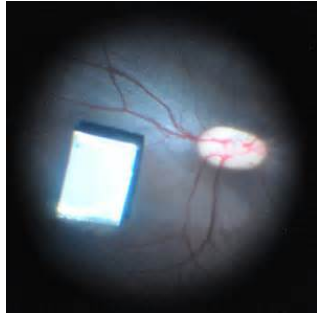
## Bio-Retina Features

- 3X4mm microchip
- 2 generations of pixel grids
  - Gen 1 24X24 pixel grid
    - 576 photodetectors
  - Gen 2 72X72 pixel grid
    - 5184 photodetectors
- 30 minute procedure to implant
  - Glued to surface of retina

## Bio Retina Micro Electrodes



## Rodent Implant



## Science Behind the Images

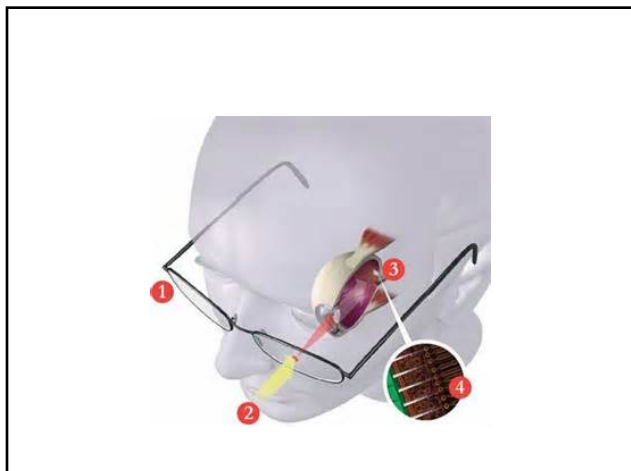
- Substantial amount of time developing a proprietary algorithm that translates the received visual information and image into the neuron language
- Translating circuitry that discriminates 100 gray-scale levels and responds to varying light levels
- But this is only half of the problem. In order to transmit the information to the neurons, you need to connect to them. To do this, the implant uses an array of micro-electrodes that first penetrate into the retina, then connect closely to the neurons and thereafter transmit the information. The goal is that every pixel will connect to a neuron, so that every pixel in the array would use a micro-electrode.

## Transmitting Information

- However, transmitting information to the neurons is not a passive process. The neurons must be stimulated electrically, meaning that the bio-retina implant also requires a source of electrical power

## Bio-Retina Power Source

- Rechargeable battery powered mini infra-red diode laser powers the implant wirelessly
- Laser is mounted on a pair of glasses
- Infrared laser light is transmitted into the eye and captured by a miniature photovoltaic cell on the bio-retina



### Brainport V100 "Lollipop"

- Wicab; USA
- Not FDA approved
- Theory of Neuroplasticity by Paul Bach-y-Rita, MD PhD
- "We see with our brains not our eyes"
- Brain develops neural pathways
- Sensory substitution
  - Echolocation

Cpl. Mike Jernigan, USMC



British Lance Corporal Lance Lundberg



## Device Mechanics



## Lollipop Indications

- Near or total blindness
- Intended to complement and not replace other assistive aids

## Lollipop Function

- FDA Approved
- Uses the highly innervated and moist surface of the tongue
- Electrode array placed onto the surface of the tongue rather than inside the eye
- Transfers electric simulated images captured by a wearable camera
- Camera is housed in sunglasses which is connected to Base Unit

### Lollipop Base Unit

- Translated the captured images into an electro-tactile pattern
- Electro-tactile pattern is displayed on the tongue via a thin postage stamp-sized resin pad
- Resin pad has 400 electrodes
- Electro-tactile stimulation feels like “champagne bubbles”

### Interpretation of Stimulation

- Intensity of the stimulation varies with color
  - White is strongest stimulation
  - Black is no stimulation
- Patients can ultimately interpret
  - Shape
  - Size
  - Location
  - Motion

### OrCam

- OrCam Technologies; Israel
- Assistive technology
- Translates visual information into auditory information
- Similar to video-magnifier and CCTV’s
- Mobile device, capable to “text in the wild”
- Non-disease specific
- Available in the US and on the company website

### OrCam VIDEO

## OrCam Device

- 2 Parts
  - Head Unit
  - Base Unit
- Head piece has a miniature camera combined with a bone conducting earpiece
- Mounted to right temple on spectacles
- Camera connected via wire to a base unit on the users belt



## OrCam Method

- Point with index finger towards something to read
- Unit converts the identified text, facial or learned image into speech
- Spoken into ear
- Earpiece is removable, can switch to other spectacles

## Morgenstern Bluetooth Visual Bypass System

- If these devices need the infrastructure from the retina to send the image to the brain, what if you bluetooth the signal from artificial photosensor to occipital cortex?
- Why use damaged goods?