Biohazard

Education at the Speed of Fear

Versions

Version 1.00

Kurt Squire, February, 14, 2002. Took Sangita's document, integrated earlier work. Added Versions. Fixed Table of Contents.

Version 1.1

Kurt Squire. Added Elliot Targum's edits to this document.

Version 1.2.

Tried to merge Alice's stuff. Had no confidence in it, so started over.

Version 1.3

Kurt Squire. February 15, 2002. Merging by hand now…

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GAME SUMMARY:

The year is 2050 AD. You're a young medical professional on a new job in an urban hospital. You're walking down a crowded hospital hallway, doctors, gurneys, technicians, and patients whizzing by. A series of patients come in with bizarre, yet strikingly similar symptoms. Alarm spreads through the neighborhood (city, country) as more people get infected and news of first deaths leaks to the local press. Time is ticking as you begin your investigation to identify, cure and eventually prevent the disease. The stakes are high, and risk of infection is a constant. You must use all available expertise and medical tools to find out who is sick, how they got infected and what can be done to contain the impending epidemic.

Your ability to progress through this case will not only save lives but will also help your personal career progression. If you can crack this you will be one step closer to becoming a widely and publicly acclaimed epidemiologist. First you deal with more local cases, hone your medical and immunology skills and prepare for the portents of some horrible disease that may lie beyond…

Diseases for each level - ebola or legionnaires disease, rabies, tuberculosis and meningitis - have been selected for their dramatic impact,and their ability to present a varied range of problems for the student to solve. Further, in battling each disease, the player elaborates on skills developed on theprevious level. Significantly, Biohazard does not attempt to train doctors, but rather, invokes the dramatic nature of popular cultural forms such as ER, and films such as Outbreak or Andromeda Strain to create a compelling game experience.

Through your journey as an epidemiologist, you will travel to crowded urban hospitals, dangerous sites of bioterrorism, and exotic jungle locations. Can you use your life science and investigative skills to save your patients' lives?

Gaming Objectives:

The objective of the game is to identify, cure and prevent infectious diseases before they reach epidemic proportions. Threatening exponential infection rates make speed, effectiveness and professional ability critical. The use of narrative and melodramatic storytelling elements creates emotional investment of players in their patients.

Educational Objectives:

This game teaches the players the basics of scientific inquiry (observing, gathering data, analyzing findings) while allowing them to explore their "practical" application in a simulated environment. Players also develop understandings of the basic biological systems and organs of the human body. As a medical practitioner, the player can use instruments and resources available to a fully qualified medical practitioner. Through the character, the player uses these tools to attain a deeper understanding of how multiple body systems are affected by disease.

Biohazard leads the student to discover normal physiology through Pathophysiology. AI features for animated characters should include temperature, suspicion level (are they infected, who have they been in contact with, if the disease is spread by droplet infection), hydration level, pain level, hunger, and antigen presence in blood.

Players learn when and how to use the following tools to aid in their investigation:

- Thermometer
- Stethoscope
- Electron microscope
- Spinal tap / CSF (cerebrospinal fluid)
- History notes
- Blood test (immune response and / or sepsis)
- X-ray

- Blood pressure
- Blood gases and biochemistry (urea and electrolytes)

Specific biology[1] areas, which could be covered through the infectious disease game format, include:

- Molecules and Cells
- Chemistry for Life
- Water
- Organic Molecules in Organisms
- Free Energy Changes
- Enzymes
- Membranes
- Subcellular Organization
- Cell Cycle and Its Regulation
- Cellular Energetics
- Fermentation and Cellular Respiration
- Heredity
- Meiosis and Gametogenesis
- Inheritance Patterns
- Molecular Genetics
- Mutation
- Viral Structure and Replication
- Reproduction, Growth and Development
- Structural, Physiological, and Behavioral Adaptations
- Response to the Environment
- Ecology

Victory Conditions:

The player wins a game when he/she identifies the disease, prevents further infections, and if relevant, cures those already infected. On each level, there will be an appropriate win-condition, such as issuing a public health notice, phoning the CDC, or simply telling the hospital that there is no cause for alarm.

Failure States:

If the player does not succeed in identifying the disease within a specific period of time, more and more people will get infected and eventually there will be no medical personnel available for conducting medical tests. The player controlled character is of course also always at risk of getting infected. If this occurs then the

[1] Advanced Placement Biology

time which the character has decreases significantly as he is likely to begin developing debilitating symptoms of the disease (including fever, loss of vision, nausea etc). The final failure state of the game is death of the character.

Game Levels:

The game progresses though several increasingly difficult levels. In each level the character has to deal with a specific infectious disease epidemic. Though the disease specifics may vary slightly, the disease/setting scenarios for the progressive levels are as follows.

Setting	**Disease**	**Learning Objectives**
Busy Hospital	Meningitis	anatomy and physiology of the central nervous system and brain, immune defense systems, body's response to infection
Urban Setting	Rabies	aetiology, epidemiology and pathogenesis of rabies, a rhabdovirus, DNA and profiling.
South African Hospital	Ebola	physiological role and function of the liver, and the systemic effects of severe haemorrhage, hypovolaemic shock, homeostasis, cardiovascular system, cellular metabolism, metabolic acidosis, normal blood gases and chemistry
New York City Neighborhood	Tuberculosis	Anatomy and physiology of the respiratory system, transportation of respiratory gases. Epidemiology of TB in North America.
London	Bubonic Plague	the lymphatic system, lungs and pneumonia, sepsis, adult respiratory distress syndrome and pulmonary

		oedema, blood clotting mechanisms (disseminated intravascular coagulation)
Boston University	Chickenpox	an opportunity to combine material learned thus far, and includes an unusual case scenario (Steven-Johnson Syndrome); eyes, fluid and electrolytes, integumentary system.
Alien Spacecraft	Escherichia Coli 0157	gastrointestinal system, Haemolytic-uraemic syndrome, the renal system.

7 Levels of Education at the Speed of Fear

1. DISEASE - MENINGITIS

Setting - busy hospital

Player - is a junior doctor, new to the hospital

Learning Objectives - anatomy and physiology of the central nervous system and brain, immune defense systems, body's response to infection

Narrative - following the tutorial, the player arrives in the emergency room of the hospital, and is urgently required to deal with a critically sick patient who has just been rushed into hospital. The patient seizes, arrests and dies within minutes of arrival. The body is sent for a post-mortem. Meanwhile the dead patient's relative who has been kissing him in sorrow, leaves the resuscitation room and promptly sneezes near the nurses station. The player needs to find out what the disease was, and prevent an epidemic.

2. DISEASE - RABIES

Setting - urban space

Player - is an FBI agent tracking down a serial killer known to have been bitten by a rabid dog. Player is doing an internship in the forensic section of the FBI.

Learning Objectives - aetiology, epidemiology and pathogenesis of rabies, a rhabdovirus, DNA and profiling.

Narrative - a serial killer much like Hannibal Lecter (and therefore apt to bite his victims) is bitten on the hand by a rabid dog, whilst trying to enter the home of a potential victim. The killer flees, worried that he might have contracted rabies, but does not seek medical attention. He is on the run, and will die from rabies in 3 - 6 months (the duration of the incubation period) and, in the meantime, represents a danger to society because he is both a serial killer and also likely to pass on rabies to another human through biting. The FBI has a description of the killer.

There are many other agents within the game space who vaguely fit the description, and it is the player's role to identify whether each man fitting the description is the one. The player can choose to do DNA profiling or, alternatively, diagnose rabies, in order to do this. Rabies will not become manifest, clinically, until a long incubation period has passed, though there may be clues, nonetheless, such as tingling in the peripheral nerves of the affected hand. The virus travels through a peripheral nerve centripetally and enters the central nervous system at which point it replicates within the gray matter and then passes centrifugally along autonomic nerves to reach other tissues - the salivary glands, adrenal medulla, kidneys … now the person develops rabies encephalitis and brainstem dysfunction, as well as hyperaesthesia, hydrophobia and inability to swallow, diaphoresis and pyrexia above 40.5. The patient falls into a coma and involvement of the respiratory centre in the brainstem leads to an apnoeic death.

