Serendipity in science assignment

Serendipity – Accidental Discoveries in Science ABSTRACT Serendipity means the faculty of making fortunate and unexpected discoveries by accidents. Penicillin, X-ray, Viagra, Teflon are common examples known as accidental discoveries in science. The stories of these discoveries are interesting and meaningful. X-ray for medical diagnosis and treatment, miracle drug penicillin, Viagra for treatment of erectile dysfunction, Teflon for frying pans, all of these discoveries make our life wonderful.

Most of people who have been blessed by serendipity are not reluctant to admit their good fortunate, but serendipity does not diminish the credit due them for making the discovery. Famous Scientist Pasteur and Nobel laureate Paul Flory described serendipity as discoveries made by “ by accident and sagacity”. They expressed it “ In the field of observation, chance favors only the prepared mind. ” The importance of the study is how to turn accidents become discoveries. Cases of serendipity in science technology are presented in this thesis. Content

Chapter 1 – Introduction 1.) Definition of Serendipity in Science The term " serendipity" was coined by Horace Walpole.

In a letter written to Horace Mann in January 1754 he says that he formed this term following his reading of a " silly fairy tale" called " The Three Princes of Serendip" (Serendip is an ancient name for Ceylon or Sri Lanka). The three heroes of this tale were always making discoveries by accidents and sagacity. The Oxford English Dictionary defines the term was " the faculty of making happy and unexpected discoveries by accident". The Dictionary adds, however, the following sharper definition: looking for one thing and finding another. The latter definition refers to cases where one looks for A and finds B.

Thus the scientist may act in a guided manner in order to solve a problem, while he discovers that the end result provides a solution for another problem, of which he was not aware. The notion of serendipity implies that the discoverer is aware of the fact that he found B, or at least of the fact that he found something unexpected or significant. Thus, science can benefit from a hint given by Nature only if there are open-minded scientists who grasp the significance of the hint. Sometimes the scientist who made the discovery is not aware of the full significance of his discovery while other scientists complete the task.

So in many cases serendipity in science is a collective enterprise. 2) The main aim of the dissertation What do Velcro, penicillin, X ray, Teflon and dynamite have in common? Serendipity! These things were discovered by accident, as were hundreds of other things that make everything living more convenient. One of the first recorded examples of serendipity was the detection of the base metal by Archimedes. Such happy accidents have happened to all around us. I have attempted to describe the discoveries for scientists and non scientists to find these stories meaningful and useful.

Serendipity is the art of science. This is so amazing because the most famous example of serendipity is the discovery of penicillin, a story which essentially captures the powerful interaction of chance with the prepared mind. The dissertation is for education purpose. The aim of the dissertation is to do a historical research on the literature about accidental discoveries in Science from journal and books. Then the cases of accidental discoveries are found out in the history of Science and discussed which then needed to study the significance of the accidental discoveries to the development of Science.

Since many of people ignore the credits of accidental discoveries to the development of science. It is necessary to discuss the importance and significant of accidental discoveries. Lastly it is hoped that the dissertation can raise the interest of science to non scientist to encourage them to study science in the nearest future and also introduce and stress the importance of

“ chance with prepared mind” to both scientist and non scientist 1. 3) A story summary of the context of the study Recently, The Discovery Channel selected the top 10 big accidental discoveries in last two century [1].

One of the best known cases of that nature is Fleming’s discovery of penicillin. Taking a Petri dish containing a bacterial culture he noticed that the loose cover had not been properly set, and a mold had grown over the exposed area. The bacteria, on the other hand, were dead. This may have occurred to other researchers before him and their conclusion must have been to see that lids should be properly clamped. Fleming realized that this implied that some molds could kill the bacteria. Finally his observation became a famous case of accident: discovery of penicillin.

In this dissertation, I am going to talk about four accidental discoveries. Why I choose Viagra, Post-it notes, Teflon and Penicillin these four inventions for the subscription of this dissertation? It is because these cases are typical for accidental discoveries. We often use or see these discoveries and they have great impact on human’s lifestyle. Also, they are well known to everybody even they don’t know anything about science and I found the stories of them are more interesting and feel enthusiastic than others.

After the introduction of the four serendipitous cases, it will be talked about the significance and contribution of serendipity to science. It is hoped that serendipity of science will become a classroom discussion in the future and the concept of “ chance favors only the prepared mind” can encourage students to study hard in science. Chapter 2 – Story of Viagra 2. 1)Background information Viagra® [2] is an oral therapy for erectile dysfunction which registered by a pharmaceutical company called Pfizer. The erections will be lasting for 4 hours [3] after taking the pill.

The most common side effects of Viagra are headache, facial flushing, and upset stomach. Less commonly, bluish vision, blurred vision, or sensitivity to light may briefly occur. Viagra is the citrate salt of sildenafil, a selective inhibitor of cyclic guanosine monophosphate (cGMP) [4], specific phosphodiesterase type 5 (PDE5). Sildenafil citrate is designated chemically as 1-[[3-(6, 7-dihydro-1-methyl-7-oxo-3-propyl-1 Hpyrazolo[4, 3-d] pyrimidin-5-yl)-4-ethoxyphenyl]sulfonyl]-4-methylpiperazine citrate. Figure 2. 1: The structural formula of Sildenafil citrate

Sildenafil citrate is a white to off-white crystalline powder with a solubility of 3. 5 mg/mL in water and a molecular weight of 666. 7. Viagra is formulated as blue, film-coated rounded-diamond-shaped tablets equivalent to 25 mg, 50 mg and 100 mg of sildenafil for oral administration. In addition to the active ingredient, sildenafil citrate, each tablet contains the following inactive ingredients: microcrystalline cellulose, anhydrous dibasic calcium phosphate, croscarmellose sodium, magnesium stearate, hypromellose, titanium dioxide, lactose, triacetin, and FD & C Blue #2 aluminum lake. . 2) Biography of inventor or discoverer Discovering the function of nitric oxide (NO) [5] in human body lead the invention of Viagra by Pfizer. The contribution of discovering the use of NO bring the three scientists: Robert Furchgott, Louis Ignarro and Ferid Murad, the Nobel Prize in Physiology or Medicine (1998). [6] Robert Furchgott, 82 years old, does his work at the State University of New York in Brooklyn. Louis Ignarro , 57 years old, is a professor at the University of California-Los Angeles.