It might be appropriate to use DNA profiling during the first 3 months or so, since rabies is extremely insidious and difficult to diagnose prior to the encephalitis stage.

The player had better be quick about finding the rabid serial killer, because he continues to commit crime for several months until he falls ill. News reports

inform the player about missing persons, and human remains, as well as possible sightings of the killer.

During the game, a man fitting the description but with a beard, and a bat bite, is found dead in the gutter. Is this the suspect, having succumbed to rabies? No! A tramp has died of the cold. But this should be enough to mislead the player while the clock is ticking, and while the killer is still at large, wreaking havoc. The object of the level is to minimize the number of killings, and find the serial killer amongst all the other similar looking people, as soon as possible, and to minimize the likelihood of another human developing rabies. If the serial killer dies before the player finds him, then it is most likely that surviving victims will have rabies. Hence the player still has to find out who has rabies.

http://www.vh.org/Providers/TeachingFiles/CNSInfDisR2/Text/PInf.VR.html

3. DISEASE - EBOLA (HAEMORRHAGIC FEVER)

Setting - South Africa

Player - is working in a hospital.

Learning Objectives - the physiological role and function of the liver, and the systemic effects of severe haemorrhage, hypovolaemic shock, homeostasis, cardiovascular system, cellular metabolism, metabolic acidosis, normal blood gases and chemistry.

Narrative - Ebola is usually transmitted to close family members, and can then reach epidemic proportions when a patient is admitted to a hospital. The incubation period is 2 - 6 days. Haemorrhage occurs throughout the body, including the gastrointestinal tract, pleural, pericardial and peritoneal spaces. The player's role is to find the virus (first figuring out what is happening to the infected people in the hospital) and then to get out fast!! There will be a new tool available - the liver biopsy - and the player may use this for living patients, or in autopsy. Additionally, the player may use the electron microscope in order to

visualize the very striking ebola virus (which features in the trailer). The player might decide to isolate all patients with ebola, which will necessarily involve keeping a student nurse, whom he dates, from entering certain infected parts of the hospital. This is not easy as she has a busy shift and needs to run errands to X-ray, pharmacy, and haematology. Intermittently, she disappears, and the player has to find her, before she becomes exposed to infection. By doing this, he risks his own life. Success on this level is achieved when the player has identified the virus, located the student nurse, and they have together left the hospital, neither of them infected.

4. DISEASE - TUBERCULOSIS

Setting - New York

Player - is called in as part of a World Health Organization drive to combat the TB epidemic sweeping across New York

Learning Objectives - Anatomy and physiology of the respiratory system, transportation of respiratory gases. Epidemiology of TB in North America.

Narrative - Tuberculosis is a bacterial infection, caused by Mycobacterium Tuberculosis. Primarily it affects the lungs but can also affect other organs. Respiratory TB is transmitted by droplet infection, and epidemics usually occur within poor communities. The player's role is to identify all of the people in a suburb of New York who have TB, and initiate an appropriate drug regime for each of them, so that the spread of infection is greatly reduced. This will involve tracing connections between families, gang members, local hospital staff *et cetera*.

5. DISEASE - BUBONIC PLAGUE (YERSINIA PESTIS)

Setting - London

Player - is taking a vacation and gets accidentally caught up as panic spreads throughout the UK when 3 cases of bubonic plague are discovered in a nursery school.

Learning Objectives - the lymphatic system, lungs and pneumonia, sepsis, adult respiratory distress syndrome and pulmonary oedema, blood clotting mechanisms (disseminated intravascular coagulation)

Narrative - while taking a vacation in London, the player sees a rat in his hotel room. The following morning he wakes up with an itchy rash on his leg. Has he been bitten by an insect? Worst case scenario is that he has been infected with bubonic plague due to a flea bite. He has 2 - 6 days before becoming symptomatic, and not much longer to do something about it. Meanwhile, 3 children from a nearby nursery school are also taken ill with bubonic plague. The player only finds out this information if he watches the BBC News at Ten. He has to locate the source of the infection, prevent further transmission, and work in the public health department examining fleas under microscopes, and so on. Not much of a vacation. If he identifies the organism in time, he will seek medical attention, realizing the significance of his flea bite, and will live. Much of this level will be spent running around virtual underground tunnels, including sewers, and the London Underground system, where rats are most likely to be found and caught. And, of course, there is a clock ticking with the player's life at stake. The player will develop defects and lose capabilities during game play if he takes too long with this, as he develops disease. This might be represented by blurred vision, inability to run, and so on …

6. DISEASE – VARIATIONS OF CHICKENPOX, including Steven-Johnson Syndrome, Shingles, and Herpes Encephalitis
Setting - Boston University
Player - is assisting the university health department
Learning Objectives - an opportunity to combine material learned thus far, and includes an unusual case scenario - Steven-Johnson Syndrome. Herpes Simplex and Varicella Zoster viruses. Anatomy and physiology of the integument and the eyes. Fluid and electrolyte balance.

Narrative - A few students have chicken pox, all from the same department. Two weeks later, a student from a different department presents to the university medical centre with some blisters on his trunk and he complains of burning eyes. It might appear that he, too, has contracted chicken pox. Has he? The player's role is to discover that he has something far more sinister and extremely rare -

Steven-Johnson Syndrome, a reaction to the herpes virus, and some drugs. The entire epidermis will slough off, and severe ocular damage can occur. To all intents and purposes, a patient with this syndrome needs to be treated like a burns victim. Severe dehydration can occur in addition to sepsis. If left untreated, the disease is fatal. The object of this level is to identify the student suffering from Steven-Johnson Syndrome, amongst all the other students suffering from chicken pox, and not to let him die! Both illnesses are very similar on initial presentation, beginning with blisters and flu like symptoms.

7. DISEASE - ESCHERICHIA COLI 0157

Setting - alien spacecraft

Player - called in to assist a group of aliens who have fallen ill shortly after arriving on our disease infested planet

Learning Objectives - gastrointestinal system, Haemolytic-uraemic syndrome, the renal system.

Narrative - Escherichia Coli 0157 causes haemorrhagic colitis, and can also lead to Haemolytic-uraemic syndrome. A group of aliens who have not yet acquired citizenship have been using their craft as a refuge, and this is located in the countryside. Due to a lack of awareness about the many disease causing organisms on the ground, the aliens have become ill. For the purposes of the content, the aliens have the same anatomy and physiology as humans. HUS is characterized by thrombocytopaenia, anaemia and renal failure. It is actually quite rare.

COMMON QUESTIONS

What is the game?

BioHazard is a first-person action / adventure / role playing game where the player is a medical professional who treats patients and attempts to stem epidemics through his / her knowledge of science under time pressure. Unlike other similar titles (e.g. Emergency Room), the player is given full freedom of movement and motion in a highly interactive, immersive environment. The player interacts with a rich landscape of scientific tools, books, and autonomous agents in order to solve the puzzle behind each epidemic. Doing so requires a sophisticated understanding of life systems and anatomy.

Why create this Game?

Fighting infectious diseases is naturally an engaging activity. Role-playing games build engagement by situating players in complex situations where they can solve authentic problems using authentic tool sets. Biohazard allows the player to use tools available to a fully qualified medical practitioner. Learners get the opportunity to learn by doing within an engaging, socially rich context. While some games have tried similar approaches (Sim Hospital / Emergency Room!), none to date have been built with this high-level of simulation fidelity (which is increasingly common in role-playing games), capitalized on the dramatic potential of infectious diseases, or drawing on melodramatic traditions to create emotional involvement in players. The lack of immersion or open-ended problem solving of these games compared with the state-of-the-art role playing games can result in a frustration for many players as they feel inhibited from exploring areas of interest to them or unable to test their hypotheses. We believe that a highly immersive simulated world RPG could tap into a market looking for fast-paced action with an engaging interactive narrative.

Fighting infectious diseases is a useful means to understanding AP level biology content. To facilitate the educational components of the game, teachers will have the possibility of "zooming" in on biology specific scenes, which they can use to guide class discussions with the students. Teachers can use the library of

scientific instruments and resources (e.g. books) in presentations. Infectious diseases provide a useful means for understanding the life sciences; through understanding pathophysiology, players can learn about healthy body systems.