Ferid Murad, 62 years old, is a researcher at the University of Texas Medical School in Houston and formerly did work at the University of Virginia. At a scientific conference in 1986, Furchgott and Ignarro presented their conclusions that nitric oxide transmits signals in the human organism where nitric oxide is different from nitrous oxide, better known as laughing gas. The researchers discovered that nitric oxide tells blood vessels to relax and widen, an effect that helps control blood pressure.

This new physiology discovery leads the research of developing cardio-vasodilation medicine, which accidentally make the invention of Viagra. After the invention of Viagra, Pfizer Research Team from the company's laboratories in Sandwich, England has received The Prix Galien which recognized their pioneering observation of the role of an enzyme, the phosphodiesterase type 5 inhibitor (PDE5), in the treatment of erectile dysfunction. Viagra resulted from the efforts of a research team at the Pfizer European Research Centre in Sandwich, England.

Pfizer researchers synthesized the compound in 1989 and conducted trials in more than 4400 men of different ages, backgrounds and health status, at medical centers worldwide. Clinical trial data showed that Viagra improved erections in 7 out of 10 patients. 2. 3) how it is accidentally discovered Viagra resulted from the efforts of a research team at the Pfizer European Research Centre in Sandwich, England. Extensive clinical trials program investigated the role of selectively inhibiting the enzyme phosphodiesterase type 5 (PDE5), on which Viagra acts, to enhance the natural mechanism of penile erection.

During sexual stimulation, Viagra relaxes the blood vessels in the penis, allowing blood to flow to the area and resulting in an erection. Sildenafil did that nicely in the lab but didn’t work so well in the bodies of real live people. Still, the drug was having an effect: some men who were given sildenafil reported having erections, which meant the drug was meddling with a particular bit of body chemistry. When males become aroused, nerves in the penis release nitric oxide. The nitric oxide activates an enzyme, called cyclic GMP–that triggers walls of blood vessels in the penis to relax.

When they do so, blood rushes in and causes stiffness. The more of this enzyme, the better the rush. Ordinarily, cGMP is broken down rather quickly; sildenafil achieves its effect by causing the enzyme to stick around longer, and it does this chiefly by reining in one of ten or so other enzymes whose function is to degrade cGMP. What the Pfizer researchers now had to show was that this particular degrading enzyme was present in abundance in the penis. Deft biochemical analysis of a frozen penis, ordered from a tissue bank, soon showed that it was.

The next step required fresh penile tissue, not frozen. Pfizer researchers obtained such tissue (discarded during penile implant surgeries) and placed thin strips of it in a fluid-filled dish. When they then stimulated the tissue’s nerves electrically, they discovered that it relaxed much more, the desired state in erections, if sildenafil was added to the fluid. This phenomenon leads further investigation. Pfizer researchers synthesized the compound in 1989 and conducted trials in more than 4400 men of different ages, backgrounds and health status, at medical centers worldwide.

Clinical trial data showed that Viagra improved erections in 7 out of 10 patients. The drug was then patented in 1996, approved for use in erectile dysfunction by the Food and Drug Administration on March 27, 1998, becoming the first pill approved to treat erectile dysfunction in the United States. 2. 4) evidence and working mechanism In the human body, the " valves" of blood vessel in penis open and close using muscles in the walls of arteries. When these muscles relax, the arteries open up and blood flow increases. The valves respond to chemical messages that the brain can control.

The brain sends signals to Nonadrenergic-nonchlrinergic (NANC) cells in the artery [7]. The NANC cells release nitric oxide (NO). NO acts as a signaling molecule and stimulates an enzyme called guanylate cyclase in nearby cells. The guanylate cyclase converts a chemical called GTP into another chemical called cGMP. cGMP causes muscles in the walls of the arteries to relax. This relaxation increases blood flow. Meanwhile, PDE is decomposing the cGMP and turning it back into GTP. There is a cycle: guanylate cyclase turns GTP into cGMP, and PDE turns cGMP into GTP. Nitric oxide turns the cycle on.

The main active gradient of Viagra is sildenafil. Sildenafil has no direct relaxant effect on isolated human corpus cavernosum, but enhances the effect of nitric oxide (NO) by inhibiting phosphodiesterase type 5 (PDE5), which is responsible for degradation of cGMP in the corpus cavernosum. When sexual stimulation causes local release of NO, inhibition of PDE5 by sildenafil causes increased levels of cGMP in the corpus cavernosum, resulting in smooth muscle relaxation and inflow of blood to the corpus cavernosum. Sildenafil at recommended doses has no effect in the absence of sexual stimulation.

Studies in vitro have shown that sildenafil is selective for PDE5. Its effect is more potent on PDE5 than on other known phosphodiesterases. In addition to human corpus cavernosum smooth muscle [8], PDE5 is also found in lower concentrations in other tissues including platelets, vascular and visceral smooth muscle, and skeletal muscle. The inhibition of PDE5 in these tissues by sildenafil may be the basis for the enhanced platelet anti-aggregatory activity of nitric oxide observed in vitro, an inhibition of platelet thrombus formation in vivo and peripheral arterial-venous dilatation in vivo. 9] Sildenafil is metabolised by hepatic enzymes and excreted by both the liver and kidneys. If taken with a high-fat meal, there may be a delay in absorption of sildenafil and the peak effect might be reduced slightly as the plasma concentration will be lowered. 2. 5) Effect and influence of the discovery Since its invention in the late 1980s Viagra has given a lease of life to millions of men around the world. Originally a medication for high blood pressure, Viagra turned out to be a pill which has reversed the impotence of many men world over.

It has helped many men and their partners to life a sexually satisfying life and saved many marriages and relationships. But that’s not the end of the story for this wonder drug. Viagra or Sildenafil citrate is still a pack of pleasant surprises. Viagra has turned out to be the new cure for pulmonary hypertension. Hypertension or high blood pressure causes a strain to the heart muscles, due to which they enlarge abnormally and eventually fail.

Viagra has proved to enhance the quality of life for such patients and increase their life expectancy.

Scientists observed that sildenafil improved the growth of uterine blood vessels and helped in producing healthy babies. Sildenafil or Viagra has also helped to improve chronic heart failure in men by increasing their peak oxygen consumption by about 20 % during exercise. Viagra is a life saving drug for mountaineers, who are at a constant risk of developing cardiovascular complications at high altitudes. Viagra reduces their blood pressure and helps in easy passage of oxygen in the blood thus enhancing blood circulation. Viagra is indeed a pill with many benefits. It is not just a relationship enhancer but can save millions of lives.

The drug was patented in 1996 and approved for use in erectile dysfunction in 1998 annual sales of Viagra in the period 1999–2001 exceeded $1 billion. Chapter 3 – Story of post-it notes 3. 1) Background information A Post-it note (or simply Post-it), invented and manufactured by 3M, is a piece of stationery with a readherable strip of adhesive on the back, designed for temporarily attaching notes to documents, computer displays and so on. While now available in a wide range of colors, shapes and sizes, the most common size of Post-it note is a 3-inch (7. 5-cm) square, trademark canary yellow in color.

The notes use a unique low-tack adhesive that enables the Post-its to be easily attached and removed without leaving marks or residue. The names Post-it and Post-it note, as well as the canary yellow color, are trademarks of 3M, the company which invented and manufactures them. 3M manufactures other products towards the Post-it note concept, leveraging the success of the brand. As Post-it have been driven towards computerized versions like Stickies or PtiMemo, 3M markets its own software under the name of Post-it software note. 3. 2) Biography of inventor or discoverer Arthur L.

Fry [10] was born in Minnesota, and grew up first in a small town in Iowa and later in Kansas City. He was a tinkerer and a problem solver already as a child. His earliest engineering efforts were devoted to creating custom-designed toboggans from scrap lumber. Fry began his education in a one-room rural schoolhouse, but in the early 1950s he moved on to the University of Minnesota, majoring in Chemical Engineering. In 1953, while still an undergraduate, Fry began working for 3M in New Product Development and continued to work there until his retirement in the early 1990s. Spencer F. Silver was born in San Antonio.

He majored in Chemistry at Arizona State University (Bsc) in 1962, then earned a doctorate in Organic Chemistry from the University of Colorado (PHD) in 1966, before taking a position as a Senior Chemist in 3M’s Central Research Labs. Silver still works at 3M, specializing in Adhesives Technology. But Silver’s creativity is not confined to his career, over the years he has also won a reputation as an accomplished painter in pastels and oils. 3. 3) how it is accidentally discovered In 1968, Silver developed a high-quality but “ low-tack” adhesive, made of tiny, indestructible acrylic spheres that would stick only where hey were tangent to a given surface, rather than flat up against it. As a result, the adhesive’s grip was strong enough to hold papers together but weak enough to allow the papers to be pulled apart again without being torn. More importantly, the adhesive could be used in the same way again and again. Silver wanted to market the adhesive as a spray, or as a surface for bulletin boards on which temporary notices could be easily posted and then removed. Over the next five years, Silver shared his revolutionary product with colleagues at 3M, informally and in seminar presentations.

A marketable form of the product proved elusive, and Silver’s temporary adhesive might have been consigned to a shelf indefinitely, but then Art Fry attended one of Silver’s seminars. While Silver had been painting in his spare time, Fry sang in his church choir. Fry was frustrated by the fact that, when he stood and opened his hymnal to sing, the paper bookmarks that he used in his hymnal to mark the songs on the program would slip out of sight or even onto the floor[3. 1]. In a moment of insight that has become legendary in the realm of contemporary invention, Fry, musing during a rather boring sermon, realized that Silver.

As reusable adhesive would provide his bookmarks with precisely the temporary anchoring he required. Returning to work, Fry wrote up his idea for a reliable, reusable bookmark, and presented it to his supervisors. Management initially worried that the product would seem wasteful; but the staff could not get enough of the samples Fry was passing around. Soon, 3M gave the invention its full support. It took another five years to perfect the specifications and design machines to manufacture the product, but in 1980 Post-it® Notes were introduced nationwide.

Within two years, Post-it® Notes were established as an outright necessity in the office. As the basic product evolved into an entire product line, Post-its® could also be found in most schools, labs, libraries, and even in homes. Meanwhile, both Spencer Silver and Art Fry became heroes of innovation:

they have both won 3M's highest honors for research and numerous awards within the international engineering community. 3. 4) Evidence and working mechanism The glue of Post-it notes provides it a reversibly adhesive property. According to U. S.

Patent 3691140, the acrylate-copolymer microspheres (the adhesive formula) contains inherently tacky, elastomeric, polymers which are uniformly solvent-insoluble, solvent-dispersible, of small size, and ideally suited for use in aerosol spray adhesives. The polymers easily disperse in various solvents to provide non-plugging suspensions which spray without cob webbing. The polymers permit bonding of paper and other materials to various substrates, permit easy removal of bonded paper from the substrate without tearing, and also permit subsequent rebonding of the paper without application of additional adhesive.