Role-Playing Games share many design features with proven pedagogical approaches. Increasingly, medical educators are turning away from didactic approaches of instruction in favor of approaches in which players examine cases and solve problems (Barrows et al., 1999). Research has shown that students in these environments show increased ability to solve problems and think creatively with information in authentic contexts, compared to students trained in traditional lecture-based environments.

Role-Playing games share many features with problem-based, case-based, and goal-based scenarios. In each:

- Players adopt the role of a fictitious character
- Players are presented with a problem that is constructed in order to create emotional engagement in the player.
- Players need to manage a library of tools and resources
- Players "read" their environment to gather information and pick up clues to solve problems
- Players develop and test hypotheses on phenomena and solutions to problems (Squire, Jenkins, GTT team, in submission).

The design of virtual environments allows educators to embed problems and seductive details that are designed to elucidate students' misconceptions of phenomena.

Where does the game take place?

The game setting changes from level to level. The first level of the game is set exclusively in an urban hospital, which allows the player to become more familiar with the medical testing/investigation tools at his/her disposal. Later

levels of the game are set in increasingly less controllable environments that challenge the player's mission to track and cure the disease.

What does the player control?

The game is essentially a first person game, where the player controls his/her movements directly through a keyboard / mouse combination. In addition the player has specific tools, which appear in "cut-away" screens: the use of the extensive camera system, consultation with medical staff, medical books and resources, and access to medical background information to aid in his investigation.

The PC game is set up for a standard first person perspective (mouse controls view; keys control movement). When focusing on an object, it becomes illuminated (ala Thief). Double clicking on an object will pick it up. If the player focuses on a patient while using an object, she can click to use the instrument on the patient.

How many people can play the game?

Biohazard is a single player game with multi-player levels for up to 16 people to play. Levels 1-7 are designed as single player levels. The objective of the lower levels is for the player to master the basics skills he/she will need to succeed in higher levels. Though a player can attempt to play a higher level at any time, it is very likely that he/she will be killed immediately if they do not possess the necessary skills and competence acquired in the lower levels. The final level of the game has a multi-player playing possibility which will allow more than one person to play the game simultaneously. To allow for replayability, the diseases for this level in the game can be downloaded from a central constantly updated server. Further, a full suite of editing tools is included with the game to encourage students to design their own levels.

Are there other similar games available on the market?

Emergency Room! by Legacy Interactive is similar in that it places the player in the role of a junior doctor. Over the past three years, the *Emergency Room!* series has

sold over 400,000 copies. Players treat patients with a wide variety of illnesses, and have access to a broad set of medical tools. Built with MacroMedia Director, *Emergency Room!* constrains the player in ways not found in most simulated world RPG games; Emergency Room features a Myst-like navigation system, a menu-based interaction system, and text-heavy instructional resources. We believe that a game that picks up where Emergency Room! leaves off – by combining deep medical information / simulation but adds in drama and action found in simulated world RPG games. Further, BioHazard's action game control and navigation system is consistent with the fast-paced, open-ended play the game features.

Pedagogical Notes

Biohazard is pedagogically informed, primarily, by Roger Schank's *Goal-Based Scenarios* (1994). Emphasizing the benefits of experiential learning, Schank is a leader in the field of artificial intelligence and multimedia-based interactive learning. Building on recent cognitive science research, Schank argues that people learn through making mistakes rather than by perfecting routines. Successful learning environments start not with what content is to be "mastered," but rather in immersing learners in authentic activities like those that experts in their fields actually do. This approach to learning by doing (which is often described as problem-based or case-based learning) is increasingly common in medical, business, and law schools. With BioHazard, we are building on the design history of Goal-Based scenarios while adding in the story, interactivity, and emotional draw of Role-Playing Games.

Schank's Goal Based Scenarios take place within the dramatic narrative of the game in the form of a simulation environment. By playing a junior doctor, Biohazard allows the player to use tools available to a medical practitioner. The player uses these tools to attain a deeper understanding of how multiple body systems are affected by disease. Pathophysiology will lead the student to better understand normal physiology;

From the perspective of Schank's Goal Based Scenarios framework, it is critical that players think with authentic tools and resources, confront challenges designed to elicit their failure, and gain detailed feedback so that they might debug their performances. Biohazard challenges the student by presenting irregularities in the course of events that occur in the gameplay. For example, the player quickly discovers that AI characters in the first level have several flu-like symptoms, which include headache, fever, and a stiff neck. However, if the player reads these symptoms as the flu, she will kill her patient. In each level, there are several other details designed to seduce the player into triggering a failure state through false diagnosis or accidentally spreading disease. Consistent

with good game design practice, clues are embedded in each level to tip the player to the need for avoiding the failure state.

Placing players knee-deep in the role of trained medical professionals has the potential to be overwhelming. Given such a vast assortment of tools, which test should the player run? In Biohazard, we provide scaffolding for players by embedding information in the role of other doctors, patients, and medical technicians (e.g. Vgotsky, 1977). So, when a player encounters a patient, the nurse may suggest a treatment, the patient may give clues that she is suffering from a chronic condition, a senior doctor might suggest an alternative diagnosis, and / or the lab technicians will act puzzled if the player orders an inappropriate treatment. In later levels, the players will be given less scaffolding. Balancing how much information is too much and how much is not enough will be a critical component of play-testingNot only do students gain knowledge in this way, but they also learn how to think with that knowledge as they judge the validity and usefulness of investigations. Consistent with Schank's work with Goal-Based Scenarios, each level will be rich with extraneous information, forcing the player to evaluate the utility of the information she finds in the game.

Goal based scenarios are comprised by seven key components.

1. The learning goals – should be intrinsically motivating,
2. The mission – which can only be accomplished by using specific skills and knowledge,
3. The cover story – creates the need for the mission to be accomplished,
4. The role – the player as protagonist,
5. The scenario operations -- the level design
6. Resources (tools and resources available), and
7. Feedback. Both negative and positive feedback is inherent and automatic in Biohazard. Players can accumulate knowledge and skills that are then taken into the next, more complicated, level. Skills and knowledge are tantamount to 'power-ups', and represent a form of currency, which might serve as a form of exchange in the multiplayer version of the game. Mastery of these skills becomes a strong motivating factor.

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Hours of Game Play:

Biohazard will ship with at least 7 levels, a suite of editing tools, and the potential to download levels over the Internet, totalling approximately 20 hours of stock gameplay. (Each level takes 60-180 minutes to complete). Players can build or replay levels for extra replay value.

Character Progression:

The player progresses through the game levels as a single character, advancing in his/her career. By the end of the game (i.e. most advanced and challenging level) the character and the player will have internalized enough information, and accrued enough allies/knowledgeable contacts, that certain tasks can become automated (or at least assigned to agents/underlings/the machine). The more advanced levels also introduce a departure from existing disease precedents. The character increasingly encounters diseases that have either mutated or are extremely rare in the medical field. The player/character will have to apply the expertise they have developed during the course of their career/previous game levels to prevent impending epidemics.

Playing the Game/Level 1:

The objective of Level 1 is to provide the player/character with basic medical/immunology knowledge, increase his/her ability to use available tools, anatomical and physiological knowledge and expertise to identify, cure and prevent infectious disease.

Level 1 is set in a fully equipped hospital with labs, surgery facilities, wards, reception, and of course a morgue. The year is 2050. The site is also equipped with an extensive camera tracking system which tracks characters' movements and interactions thus allowing the player to monitor potential transmission of the disease between characters. The player controlled first person character is a junior resident doctor, fresh out of university and new to the hospital.

In the first minutes of game, the character takes a semi-guided tour/tutorial of the hospital. He is introduced to the hospital staff (receptionist, lab technicians,

pathologist) who explain their areas of expertise. Though the tour the character also learns about the various testing tools at his/her disposal including an x-ray, electron microscope, laboratory facilities, and post-mortem options.

The tour is unexpectedly aborted as the character gets called into the emergency ward to treat a patient in critical condition. As the character begins treatment, he/she is alerted to another patient who seems to be exhibiting similar symptoms and who is not responding to conventional treatment. Soon the emergency ward is flooded with similar cases. A medical professional falls ill and the first death is reported. The head of the hospital asks the character to investigate.