About 90 to about 99. 5 % by weight of at least one alkyl acrylate ester and about 10 to about 0. 5 % by weight of at least one monomer selected from the group consisting of substantially oil-insoluble, water-soluble, ionic monomers and maleic anhydride. The microspheres are prepared by aqueous suspension polymerization utilizing emulsifier in an amount greater than the critical micelle concentration in the absence of externally added protective colloids or the like. The tacky microspheres provide a pressure-sensitive adhesive which has a low degree of adhesion permitting separation, repositioning and rebonding of adhered objects.

Additionally, these polymers are readily removable from surfaces. They also exhibit a very low film or tensile strength, less than about 10 psi. The alkyl acrylate ester monomer portion of the copolymer microspheres may comprise one ester monomer or a mixture of two or more ester monomers. The alkyl acrylate ester portion of these microspheres consist of those alkyl acrylate monomers which are oleophilic, water-emulsifiable, of restricted water-solubility, and which, as homopolymers, generally have glass transition temperatures below about -20oC.

Alkyl acrylate ester monomers which are suitable for the microspheres of the invention include iso-octyl acrylate, 4-methyl-2-pentyl acrylate, 2-methylbutyl acrylate, sec-butyl acrylate, and the like. Acrylate monomers with glass transition temperatures higher than -20oC. (i. e. tert-butyl acrylate and iso-bornyl acrylate) may be used in conjunction with one of the above described acrylate ester monomers. The water-soluble ionic monomer portion of these microspheres is comprised of those monomers which are substantially insoluble in oil.

By substantially oil-insoluble and water-soluble it is meant that the monomer has a solubility of less than 0. 5% by weight and, a distribution ratio at a given temperature (preferably 50-65oC.), of solubility in the oil phase monomer to solubility in the aqueous phase of less than about 0. 005 Figure 3. 4: Adhesive molecule under SEM The mixture of the adhesive bonding produces the weak repositionable adhesive property for the Post-it notes. 3. 5) Effect and influence of the discovery The Post-it® Note is one of the best known of all 3M products.

It is used by loyal customers all over the world, many of whom declare that they can’t imagine how they ever got along before Post-it® Notes were invented, which permanently changed the way we communicate. Since 2001, the glue used for Post-its has fallen into public domain and can be produced and marketed by companies other than 3M, lowering their price and making them even more popular. The term “ Post-it” is still a trademark of 3M and cannot be used by any other company, whether for commercial use or not.

Electronic versions of Post-it have since been developed as well, making it a universal concept. Since they cannot be marketed under the term “ Post-it”, they often use the term “ desktop notes”, “ Stickies” or “ Ptimemo” (french). Chapter 4 – Story of Teflon 4. 1) Background information Polytetrafluroethylene was discovered serendipitously by Roy Plunkett of DuPont in 1938, while attempting to make a new CFC refrigerant, when the perfluorethylene polymerized in its storage container. DuPont patented it in 1941 and registered the Teflon trademark in 1944.

This name has since become a genericized trademark. An early advanced use was in the Manhattan Project as a material to coat valves and seals in the pipes holding highly reactive uranium hexafluoride in the vast uranium enrichment plant at Oak Ridge, Tennessee, when it was known as K416. It was first sold commercially in 1946 and by 1950, DuPont was producing over a million pounds per year in Parkersburg, West Virginia. In 1954, French engineer Marc Gregoire created the first Teflon-coated cooking pan. The common statement that PTFE is a spin-off from the U. S. space program is thus an urban legend.

Teflon has been supplemented with another DuPont product, Silverstone, a three-coat fluoropolymer system that produces a more durable finish than Teflon. Silverstone was released in 1976. 4. 2) Biography of inventor or discoverer Roy J. Plunkett (June 26, 1910 – May 12, 1994) [11] was the chemist who accidentally invented Teflon in 1938. Plunkett was born in New Carlisle, Ohio and attended Manchester College (BA chemistry 1932) and Ohio State University (Ph. D. chemistry 1936). In 1936 he was hired as a research chemist by E. I. du Pont de Nemours & Company at their Jackson Laboratory in Deepwater, New Jersey.

On April 6, 1938 Plunkett checked a frozen, compressed 100 pound (45 kg) container of tetrafluoroethylene, used in chlorofluorocarbon refrigerant production. When he opened the container to remove an amount for chlorination (using hydrochloric acid), Plunkett discovered that nothing came out. When he checked to see why, he discovered that a white powder had formed which did not adhere to the container. The tetrafluoroethylene in the container had polymerized into polytetrafluoroethylene (Teflon), a waxy solid with amazing properties such as resistance to corrosion, low surface friction, and high heat resistance.

He was the chief chemist involved in the production of the gasoline additive Tetra-ethyl lead at DuPont’s Chambers Works from 1939 to 1952. After that he directed Freon® production at DuPont before retiring in 1975. He was inducted to the Plastics Hall of Fame in 1973 and the Inventors Hall of Fame in 1985. Plunkett died on May 12, 1994 at the age of 84. 4. 3) how it is accidentally discovered Polytetrafluoroethylene is another of those amazing accidental discoveries of science. In the late 1930s, when PTFE was discovered in DuPont's laboratories, DuPont was not at all concerned with nonstick frying pans or artificial heart valves.

What they were really interested in was refrigeration. At the time, refrigerators used things like ammonia and sulfur dioxide as refrigerants. These are pretty nasty things to have leaking out of your refrigerator and into your kitchen. The quest was on, then, to make a non-toxic refrigerant. One of the compounds being investigated was tetrafluoroethylene. Plunkett's first assignment at DuPont was researching new chlorofluorocarbon refrigerants, then seen as great advances over earlier refrigerants like sulfur dioxide and ammonia, which regularly poisoned food-industry workers and people in their homes.

Plunkett had produced 100 pounds of tetrafluoroethylene gas (TFE) and stored it in small cylinders at dry-ice temperatures preparatory to chlorinating it. When he and his helper prepared a cylinder for use, none of the gas came out, yet the cylinder weighed the same as before. They opened it and found a white powder, which Plunkett had the presence of mind to characterize for properties other than refrigeration potential. He found the substance to be heat resistant and chemically inert, and to have very low surface friction so that most other substances would not adhere to it.

Plunkett realized that against the predictions of polymer science of the day, TFE had polymerized to produce this substance, later named Teflon, with such potentially useful characteristics. Chemists and engineers in the Central Research Department who had special experience in polymer research and development investigated the substance further. Meanwhile, Plunkett was transferred to the tetraethyl lead division of DuPont, which produced the additive that for many years boosted gasoline octane levels. At first it seemed that Teflon was so expensive to produce that it would never find a market.

Its first use was fulfilling the requirements of the gaseous diffusion process of the Manhattan Project for materials that could resist corrosion by fluorine or its compounds. Teflon pots and pans were invented years later. The Philadelphia's Scott Medal was then awarded to Plunkett in 1960. It is he first of many honors for his discovery which provided the occasion for the introduction of Teflon bakeware to the public. Finally each guest at the banquet went home with a Teflon-coated muffin tin. 4. 4) Evidence and working mechanism

Polytetrafluoroethylene (PTFE) has a carbon backbone chain, and each carbon has two fluorine atoms attached to it. [pic] Figure 4. 4. 1: The picture shows part of the carbon chain of Polytetrafluoroethylene. [pic] Figure 4. 4. 2 : The picture shows the monomer of tetrafluoroethylene Fluorine is an strong electron acceptor, it tends to withdraw electron form carbon atom in order to obtain a stable electronic configuration as a noble gas (fulfill the octet rule). When fluorine is being a part of a molecule, it repels other molecules, even the fluorine atoms on other molecules.

So a molecule of PTFE, being just chock full of fluorine atoms as it is, would like to be as far away from other molecules as it can get. For this reason, the molecules at the surface of a piece of PTFE will repel the molecules of just about anything that tries to come close to it. That's why PTFE is low coefficient of friction and nothing sticks to it. [pic] Figure 4. 4. 3: The properties of PTFE Because of its non-stick property, PTFE means can fry things without grease or butter. This means less fat and cholesterol, for a healthier heart.

It is also chemically inert because fluorine and carbon atom from a strong covalent bond and it won’t react with anything with high wear resistance, even organic solvents. Why it is suitable for making frying pan? First of all, if it repels everything, then no molecule can get near it to react with it. Then there is the fact that the bond between the fluorine atom and the carbon atom is just really, really strong. It’s so stable that nothing will react with it and can undergo wide range of temperature, even when it gets as hot as a frying pan. 4. 5) Effect and influence of the discovery This is the kind of accident that makes science fun.

There are kinds of accidents in science which aren’t fun, say, those which involve big booms, but we won’t talk about those right now. The fun kind of accident, which all scientists hope for, is an unexpected discovery which opens up a whole new area of investigation and makes you famous. Chapter 5 – Story of Penicillin 5. 1) Background information Today, the use of penicillin and other antibiotics are common place. The various antibiotics are used to treat a number of what are now common Figure 5. : The structure of Penicillin nucleus diseases and to prevent the onset of infections when our skin, our first barrier to fight off disease, is somehow broken through a simple cut or a more serious wound. It is something that we all take for granted today. However, many diseases and simple wounds that are so easily treated in last century because of the availability of antibiotics have not always been available. Antibiotics are a relatively recent discovery and the first practical one, penicillin, was not available until the early 1940s.

Even the concept of using fungal products, such as penicillin, to produce medicine is a relatively new one. The discovery of penicillin has often been described as a miracle drug, and that is exactly what it was. Prior to the discovery of penicillin, death could occur in what would seem, today, to be very trivial injuries and diseases. It could occur from minor wounds that became infected or from diseases such as Strep Throat, and venereal diseases such as syphilis and gonorrhea were a much more serious issue. 5. 2) Biography of inventor or discoverer Alexander Fleming [12], was born on August 6, 1881 in Ayrshire, Scotland.

A bright student, Fleming worked in a shipping office for several years before returning to school to pursue a degree in medicine. He earned his M. D. , with honors, from St. Mary’s Medical School in London in 1908. He then worked for Almroth Wright’s research team there where he developed a strong interest in bacteriology. Fleming became a lecturer at St. Mary’s, staying on until 1914, when he left to serve as a captain in the Army Medical Corps. During this experience he realized that more needed to be done to save soldiers who suffered infections from their wounds.

His interest in bacteriology deepened. In 1918, he returned to St. Mary’s, where he continued to conduct research in the bacterial action of the blood, mucus and other body fluids, searching for antibacterial substances that were non-toxic to animal tissues. He discovered, in 1921, the bacteriolytic substance he named lysozyme found in tears and other bodily secretions, but this substance was not particularly strong. In 1928, Fleming left his lab for a two-week vacation and his failure to clean up his workspace resulted in one of the greatest medical discoveries of all time.

He returned to the lab to find that a mold had accidentally developed on a staphylococcus culture plate he had left out in the open. On the plate, a bacteria-free circle surrounded the yellow-green mold. This intrigued Fleming. He deduced that the mold must have released some substance that had inhibited the growth of the bacteria. He conducted experiments on the specimen, and found that the mold culture prevented growth of staphylococci, even when diluted 800 times. The mold, he discovered, had been created by a spore of a rare variant called Penicillium notatum, which had likely drifted up from a mycology lab on another floor.

Fleming named this mold substance “ penicillin” and reported his findings in 1929 in the British Journal of Experimental Pathology. However, his work would remain obscure for nearly a decade. In 1939, a team of scientists at Oxford University led by Australian physiologist Howard Florey began working to identify and isolate substances from molds that could kill bacteria. Among the substances they studied was Fleming’s penicillin. They were able to purify the substance and use it in experiments to treat mice who had been given lethal doses of bacteria. The experiments were overwhelmingly successful.