The character moves around within a Tomb Raider-esque game space, rushing down hospital corridors, up and down in elevators. He/she asks the pathologist to investigate the corpse. During the post-mortem the pathologist somehow becomes infected and falls ill shortly after submitting his report. Soon the game space is full with other animated characters (police, nurses, patients, healthy persons, infected persons). Who is healthy and who is not? How are people contracting the disease? What are its exact symptoms? What is the diagnosis? What is the necessary treatment?

The character will have to learn to recognize the signs and symptoms of the disease (pyrexia, photophobia, stiff neck, headache, anorexia, rash (sepsis)). This recognition will lead him/her to a correct diagnosis of the disease as viral or bacterial meningitis.

Time starts to run out as the character and some medical assistants become infected towards the end of the level.

The primary goal is to survive, halt the spread of the disease, get promoted and move on to the next level. Resources, knowledge and tools the character has accumulated are transferred to the next more difficult level.

The challenges which the character faces in Level 1 of the game will allow the player to begin to master the following skills / knowledge areas:

- Skills of observation and analysis
- Ability to judge the validity and usefulness of results of investigations
- Ability to apply accumulated knowledge
- How infectious disease manifests and incubation period
- Modes of contagion / etiology
- Cardiovascular system
- The central nervous system and raised intracranial pressure, anatomy and physiology of the brain, spinal cord and meninges
- Hydration, fluid and electrolyte balance
- Immune response

The Physical World

The physical world of the game changes from level to level. This change of game setting challenges the player to become acquainted with new environments and apply the knowledge he / she has accumulated. Irrespective of the specific setting for the game (hospital, suburbia, jungle or urban) the player will have access to the same medical testing facilities and staff. They travel with him.

The Tools:

The player has access to several gaming tools that aid in his investigation:

1. *Extensive system of cameras that allow for the tracking of characters whereabouts and interactions between characters.*

2. *Knowledgeable medical personnel in the hospital who operate the medical equipment and provide the player with detailed analyses of tests conducted.* They may occasionally recommend that a specific test be conducted. Unfortunately their advice is not always completely accurate and there is always a risk that they too may become infected.

3. *Detailed medical records of past cases accessible at all times.* These records are an invaluable resource for the player as they provide historical and medical clues about the nature of the infectious disease.

4. *A knowledgeable mentor who can be consulted on puzzling developments.* The mentor is the character's university professor and is an expert in the field. As the player progresses through the levels and picks up expertise, however, the mentor becomes less and less able to provide advice and the player is more and more on his/her own.

Creating Game Characters:

Prior to beginning the first level, the player is able to build customize his/her character. After hearing about the mission briefing, players can choose what tools and resources they want to bring along. We believe that this will support reflection, and research into the tool use.

Scenario 1

Bacterial and Viral Meningitis - Level 1

Content Notes

Learning Objectives - anatomy and physiology of the central nervous system and brain, immune defense systems, body's response to infection. Cardiovascular system.

Narrative Overview- following the tutorial, the player arrives in the emergency room of the hospital, and is urgently required to deal with a critically sick patient who has just been rushed into hospital. The patient seizes, arrests and dies within minutes of arrival. The body is sent for a post-mortem. Meanwhile the dead patient's relative who has been kissing him in sorrow, leaves the resuscitation room and promptly sneezes near the nurses' station. The player needs to find out what the disease was, and prevent an epidemic.

Tools / Objects in the Level

1. Spinal tap - obtain a sample of *cerebrospinal fluid* and measure the *intracranial pressure*. This is the most important tool in discovering meningitis (infection in the subarachnoid space), and differentiating between *bacterial* and *viral* origin.

> *Raised Intracranial Pressure* - characterized by *bradycardia* (slow heart rate) and *hypertension* (high blood pressure) due to cerebral ischaemia, otherwise known as the *Cushing's Reflex*, and also involves *seizures*. Additionally nausea, vomiting, photophobia.
>
> Physiology should include the reasons for why raised intracranial pressure produces the above effects, in addition to other complications such as *obstructive hydrocephalus, subdural effusions* and *cerebral oedema.* At worst *herniation* of the brainstem through the *foramen magnum* can occur. Regulation of blood pressure.

Pathophysiological consequences of *subarachnoid space inflammation* - decreased cerebral blood flow, *cortical hypoxia*, and increased *permeability of the blood-brain barrier*.

Anatomy of the brain, spinal cord and meninges - pia mater, arachnoid mater and dura mater, constituents and flow of cerebrospinal fluid. Types of neural tissue, spinal nerves.

Player must establish whether there is severe cerebral oedema, or papilloedema, prior to doing the spinal tap, otherwise the patient will certainly develop potentially fatal herniation when the spinal tap is performed! In the absence of the above two signs, a spinal tap is safe (for the purposes of the game).

2. Microbiology - a tool to determine the pathogenic organism. Specimens of cerebrospinal fluid and blood can be sent for examination, in addition to sputum.

For purposes of the game, the pathogenic agent will be Haemophilus Influenzae Type B, for bacterial origin, and this is most likely to be associated with a purpuric rash which means that life threatening sepsis is present. In this case bacteraemia leads to invasion of the central nervous system and cerebrospinal fluid. Cerebrospinal fluid will mostly, but not always, contain the bacterial organism, will appear cloudy and contains large numbers of neutrophils. (Normal CSF is crystal clear). There is an elevated protein concentration. *Gram's stain*, *culture* and *sensitivity* of the CSF will reveal the aetiologic agent. Significantly, particularly for the player, this form of meningitis is rarely seen in persons older than 6 yrs.

Viral meningitis (which will primarily be found in the adults in the game) can be differentiated from bacterial origin, simply by the absence of bacteria in the CSF. Causative viral agents can be enteroviruses, arboviruses, HIV, mumps and, rarely, influenza A. Viruses can also be isolated from other specimens such as sputum. Definitive diagnosis of

viral infection is by measurement of anti-viral antibodies. Due to the timing of antibody response, this has to be retrospective.

With the exception of life threatening sepsis associated with bacterial origin, the two forms of meningitis can lead to a similar clinical picture, with similar symptoms, though bacterial meningitis is more severe. Arboviral meningitis is epidemic in nature, whereas the bacterial form is not so. Haemophilus Influenzae, Type B, meningitis is transmitted primarily by kissing.

3. Electron microscopy - can be used to visualize some of the above mentioned pathogenic organisms.

4. Opthalmoscope - a tool used to look in the eye for papilloedema.

5. Haematology - a tool for examining the constituents of the blood.

Serological examination will reveal a rise in total specific antibody, which means a positive diagnosis. A rise in white cell count suggests a response to infection. Clotting abnormalities, such as a prolonged prothrombin time, suggest serious complications of bacterial disease and sepsis.

Constituents and functions of blood and plasma. Erythrocytes, leucocytes and thrombocytes. Differential white cell count - neutrophils, lymphocytes, monocytes, basophils, eosinophils - phagocytotic processes, the antigen-antibody response, immunity, allergies, cytotoxic (killer) T-cells.

See also: http://www.bact.wisc.edu/Bact330/lectureHflu for immunity.

A high number of neutrophils in both the blood and CSF represents a significant find for the player.

Physiology of haemostasis and coagulation. Disseminated intravascular coagulation.

6. Magnetic Resonance Imaging (MRI) - produces images that represent a biochemical blueprint of cellular activity.

- Colour and 3 dimensional images are possible.
- Provides both visual information, and information about chemicals present in an organ or tissue.
- This tool will provide no important information for this level, but players may use it anyway.

This tool represents a potential hazard because, to all intents and purposes, it is a giant magnet. So if the player enters the room with any metal object on his person, such as keys, or even a scalpel, the said object will go hurtling across the room, probably killing any person in its path. It might be necessary for the player to carry a set of keys during game play, with which to access the virtual "controlled drugs" cupboard. A thoughtful player will realize the significance of entering the room in which the MRI scanner is located before disaster occurs. If disaster does occur, it will be useful for the player to be able to click on a "what happened?" icon, which will give an immediate explanation of the mistake. Such an icon will be useful in all levels of the game, and there will be other anomalies, too, all of them avoidable by the savvy player!

7. *Computerized Axial Tomography (CAT)* - provides a detailed cross-sectional picture of any area of the body. This tool will provide no important information for this level, but players may use it.

8. *Radiography* - a chest X-ray will provide the player with no information leading to a diagnosis of meningitis, but may illustrate pneumonia, which can be concomitant. See either normal chest radiograph, or radiograph for patient with TB (to mislead the student).

9. Thermometer - infected patients or staff will have a high pyrexia.

10. *Stethoscope* – used to measure heart rate, bradycardia or tachycardia.

Treatment and resolution

1. For those with bacterial origin:
Ampicillin, and a third-generation cephalosporin.
Chloramphenicol for penicillin resistant strains, but highly toxic side effects.

2. For contacts of those with bacterial origin:
Antibiotic prophylaxis with rifampicin.

3. For viral meningitis:
Intravenous gamma globulin (rarely) and / or acyclovir (anti-viral agent).
Analgesia.

4. Methods for reducing intracranial pressure, such as diuretics, electrolyte management, hyperoxygenation.

Tutorial

You find yourself walking down the hallway of a crowded hospital, the action rendered by the game engine in letterbox, not a cut scene (a la 'Deus Ex'). Your supervisor, Dr Jenkins, walks beside, keeping up a stream of dialogue describing the hospital's working: 'There's the X-Ray lab, you'll see that a little later on if you'd -- hey Barbara, I need those -- wait -- I need those papers by three, *not* four. Player looks into the x-ray lab and sees a number of x-rays mounted on the wall waiting to be viewed. Option to zoom in and check them out. Doctor Green, your office (such as it is) will be -- wait, where's the elevator pass key? Damn thing -- office on the second floor, next to Oncology...we need you to carry these keys for the controlled drugs cupboard … don't let them out of your sight …' As you look left and right, you see characters and settings passing. Some you know already, and labels briefly flicker on the game screen to remind you of their identity. Others you'll meet later on, as Doctor Jenkins says.

You enter the elevator, and the noise subsides (but the Muzak does not -- it's everywhere, encroaching. A plague). Jenkins begins to tick off the locations of various wards, wings, offices; in the middle of his speech, his pager goes off. 'Aah, hell. I'm being beckoned.' 'Patients to see?' you ask, genuinely interested on your first day. 'Trustees to see. Rich sons of -- hey, can you do me a favor?' He pulls out a lab form. 'Since your shift doesn't start for another ten minutes or so, can you run this down to the microbiology lab on the third floor? Out the door and to the right.' He gives you a friendly, if condescending, slap on the shoulder, and steps out on five, helpfully pressing the button for 'three' as he exits. You look at the form, it says 'M, C and S'

(Microscopy, Culture and Sensitivity) and, under 'comments' it reads 'urgent – meningitis?' … you observe the 3 containers of cerebrospinal fluid in the bag attached to the form as you run … your pace quickens, you turn into the lab … 'thank you sir, this the gram stain, yeah?' … 'yep, I guess … my name is Dr. Green, new resident' … 'Green, good to meet you at last, we saw your paper … listen … take a look at this …' The lab technician takes a petri dish, slaps a slide

under the microscope, and you look … a sinister twisted bacterium with a tail comes into view … you zoom further … ‘patient came in yesterday with fever and petechial legions … first case we’ve had in months … looks like it may be a cluster’ … The tutorial proceeds, giving a tour of the hospital, up and down bustling corridors, meeting other characters upon whom you will rely when you find yourself tracking down a killer …

You hear a voice behind you: 'Can I help you?' Across the hall in one of the Radiology labs, you see a face, and quickly match it to a nametag (hearing yourself say the name in voice-over): Dr Hass. Options appear on screen for responses, and you choose one of three: 'I'm looking for ER? 'Down the hall, on your left. You new here?' You walk away, however, not responding. Names and beacons come over the P.A. system, and you would do well to note some of the information being given out. Dr. Jenkins reappears and takes the time to walk you briefly through the workings of the scanning electron microscope (SEM), to 'bring you up to date'. Interface help appears at screen's top, 'labeling' components with the commands necessary to operate them.

A moment later, your pager goes off; Jenkins’ pager goes off; a voice comes over the intercom, calling you immediately to the ER; the doors at each end of the hall burst open, patients being wheeled through the already busy hallway. The ER is an explosion of light and sound and motion, voices barking commands on all sides …We have a young patient here, he's short of breath, his heart's barely there. We've already given him --'

The words are nearly drowned in the roar of the ER. You bend to look at the body, which seems to slump perceptibly. A senior doctor arrives and orders some drugs, some tools; you look down and realize that treatment has come too late. "Okay, forget the spinal tap ... we're losing him ... his pressure's dropping, any news on his clotting?" The doctors start cardiac massage,
"let's have some adrenaline" another doctor shouts "clotting is deranged" ... "looks like meningitis". As his mother throws her arms around his neck, kissing his face, his forehead, the boy on the table quietly dies. "Can someone please

make sure the relatives get rifampicin" says a senior doctor, now walking away from the scene.

What you do not know is that, in death, he continues to be a risk. And as his mother is taken away to calm down, you realize that you don't know what killed this boy, and that ignorance, in this case, could be the very death of you.
Out of the corner of your eye you see the boy's mother walking away, sobbing...and as she passes the Nurse's station, she stops a moment and suddenly sneezes. She continues to walk away.

Tutorial over, you set parameters for your character and begin:

The letterbox format widens to fit your screen, and interface elements pop up, unobtrusive but accessible: a collapsed inventory bar in the bottom right corner of the screen, and in the bottom left, a list of keywords, things you've just heard and things you were supposed to remember. There's a lot of information to consume in a short time (the day flies by as in 'ER', not 'St Elsewhere') and it seems reasonable to expect that you (and your character) should know certain things. Now with control over your character, you step out of the elevator on three, just as two orderlies wheel a sick boy on a trolley into the lift. You notice lesions on his face and neck, but have no time to examine.

Who are you and who is your character?

Tina is an 18 year old female, who doesn't play many games. She played some Zelda growing up, and plays the occasional arcade game with her boyfriend. Crazy Taxi, for example. She likes Crazy Taxi. And Mario, of course. But, other than that, games aren't her thing.

As she's assigned BioHazard for homework, Tina has mixed feelings. On the one hand, she's excited about the chance to play a sophisticated 3D game like the ones that some of her friends play (both men and women). Maybe she'll like this game enough even to try a game like Quake. At the same time, Tina is a little

afraid of the game. Will it be too gross? She doesn't really like sick games like Quake and, well, with all of the bio-terrorism stuff going on, she's a little afraid that this will really be tasteless. But, it's better than lectures. And, Tina's mother has been hinting around about her going to med. school since she can remember, so maybe this will give her a taste of what it's like to be a doctor.

Tina opens up the box and clicks on the single player game. She goes through the tutorial and finds it a little exciting, but she's eager to get this thing going. I wonder how I'm going to be graded, she thinks. Ah well.

"It should be pretty fun being a doctor," Tina thinks as she creates her character. She names her doctor Dr. (Marlena) Evans after one of her favorite characters on *Days of Our Lives*. Marlena's a bit preachy, though, so Tina thinks she'll probably be less preachy than Dr. Evans, but, it would be fun to play around with being Marlena. She thinks to herself that she probably won't tell anyone about it.

Finally, I'm a doctor. "Your first patient, Doctor." A young male nurse introduces himself to Tina. "Her information should be in your PDA" She holds her PDA towards yours and zaps you the info "Now". The nurse looks at Tina and smiles.

Tina walks into the waiting room. To her left is a woman, in her 30s. She looks concerned. To her right is the examining table where the patient, a girl of about 5 years old is lying down. Tina looks at the girl. The older woman stands up and introduces herself. "Hi, I'm Marjorie. This is my daughter, Sally." She explains. Tina clicks on Marjorie. As she moves her mouse over Marjorie, she notices that some information appears above Marjorie's head, including the information she just learned. Marjorie. Daughter=Sally.