Penicillin rapidly became a mainstream medical treatment for a variety of infections, such as syphilis, scarlet fever, diphtheria, and pneumonia. British and American drug companies began to manufacture the drug in large quantities, and by the end of World War II, it had saved millions of lives. Fleming was elected Fellow of the Royal Society in 1943, and was knighted in 1944. Along with Florey and chemist, Ernst Boris Chain, Fleming was awarded the Nobel Prize for Medicine in 1945. Fleming was named Emeritus Professor of Bacteriology, University of London, in 1948.

He was Rector of Edinburgh University from 1951 to 1954. Fleming died on March 11, 1955 and is buried in St. Paul's Cathedral in London. 5. 3) how it is accidentally discovered In 1928, Alexander Fleming was researching the properties of the group of bacteria known as staphylococci and became another in the long line of scientists to benefit from a seemingly chance observation. [pic] Figure 5. 2: Staphylococci under SEM His problem during this research was the frequent contamination of culture plates with airborne molds. However, he was also known as a sloppy scientist as well.

Cultures that he worked on were constantly forgotten, in his lab, which was normally in a state of great disorder. After returning from a month long vacation, Fleming observed that many of his culture plates were contaminated with a fungus. He immediately threw the plates in a tray of Lysol. Fortunately, a former member of his lab was visiting and he took the contaminated cultures that had not been submerged in the Lysol to show his visitor what he has been doing. It was only then that he noticed the unusual inhibition zone around the fungus.

He realized at this point that that this may be something important and for the rest of that day showed all of his colleagues the culture and continued to study the anti-bacterial properties of the mold. Subsequently Fleming isolated an extract from the mold and he named it penicillin. Although his discovery was published, there was not a great deal of attention paid to this paper. Despite this success, further attempts by Fleming to produce a concentrated extract of penicillin failed and he was unable to prove that it had any therapeutic value and doubted it himself at this time.

It could be argued here that Fleming did accidentally discover penicillin since he wasn't looking for it at that moment in time. However, he had been looking for several years prior to this and without his background in lysozyme research, Fleming may not have really ever considered further investigation of the contaminating mold just as several scientists before him had done. This was certainly the opinions of his colleagues at St. Mary's Hospital. As further test continued, Fleming began to realize that he was on the verge of a great discovery. However, he still did not know the identity of the fungus.

He had virtually no background with fungi and knew little about these organisms. Because of the lack of information on this fungus, the press had initially called this mold " yellow magic" because when it was cultured in a large vat of liquid nutrient, the liquid became a bright yellow color. However, it was his identification to genus, which prompted Fleming to name this compound, which inhibited bacterial growth, penicillin. The fungus would eventually be identified by Charles Thom, who was the authority on the taxonomy of Penicillium, as Penicillium notatum. . 4) Evidence and working mechanism Penicillin refers to a group of ? -lactam antibiotics used in the treatment of bacterial infections caused by susceptible, usually Gram-positive organisms. Figure 5. 4. 1: The structure of ? -lactam ring in

Penicillin ?-lactam ring is very strained and the bond between the carbonyl and the nitrogen in the ? -lactam ring is very labile and hence makes the molecule reactive. The R-group substituent of the penicillin nucleus can be changed to give the molecule different antibacterial properties.

The most common naturally occurring penicillin from Penicillium notatum is Penicillin G (Benzyl penicillin, R = C6H6) The ? -lactam structure is derived from two covalently bonded amino acid residues: cysteine and valine. This forms via a tripeptide intermediate where the third amino acid is replaced by the variable R-group. [pic] Penicillin attacks bacterial cells by inactivating an enzyme that is essential for bacterial growth. The enzyme is peptidoglycan transpeptidase and it catalyses the cross-linking of the peptidoglycan, which forms the cell wall of the bacteria. [pic] Figure 5. 4. : The picture shows the cell wall and cell membrane of bateria The peptidoglycan transpeptidase enzyme is not needed in animals as their cells do not have cell walls. Therefore, the penicillin can safely disrupt the bacterial cell wall biosynthesis without harming existing cells in the human body. The penicillin stops the growth of the bacterial cell wall, causing the pressure inside the cell to rise considerably until the cell lyses and thus the cell is destroyed. Penicillin G [17] is only active against Gram Positive bacterial cells, which have an exposed layer of peptidoglycan around the outside of the cell wall, as shown above.

Gram Negative bacteria have a more complicated composition, which Penicillin G [13] cannot destroy. The peptidoglycan cell wall is a branched polymer made of alternating NAG [? -D-N-acetylglycosamine] and NAM [? -D-N-acetylmuramic acid] residues. Polypeptide chains are attached to the NAM residues and these vary depending on the strain of bacteria. The mechanism for cross-linkage is shown below. It is the terminal D-alanyl-D-alanine residues of the polypeptide chain off of the NAM residues that binds to the transpeptidase which cross-links that chain with the adjacent peptidoglycan strand. pic] Figure 5. 4. 3: The picyure shows the mechanism for cross-linkage Penicillin binds at the active site of the transpeptidase enzyme that cross-links the peptidoglycan strands. It does this by mimicking the D-alanyl-D-alanine residues that would normally bind to this site. The labile ? -lactam ring in penicillin reacts with a serine residue in the transpeptidase as shown below. This reaction is irreversible and so the growth of the bacterial cell wall is inhibited. The resulting complex is stable to water and remains attached to the polypeptide chain. [pic] Figure 5. 4. 4: The reaction of ? lactam ring in penicillin and transpeptidase. Due to it is an irreversible reaction, the bacteria cell wall collapses and bacteria is killed. 5. 5) Effect and influence of the discovery It is noteworthy, however, that it was Fleming's emphasis on the role of penicillin as a laboratory tool that was critically important in its ultimate development as an antibiotic. Many microbiologists quested samples of the mold culture that would allow them to isolate it, so Fleming produced such samples for distribution to other laboratories. Cultures of these samples were retained in ample volume in various laboratories in London.