Tina clicks on Marjorie. A clear dialog box appears, although the world keeps moving. "Double Click on a character to interact with them" Tina thinks to herself "Ok, makes sense." She double clicks on Marjorie.

The screen cuts to letterbox format. Marjorie turns to face Dr. Evans.

"I'm sorry to hear that," Tina begins, "Tell me more."

The camera shifts to show Marjorie, who is clearly worried. Tina thinks to herself, "My she looks worried. I hope that I don't screw it up."

Marjorie continues "she's been complaining about a headache, a stiff neck, and feeling a bit sleepy. Think that it could be the flu?"

Tina thinks to herself, "Sure sounds like the flu. Also sounds like what they'd probably have you do for the first level. Cool. I can do this." The camera cuts to Dr. Evans. "We'll see". The letterbox disappears and Tina is given control of the game again. "Hmmm." She thinks to herself. "I wonder what I do next." She quickly scans the room. Sally is lying on the table, awkwardly, her eyes shut tight. She looks on the desk and sees a series of instruments. As she moves her mouse over the stethoscope, it becomes illuminated. She tries clicking. The stethoscope moves into her hand. A small dialog box pops up. To use an object, hold the mouse over a person and left click. To drop it, right click. "Hmmm, that's kind of cool.

Maybe I'll try that. That's what doctors normally do, right?" Tina thinks. Tina moves over to Sally. Sally flinches a bit. Marjorie comments, "I'm sorry, I think she might be a little scared."

"Oh no" Tina thinks. I didn't even say anything to her. Tina right clicks to put away the stethoscope. She clicks on Sally.

Sally begins (still in game, not cut scene) "I hurt. And, I have a rash like bruises." Tina can see a petechial rash on Sally's neck and face. Sally also looks pale. "Her hands and feet are freezing cold" says Marjorie.

Seeing the rash immediately reminds Tina of the introductory cut scene she saw of the boy who was sick and died. "Oh no. If I kill this kid, I'm sure to flunk," Tina thinks to herself. Tina tries to recall what that was all about? "That's right, I

remember it sounded like the flu, but people were dying, and then they ordered some sort of crazy test. What on Earth was that again? Why wasn't I paying more attention? Now what do I do?"

Tina's thinking is interrupted by Marjorie, who speaks (she is timed to speak 15 seconds after Sally). "Ummm, are you going to help her, Doctor?"

“Whoops! I’d better do something,” Tina thinks. She decides to go ahead and check Sally. As she pulls out the stethoscope, her character speaks, Hi Sally. I'm here to help you. Let me check your heart rate, here." The stethoscope and hand move towards the patient and begin to check her heart rate. 55 beats per minute pops over Sally's head. A dialog box appears. Click on information and drag it into your PDA for more information.

Sally clicks on 55 beats per minute and drags it to her PDA icon. The PDA icon expands, showing the following information, displayed on a visual graph.

Heart Rate
Normal: - 80 - 100 beats per minute for 5 year old child
Your Patient: - 55 beats per minute.
Sign of: - Cardiovascular system is depressed, poor cardiac function.
Suggested actions: -
Ask Patient About Other Symptoms
Take Temperature
Order Spinal Tap
Give Fluid
SAVE

Tina clicks on Save and saves the information, entering in Sally's name.

Tina reads the read-out. "Uh-oh" Tina thinks. "Sounds like more than the flu!" Tina scans the list. She sees that some information is presented in blue links, like on the web. I bet I can click on them to get more information. She clicks on the

first one, "Cardiovascular system is depressed." She is presented with the following screen:

Cardiovascular System

Overview of anatomy and physiology of key organs – heart, arteries, veins.

Physiology behind the maintenance of normal blood pressure, cardiac output, the difference and relationship between the arterial and venous systems, arterial dilation versus arterial constriction, perfusion and oxygenation of the brain and other vital organs. Circulating fluid volume and oxygen transport, together with constituents of the blood, erythrocytes, *et cetera*.

The physiology of shock – hypovolaemic and septic shock, characterized by tachycardia and hypotension (fast heart and low blood pressure) and cool extremities (because all the oxygenated blood gets redirected to the vital organs such as the heart, lungs, kidneys, liver, and brain).

Signs of cardiovascular dysfunction and / or shock:
Low blood pressure … mean arterial pressure below 50 mmHg
Poor peripheral perfusion (cold extremities and pale)
Tachycardia … fast heart rate 110 – 150 beats per minute in 5 year old child
Slow capillary refill > 1 minute
Diaphoresis … sweaty and clammy
Confusion or unresponsive
Low output of urine (due to poorly perfused kidneys) < 1 ml / kg / hr
Sunken eyes and depressed fontanelle in a baby
Metabolic acidosis

(Taken from: http://www.niaaa.nih.gov/gallery/cardiovascular/269f1.htm)

“Okay,” Tina thinks. “At least I'm not totally helpless, here.” She clicks around on a few of the topics, to get a sense of what's in here. "Okay", she thinks to herself. "This is a database of stuff I can use to learn about diseases."

Sally looks up again, "Dr., am I going to be okay." Tina realizes she's lost again, and that time is ticking on. Tina closes the PDA. She clicks on the girl. "I'm sure you will be okay...we're going to do everything we can..."

Tina takes Sally's temperature. Again, she uses the PDA. "Ok, a fever and a low pulse rate. Hmmm. The PDA says some sort of infection. It also says that a high temperature is normally associated with tachycardia, but Sally has a low heart rate, so what’s going on here? And there's this rash - I'm getting worried,” Tina thinks. She leaves the room to find out more about what that other disease was. Tina decides to walk down the hall. She could go to the medical library if she wished.

INTERLUDE

Tina walks down the hall and asks another doctor about the disease. She finally finds a doctor who was working on the case. In another game, Tina may have chosen to talk to the girl more, and found out that Sally went to school with the boy who came in sick before, helping her identify possible contacts. However, she didn't, so now she's going to have to figure it out on her own. She might have also talked to the mother more, and learned about more of Sally's symptoms. Or, Sally might have ordered the Spinal Tap right away. Had she done so, the following might have occurred:

Tina thinks to herself, "Wow..I remember how quickly that boy crashed in the introduction. Must be the same disease. I remember one of the nurses mentioning a Spinal Tap. I'll go ahead and order one of those. But how do I do that?" She heads down the hall to where she saw the "Spinal Tap" picture. Tina bumps into the assistant who is running the lab.

If Tina clicks on the assistant, the following cut scene appears."I need to order a Spinal Tap in 213b," she orders. The assistant responds, "Okay, just send me the information on the PDA." You click on your PDA, call up the patient information, and hit "send." The technician gives Tina the tools to conduct the spinal tap, and the test is ordered. Tina takes the tools back down to Sally.

As Tina enters the room, Marjorie approaches her. Zoom to letterbox. "I'm nervous. Do you think this might be something dangerous? I didn't know about the rash." She comments, "Is everything going to be okay?"

"I think it might be meningitis, which is serious, but it looks like we've caught it in time. Let me run this quick test."

"Are you giving a Spinal Tap? I heard it hurts. Are you sure it's safe?" asks Marjorie. End cut scene.

Tina stops to think. Should I check more into my PDA and learn about a Spinal Tap? After all, I have no idea what one is really. On the other hand, that boy crashed really quickly. Maybe I should just try it?

Let's say that Tina decides to try it … she clicks on the spinal tap tool, which illuminates, she moves it with the mouse cursor towards Sally and proceeds. But then cut scenes appear in which, to Tina's horror, Sally has a cardiac arrest … the monitor makes a loud alarm, and shows a flat line (asystole).

End cut scene. "oh damn, what have I done wrong … I think I just killed her"

Then Tina notices the skull and crossbones icon flashing, with the words "What Happened" situated just below. Tina double clicks on the skull and crossbones, and reads the following information:

- Your patient is dead!
- File a death certificate.

- Explain to Dr. Jenkins what happened.
- Autopsy

As previously, Tina can see that these comments are hyperlinks, so she clicks on "Explain to Dr. Jenkins what happened", not that she has the faintest idea what happened, "but I had better find out quickly" she thinks. Here, a text box opens up and she is supposed to write in a description of what she did, and then check on some boxes which are labelled as follows:

• Patient had papilloedema.
• Patient had the Cushing Reflex.
• Death caused by herniation of the brainstem through the foramen magnum.
• Death caused by the removal of too much cerebrospinal fluid.
• Death caused by accidental puncture of the spinal cord.

The first three items are consistent with the death of Sally, and the last two are plausible complications of a spinal tap, but would not cause Sally's death. (If the player checks on the last two boxes, this suggests that they are either guessing, or have not understood the anatomy and physiology that they will learn from the autopsy).

"Well, I don't know what any of these weird things are" thinks Tina "How can I explain to Dr.Jenkins what happened, if I just don't know, but I guess I could ask the autopsy … I bet that's a way of finding out?" so Sally clicks on the hypertext link to the autopsy, and sees a great deal of information, giving definitions and answers to all the strange words she saw on the previous screen … this includes an animated "rewind" of the brainstem herniating through the foramen magnum. In summary, it includes:

Diagramatic information about the anatomy and physiology of the central nervous system and brain. Comprehensive information about the Cushing Reflex, and its physiology, raised intracranial pressure and its complications and

consequences, including poor perfusion to the brain, cerebral hypoxia, and the mechanism of “coning” – the herniation of the brainstem through the foramen magnum, with animation. See content information.

After reading the autopsy report, Tina returns to tell Dr.Jenkins what happened, “hey, I know that it is these three boxes here, which I have to check” thinks Tina, satisfied that she has mastered this new knowledge. “I wonder if I should file the death certificate?” … she follows the signs to the mortuary, down several corridors … “fancy being able to go to every room in this hospital including the mortuary” says Tina to herself as she follows the corridor around some corners “maybe it will be realistic?” … when she arrives there, she meets the mortician, and clicks on the death certificate which has been up in the right hand corner of her screen since the incident (rather annoyingly) and it disappears from the screen … then she notices that the mortician is holding it. “Have you reported this to Dr. Jenkins?” says the mortician. If she has, she replies “yes” and the mortician says “have a good day” and Tina returns to the game. If she hasn’t, and she replies “no” then she will receive a similar screen to the “Explain to Dr. Jenkins what happened” screen, from which she will be able to learn the material, and file the death certificate. If she hasn’t explained to Dr. Jenkins what happened, but tells the mortician she has (because she is in a hurry to return to the game), then the mortician will ask for a report on the death certificate, hence prompting the “File a Death Certificate” screen which will, of course, be much the same as the “Dr. Jenkins” screen. One way or another the player will have to report back on something … either to Dr. Jenkins or to the mortician. Explaining the incident to another character works not only to reinforce learning, but also functions as an assessment tool. The grim reaper has all the answers where death is concerned.

ALTERNATIVE ROUTE

If Sally does look up Spinal Tap in her PDA before proceeding, she will realize that she needs to first use the opthalmoscope tool to look into Sally’s eyes to see

if she has papilloedema. She will also find the following useful information about the spinal tap tool:

Spinal Tap Tool

Obtain a sample of *cerebrospinal fluid* and measure the *intracranial pressure.*

Contraindications – *severe cerebral oedema* or *raised intracranial pressure* and *papilloedema.* Establish whether these are present prior to performing a spinal tap, otherwise patient will develop potentially fatal herniation of the brainstem through the foramen magnum.

Suggestion – check your patient for papilloedema using opthalmoscope. If papilloedema is absent, proceed with a spinal tap.

Cerebrospinal Fluid

Normal: - Crystal clear

Your Patient: –
- cloudy in appearance
- large numbers of neutrophils in the fluid
- elevated protein concentration
- may contain the aetiologic agent (Haemophilus Influenzae, Type B)

Sign of: - Infection in the subarachnoid space

Suggested actions: -

Ask Patient About Other Symptoms
Take Temperature
Give Fluid
Give Benzylpenicillin
Send CSF for Gram Stain, or Electron Microscopy
Identify Causative Agent.
Ask Patient about Allergies
Perform Computerized Axial Tomography (CAT Scan)

SAVE

"Phew! Sounds dangerous. Good thing I checked. Turns out that I need to check her eyes for papilloedema." She clicks on the opthalmoscope tool. Using the tool allows her to view actual images of papilloedema, as they are seen by a doctor, like herself, of course. It is by clicking on the tool itself that she can also choose an option to gain further information about the tool, should she have any uncertainty. But Tina figures that the opthalmoscope is used for looking in the eyes.

The raised intracranial pressure which papilloedema signifies, places Sally in danger of herniation of the brain stem, if she is given a spinal tap. "Oh, my goodness" thinks Tina "I almost killed the patient. Good thing I checked her eyes. I guess I will now have to figure out whether she has meningitis without looking at the cerebrospinal fluid (CSF). Hmmm"

She opens the PDA again … "so, I think this means that I can't look for bacteria under the electron microscope, without any CSF … maybe I'll get a look through that if the next patient is okay to have a spinal tap." Tina wonders whether she should find out some more about papilloedema … this will lead her to discover more about the raised intracranial pressure but, while she is thinking, Sally's monitor alarm goes off … Sally is deteriorating … the monitor says that her heart rate is now only 50, and that she has high blood pressure … "now what's going on" thinks Tina, feeling the urgency, and wondering if Sally is going to die before she figures it out. (A message arrives on Tina's pager to say that 2 nurses from the Emergency Room have gone home sick with headaches and high temperatures … this means that the ER is short of staff).

Tina decides, frantically, that she had better first check the PDA or the virtual medical library to find out why Sally has high blood pressure, sort that out, "then that might buy me some time to look up the papilloedema" Tina thinks. She clicks on a small icon on the monitor which silences the alarm, but only for a period of time, after which the monitor will alarm again … each time Tina silences the monitor alarm, there is a shorter period of time before the next alarm

sounds … if she is very slow, the monitor will ultimately alarm with a flat line, asystole!! But Tina is making progress and she rushes down a different corridor, following signs on the walls which point to the library. She goes up in the elevator, turns left, down another corridor, and into the library … the corridors are very busy, and Tina has to dodge many people … she recognizes the doctor from the ER who tried to save the boy who died … he's kissing someone in the library … "well, I guess that's a young student nurse whom he's dating" thinks Tina, moving the mouse cursor over him … as she does so, the status information reads:

Dr Geoffrey Holland – medical resident
Age 30
Single but in love
Temperature 38.5

"Oh no" thinks Tina "even the medical staff in here seem to have high temperatures … hope it's not a flu epidemic" … Clicking on a book titled *Blood Pressure and its Discontents* she hurriedly opens it and sees the following information:

Contents

High Blood Pressure – Hypertension
Low Blood Pressure – Hypotension
Maintenance of Normal Blood Pressure – Physiology

Tina clicks on the first choice, and immediately notes that, under "causes", hypertension can result from raised intracranial pressure. She also finds out now that raised intracranial pressure causes a slow heart rate. "Oh, I see … wow, this is so cool … I see now that the reason for why Sally doesn't have a fast heart rate, even with her high temperature, is because she has this raised intracranial pressure which gives her a slow heart rate … hmmm" thinks Tina. Tina is keen to find out more about this raised intracranial pressure so that she can do

something about saving Sally … “it’s funny” Tina thinks to herself “but the high blood pressure and slow heart rate caused by the raised intracranial pressure, seems to be rather like the inverse of the hypovolaemic shock which I looked at earlier” …. Tina returns to Sally …

Suddenly Sally’s monitor alarm is sounding again … her blood pressure is even higher. Marjorie turns and says “aren’t you going to do anything … why do you keep running off like that?” Tina wonders whether it might be a good idea to give Sally a shot of the benzylpenicillin, after all, it looks like it must be meningitis, and the other boy died very quickly. Tina decides to do this, worrying that time is running out, so she clicks on the little medicine key icon which gives her the following options:

Options - open controlled drugs cupboard

- open antibiotics
- I need to resuscitate
- give paracetamol / acetaminophen

Tina clicks on “open antibiotics” and then chooses the benzylpenicillin. Her mouse cursor changes into a syringe … Tina thinks “yeah, this is great … I’m on top of this now, I’ve figured out Sally’s diagnosis and I am going to give her the right medicine” and a few seconds after she has given the benzylpenicillin, cut scenes begin again, Sally appears not to be able to breathe … the monitor begins to sound a loud alarm, and Tina thinks “oh no, not again, what’s going on now?” and seconds later, Sally is dead, and the monitor has a flat line. Cut scenes end. Tina quickly clicks on the skull and crossbones (illuminated and flashing) and she selects “Examine Autopsy report” … Totally dismayed that she could have made such a simple mistake, she reads the following information:

Autopsy Report

Cause of Death: - Anaphylaxis, a serious allergic reaction to drugs and some foods such as peanuts and shell fish.