In the late 1930s, two Oxford scientists, Howard Florey and Ernst Chain, began to research antibacterial substances produced by molds and other organisms. They were able to procure a culture of Fleming's original mold and subsequently isolated the pure form of penicillin in 1940. Florey and

Chain developed a process for production of penicillin, and it was manufactured shortly thereafter. By 1941, some penicillin was available for use in World War II. Fleming, Florey, and Chain shared the Nobel Prize in 1945 for their extraordinarily important discoveries.

The phenomenal story of the discovery of penicillin is not a straightforward one. Rather, it is filled with elements of genius, skill, chance, hard work, and enthusiasm. Alexander Fleming’s contributions are remarkable in that he described elegant experiments that are impressive even now, and because he realized that good research does not stand alone and can always be improved upon. In a 1952 speech, Fleming quoted from a friend, ‘ No research is ever quite complete. It is the glory of a good bit of work that it opens the way for still better and thus rapidly leads the way to its own eclipse. ‘

Chapter 6 – Impact of consequence of serendipity 6. 1) Sigficance of Serendpdity in Science Everyone would ask, ‘ what is the role of serendipity in science? ‘ Prof. Rudolph A. Marcus (Year 1992 Nobel Prize in Chemistry) claimed ‘ I find it difficult to predict what might possible. In my experience, I’m sure that of many other, the most exciting studies are those that haven’t been predicted” The main claim is that serendipity in science is not a casual phenomenon. Understanding the role of serendipitous discoveries will contribute to understanding the epistemic role of science and its evolutionary character.

Serendipity supplies science with its blind edge. The human mind makes plans which have a chance of yielding successful results only in familiar territories of Nature, while serendipity causes science to deviate from its planned course towards unexplored domains of Nature. Actually, serendipity enables the human mind to transcend established frameworks of knowledge, established world pictures. The requirement of blind discovery is realized in the phenomenon of serendipity in such a way that it does not contradict the fact that scientists do act intentionally and that they direct their efforts towards solving given problems.

Indeed, when a scientist makes a serendipitous discovery he does not guess blindly. However, since he tries to solve problem A, being aware of problem A, while accidentally solving (another) problem B, the solution of problem B is, indeed, generated blindly with respect to B. Thus, the discoverer does act intentionally, being affected by the problem he intended to solve; and yet he ends up making a accidental discovery. Thus, variations are generated via the activity of problem-solving and are selected by problems which they were not intended to solve.

We might describe the situation by saying that in his problem-solving activity the scientist generates " solutions in search of problems". The contribution of serendipity is enormous. Lots of the famous discoveries are caused by accidents. 6. 2) Chance favors only the prepared mind What is characteristic of the above pattern of discovery is that the discovered entity is constructed out of existing building blocks. There can be no shortcuts in this process. A building cannot be constructed directly out of protons, neutrons and electrons or even out of chemical compounds. First the bricks must be prepared.

The new conceptual system or the new world picture is constructed on the basis of some central concepts and ideas of the old world picture. Thus, quantum mechanics employs " mutated" concepts of classical mechanics such as energy and momentum. Hence, discovery by serendipity is essential for the continuity of the advance of science. Serendipitous discovery guarantees both independence in terms of problem-solving and continuity. It should be stressed that serendipity is needed for the advance of science because we conduct our scientific investigations from within a given framework: a given conceptual system or a given world picture.

Serendipity is needed in order to transcend an established framework of knowledge. It is amazing because the most famous example of serendipity is the discovery of penicillin, a story which essentially captures the powerful interaction of chance with the prepared mind. At least 28 scientists had already reported instances of a mold killing off their bacteria colonies; they had had their accidental discoveries, but only Alexander Fleming pursued this " error" when it occurred in his laboratory. Nine years earlier he had discovered the bacterial enzyme lysozyme when his nasal drippings killed off some bacteria in another of his experiments.

The penicillin discovery also depended on Fleming's habit of frugally saving laboratory dishes through full investigate very damp laboratory in London that as well as have prevented the mold from affecting the Petri dishes. If Fleming didn't have such a observation habit and equip the kind of knowledge, he certainly just like the 28 scientists. However, he did it finally just because of his prepared mind. Pasteur, Henry and Churchill have all commented on the need for a prepared mind to realize the significance of accidental encounter.

As I have mentioned the four cases before. The unexpected drug response of the patients gave the idea of discovery of Viagra! The fallen of traditional notes gave the idea of discovery of post-it notes! The unexpected disappearance of tetrafloroethylene gas gave rise the discovery of Teflon! The unexpected contaminated sample provides the incident of discovering Penicillin! If the scientists didn't come across the unexpected observations or ideas, those discoveries may not come true. 6. 3) New scientific methods and ideas.

The phenomenon of scientific creativity is rarely examined in any detail in undergraduate or postgraduate coursees, yet it plays a most important role in allowing one to function as an effective and productive scientist. There are three primary methods by which sucessful scientists are led to examine particular problems or to pose specific and correct solutions for existing problems. The first one is the Aufbau method (building-up method). One developed hypothesis leads to another and perhaps yet another related hypothesis. The collection of data can become a subject to the ability of the investigator to design appropriate new experiments.

The second method by which scientists are led to specific problems and solutions results from what xan at best be termed insight. The best example is August Kekule get insight and reverse of bezene in dream. The third method is the method of chance or accidental discoveries which is we we have talked about before. 7) Summary and future forecast 7. 1) Summary and Conclusion Seredipity has played a crucial role in science. Some of the most important discoveries have been made by investigatos who had no inkling of what they were about to find.

Great breakthroghs in our understanding of nature, opening entire new fields or research, have come about because of unexpected, even accidental, finding in the laboratory. Serendipity is not synonymous with accident, It is not the same as pure luck. Both luck and accident play a role, but hard work, altertness, and perserverence are also demanded. Chance may throw a treasure in your path, but if you are not sharp-eyed enough to notice it, no one benefits. As Louis Pasteur [14] once said,' Chance favours only the prepared mind. ' Serendipitious or chance discovery is one of the important avenues for discovery in the sciences.