What Went Wrong: - You didn't ask Sally if she had any allergies before giving her a medicine. Sally is allergic to penicillin. Sally just died from anaphylactic shock.

Explain: - Anaphylaxis is a severe, systemic allergic reaction. Manifested by urticaria (hives) and angioedema with hypotension and bronchospasm. It involves prior sensitization with later re-exposure to the antigen, producing symptoms via an immunologic mechanism. These effects are produced by the release of mediators, which include histamine, leukotriene C4, prostaglandin D2, and tryptase. Mediator release occurs when the antigen (allergen) binds to antigen-specific immunoglobulin E (IgE) attached to previously sensitized basophils and mast cells.

Severe hypotension occurs as a result of the shift of fluid from the intravascular to the extravascular space. Results in the Renin-Angiotensin–Aldosterone mechanism … leading to massive vasoconstriction (a compensatory process).Tina has an opportunity to revisit previous knowledge about the cardiovascular system, fluid compartments, circulating volume and shock.

Anaphylaxis is treated with adrenaline, hydrocortisone (steroid = reduces oedema / swelling) and sometimes dopamine. These drugs are also substances which occur naturally in the body. Tina may be curious to learn more about adrenaline, hydrocortisone and dopamine. Adrenaline and dopamine are inotropic, meaning that they have a direct action on the heart. Tina has the option to look into this further by using the links below. Salbutamol is also given to treat bronchospasm, along with promethazine hydrochloride (an anti-histamine).

http://www-personal.usyd.edu.au/~nacolema/njc_shock.html

http://www.postgradmed.com/issues/1996/08_96/wyatt.htm

http://www.emedicine.com/EMERG/topic25.htm

Tina proceeds through the filing of the death certificate routine … she is beginning to find the whole thing quite amusing "Thank goodness this is just a computer game … I have just killed my patient x number of times, and I'm becoming good friends with the mortician, ha, ha" she chuckles "but if I ever do go to med school, I can impress all my instructors with all this foresight I'm learning!" …. "I can hardly believe this is only level one, it seems pretty advanced … the other levels must be very exciting … but at least I won't get caught out by the allergies thing again".

Tina has several things on her mind at this point in the game … her pager informs her that a young student nurse has been taken ill with a headache, and pyrexia, and she is called to the Emergency Room to see the nurse … "oh my goodness, it is the nurse who was kissing in the library" thinks Tina, tracing back in her mind that it was the doctor who was in contact with the sick boy who kissed the nurse. "Now, I see" thinks Tina "I need to stop this disease from spreading through the hospital … I wonder how it is transmitted?".

Tina will follow up this line of thought and, in so doing, she will learn about immune defense systems, and the incubation period. She will discover that meningitis is, indeed, spread by kissing and also by droplet infection … her role will be to monitor contact between all the hospital staff, trying to keep them from kissing, and gradually she will realize that all her key assistants, including the Microbiologist, will fall ill. They will all become her patients.

If Tina is savvy she will discover that prophylactic antibiotics, such as rifampicin, can be given to people in contact with the disease, thus protecting them. As her assistants fall ill, one by one, she can depend less on them for help and must become more reliant on her knowledge. The object of the game for Tina, is to prevent the spread of the disease through the hospital, cure at least some of her

patients, kill as few as possible, and move to the next level armed with a PDA full of knowledge. Ideally she needs to avoid contracting meningitis, herself. The worst scenario is that all the patients and hospital staff who contract meningitis will die, and so will Tina, leaving an embarrassing collection of death certificates in the mortuary. The best scenario is that Tina will be so clued up that she will manage to diagnose and treat all of her patients without filing any death certificates, she will not take any risks, she will give rifampicin to all known contacts, and will leave the hospital a hero, and with a PDA full of useful information. In the event that no death certificates have to be filed, then reporting back can occur by the player completing the medical notes for a given number of patients.

The optimum game experience will be as above, with one or two deaths caused by the player who then learns from the mistakes made, and has a sense of tension and drama, but also of mastery and accomplishment. There is a certain tongue-in-cheek about the player's role as a junior doctor who kills off the occasional patient. The player's skill will increase as he or she learns the tactics of the game … basically doing background research and checks before proceeding with tasks, and not always choosing the most obvious course of action. The savvy player will make connections, proairetically, and will compare and contrast new knowledge with that which she has already acquired. Each level is non-linear allowing space for the player to move at an individual pace, doing tasks in any order they so choose, and permitting replayability.

Tina will move on to the next level (serial killer with rabies) in which she can utilize some of the knowledge already gained in level one – that is, the central nervous system, because rabies is a systemic viral infection which enters via the peripheral nervous system and, after a long incubation period, causes a severe encephalitis. Hence, she will build on existing knowledge and also learn new knowledge about DNA and profiling.

Technology

Biohazard is designed to play on contemporary consoles or consumer- grade PCs. There are no unsolved software engineering / game design problems in the game. The game can be developed using most contemporary 3D gaming engines, modified primarily to simulate disease propagation.

Each patient could be modeled with table look-ups. Each player is modeled with vital signs (e.g. temperature, blood pressure, heart rate, blood work-up). These vital signs are affected by both 1) the presence of the disease and 2) how far the disease has advanced (a function of time in the system, mediated by any treatments. The spread of each disease can be modeled through standard collision detection. With diseases that are spread through airborne agents, random disease-spreading actions, such as coughs or sneezes can be embedded in characters as well.

A simpler, but less effective game could hold vital signs constant for patients, reduce diseases to binary conditions (present or non-present), and use instantiated case modeling to determine if a person has a disease or not. The game system could "flag" characters as either having a disease or not depending on if they have interacted with other characters.

The primary technological challenge would be in providing a user-friendly set of editing tools for teachers and players to construct their own game levels. Most commercial first - person game engines have mod tools that are far from user-friendly. However, adding such a feature may be the biggest asset of the game. Level / or scenario editors would allow teachers to construct assessment levels and players to create their own levels modeling diseases. Research has shown that giving teachers the ability to customize content is critical for successful implementation, and providing players opportunities to construct their own games is a very effective learning tool.

Sources

Science Fiction

- Outbreak, Deus Ex, Andromeda Strain, ER.
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Science Materials

http://www.vh.org/Providers/Textbooks/ElectricAirway/Discussion/DiscHFlu.html (Virtual Hospital)

http://gsbs.utmb.edu/microbook/toc.htm (microbiology on-line text book)

http://gsbs.utmb.edu/microbook/ch030.htm (haemophilus species)

http://gsbs.utmb.edu/microbook/ch096.htm (microbiology, anatomy and physiology of the nervous system)

http://www.vh.org/Providers/Textbooks/BrainAnatomy/TOC.html (dissections of the human brain)

Isselbacher, K J, *et al* (eds). Harrison's Principles of Internal Medicine, 13th Ed. (McGraw-Hill, Inc. 1992).

Mandell, GL, *et al* (eds). Principles and Practice of Infectious Diseases, 3rd Ed. (New York, Churchill Livingstone, 1990).

Tortora, GJ and Anagnostakos, NP. Principles of Anatomy and Physiology, 6th Ed. (New York, Harper Collins, 1990).

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Berman & Schank. (1999). Goal-Based Scenarios. In C.M. Reigeluth (Ed.) Instructional Design Theories and Models, vol.2. Hillsdale, NJ: Erlbaum Press.

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