As such, it is important to recognize it and to educate students of science in such a way so as to maximize their chances of benefitting from such discoveries during their years as functioning scientists. Some areas thst can be emphasized in the educational process, particularly in undergraduate curricula, are the making and recording of observations, the provision of dynamic structured research opportunities, the encouragement of flexibility of thought, the development of true curiosity, and the discussion of modes of discovery.

Not only do these work to the student's benefit in the area of serendipitious discovery, but they should serve the student well in all other avenues of discovery and creativity. The truly sucessful scentist will no doubt benefit from all modes of discivery. It is the task of the science educator to ensure that his students are prepared in the best possible manner for discovery.

Consider some of the accidents in the science history [15]: an apple falls to the ground at Newton's feet, Wohler produces urea instead of ammonium cyanate, Perkin makes a violet color, Pasteur obtains crystals of unique shape because the temperature on the window ledge was cool, a fluorescent screen glows in the dark when it shouldn't andphosphorescent crystals expose a photographic plate wrapped in black paper, a milkmaid's resistance to a dread disease is noticed by a country doctor, a spore falls into Fleming's open peri dish, Du Pont chemists play games in the laboratory hall and find that a stretched fiber is unusally strong, another Du Pont chemist finds that no gas comes out of a tank even though the tank is not empty, leaky and unclean eqipment leads to formation of polymers when none was expected, the accidental presence of an impurity in a starting material produces a novel molecular " crown. " Any of these accidents could have gone unnoticed and would have thus remained simply an accident of no importance.

Intead, because of the sagacity of the individuals who encountered the accidents, we have an explanation of the laws that govern the movement of the planets, the founding of the science of organic chemistry on a rational basis, the beginning of understanding the relationship of molecular struture to physiological activity, beautiful dyes that anyone, not just royalty, can afford, insight into the culture and language of ancient cilvilization, X rays for medical diagnosis and treatment, radioactivity and nuclear energy, vaccination against smallpox and other diseases, the " miracle drug" penicillin and its successors, nylon and polymers for plastic garbage bags, icechests, radr insulation, water-ski ropes, bullet-proof shields, and aireoplane windows, and synthetic molecules that promise to mimic the vital actions of nature's enzymes. These are just a few of the benefits of serendipity, discoveries made by accident and sagacity of things which they were not actually in quest of. Some of these discoveries were made centries ago, some recently. In the 20th centry our knowledge in science, medicine, and technology has grown at a fantastic rate.

We cannot conceive what advances the future may bring, interplanetary space travel? A cure for cancer? But we can be sure that accidents will continue to happen and, with human minds better prepared than ever before, we can expect these accidents to be turned into discoveries, marvelous beyond our imagination, through serendipity. 7. 2) Future forecast While most teachers of science would argue that they do attempt to develop in their students the habits of observing and recording phnomena, therei s no reinforcement is provided for this habit. The most deficiency is is the use of the preprinted laboratory report from which is frequenctly used in the teaching laboratory.

Students are asked to write down the color that resulted only, but not being taught observe properly. Instead, the habit of observing and recording should be taught by requiring the student to keep a regular laboratory notebook. , to force a student to observe carefully and critically. By forcing a student to derive methods of gathering data and to sort through the data for relevant and related and useful information, he can be convinced that he is indeed capable of solving problems creatively. ! Reference journal article: [1] Pek Van Andel. " Expect also the Unexpected". Creativity and Innovation

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com/Image__3A__Alexander__MM__fleming. jpg. html [13] Figure shows structure of penicillin G [pic] source: http://nsm1. utdallas. edu/bio/gonzalez/lecture/micro/images/B2. jpg [14] A picture of Louis Pasteur [pic] source: : http://www. lakesideschool. org/studentweb/perrichon4/LouisPasteur. htm [15] The table shows the accidental discoveries in science history | Title | year | inventor | serendipity | Nobel Prize | | Measurement of column of | B. C. 00 | Archimedes | discover water flow out caused by crown in bath | | | solid | | | | | | The law of Gravitation | 1667 | Isaac Netwon | see an apple fall down from tree | | | Invention of electric battery| 1800 | Galvani and Volta | Galvani observe a dissected frog twisted as it lay| | | | | | near an electrostatic generator | | | Invention of Vaccination | 1796 | Eward Jenner | see cowpox milkmaids never have smallpox | | | Ether as Anesthetics | 1941 | Charkes T. Jackson| inhale ether to overcome chlorine gas in | | | | | | experiment | | | Synthesize of urea | 1828 | Fredrich Wohler | Heating KCN and NH4SO4 to give urea instead of | | | | | amonium cynate | | | Discovery of {Ru(NH3)5N2}2+ | 1964 | | accidentally produced from investigation of | | | | | | Ru(ethylendiamine) complex | | | Discover of stable enols | 2003 | | Stable enols from Grignard addition to | | | | | | 1, 2-diesters | | | Invention of photography | 1835 | Daguerre | dispose silver iodide plate near broken mercury | | | | | | thermometer gave bright amalgam in light | | | Discovery of chiraty | 1848 | Louis Pasteur | Tartaric acid separate into two chiral acid at | | | | | | midnight | | | Synthetic Dye and Pigments | 1856 | Willium Perkin | Originally want to synthesize quinine from coal | | | | | | tar but resulted a purple dye | | | Formula of Benzene | 1865 | August Kekule | Dream of a snake biting it tail to propose a | | | | | | cyclic structure for the benzene molecule | | | Artificial

Ivory | 1863 | John Wesley Hyatt | Turn over a bottle of collodion give a hardened | | | | | | sheet of cellulose | | | Artificial Silk | 1878 | Hilaire de | Spill out collodion gave a long strand of fiber | | | | | Chardonnet | | |