Introduction

Substance Abuse is one of the major problems facing society. Practically every person in the U. S. has been affected. The abuser does not exist in a vacuum. Their actions impact every aspect of society. From increased medical costs, to lost productivity, substance abuse directly affects societies ability to tackle other problems. Beyond the economic effect of substance abuse there is the substantial human cost involved in substance abuse. Families are often destroyed, lives are often wasted and the pattern continues on to the next generation. Solving this problem is one of the major challenges facing society.

Researchers have studied substance abuse for many years. A wide spectrum of theories have been developed to try to understand the causes of this problem. Many of the earlier theories looked at abuse as a social phenomenon or as individual weakness. From these theories treatment systems developed. In many ways these systems are effective, an abuser who wishes to achieve recovery, can. Unfortunately, the path to recovery is often fraught with failure and personal or societal disasters. Recovery models such as Alcoholics Anonymous address the symptoms of abuse, but do not go to the root causes.

It is with the advent of modern research tools and understandings that we are able to look deeper into abuse and addiction. Going past the blinders of abuse as personal weakness is an important step in understanding the true causes of the problem. In this paper we will examine the evidence for a biological root to substance abuse. While many of the tools required to examine the biology of addiction are new, the belief that addiction

has a heritable component is not. A quote from Robert Burton, one of the first cognitive scientist will illustrate: "Foolish, drunken or haire-braine women,for the most part bring forth children like themselves" (Robert Burton 1621).

Costs

Before looking at the heritable components of addiction it is important to have a basic understanding of the costs involved in this problem. Estimating the cost is a very difficult proposition. The effects of abuse reach into every facet of society. To set an intrinsic dollar amount on many of these effects is impossible, yet to be able to understand the impact of the problem we need to set some dollar values to the problem. A rough estimate by Barry Stimmel (p 15) taking into account crime, medical and loss of productivity, cost the United States over 200 Billion dollars annually. This is a staggering amount of money and one can see why understanding and solving this problem is of immediate interest to all of society.

William Cartwright (1999) attempted to break these huge costs down in to there components. This chart illustrates some of the hard costs involved in substance abuse:

Table 1. Economic costs of drug abuse in the United States 1992 and 1995 (in millions)

	1992	1995
Health care expenditures		
Specialty drug services	$4 400	$5 258
Medical consequences	$5 531	$6 623
Productivity losses		
Earnings—premature death	$14 575	$16 247
Earnings—illness	$15 682	$17 481
Earnings—crime and victims	$39 164	$43 829
Other impacts		
Criminal justice, social welfare administration	$18 307	$20 407
Total costs	$97 659	$109 832

Source: *The Economic Costs of Alcohol and Drug abuse in the United States, 1992.*

It is more difficult to estimate the softer costs i.e. productivity losses and crime related costs. Cartwright's (1999) figures show these cost to be a major portion of the total cost of the substance abuse problem.

Estimate of premature deaths attributable to substance use.	$69 Billion
Shortfall in wages and earnings.	$14 Billion
Crime related costs.	$59 Billion
Treatment and Intervention expenditures.	$4.4 Billion
Medical Complications.	$5.5 Billion

We can see from the above numbers that understanding and properly treating this problem has a huge payoff. For a society struggling to fund social issues dollars spent on research and intervention have a huge payoff in both money and quality of life.

A final quote from Steven Belenko (1998) with the National Center on Addiction and Substance Abuse at Columbia University shows just how serious this problem is;

> " The stunning finding of this analysis is that 80 percent of the men and women behind bars--some 1.4 million individuals--are seriously involved with drug and alcohol abuse and the crimes it spawns. These inmates number more than the individual populations of 12 of the 50 United States. Among these 1.4 million inmates are the parents of 2.4 million children, many of them minors." (Belenko, 1998)

Review of Research

It is important to keep in mind as we review some of the research that much of this is still in its infancy. Many of the tools used to examine biological process on the

genetic level are of recent origins. Researchers are just beginning to unravel how genetics effects behavior.

Researchers have known for a long time that Alcohol (and other drugs) effect development. Fetal Alcohol Syndrome (FAS) is a major medical and developmental issue in the US. Even in small amounts Alcohol effects the developing fetus. Children that don't show full FAS but are still developmentally effected by pre-natal alcohol exposure are said to have Alcohol-Related Neurodevelopmental Disorder (ARND), these children often have developmental problems but don't show the classic FAS characteristics (small head/body, abnormal facial characteristics. mental retardation). It is estimated that FAS effects 1/500 children in the US (May and Gosage 2002). FAS and ARND are estimate to effect 1:100 births (Sampson, et al. 1997). It is clear that practically any amount of alcohol ingested during pregnancy has an effect on the developing fetus. The area that needs detailed research is to explore what effects alcohol has on the genetic structure of the developing fetus and are these (if any) mutations heritable.

One of the earliest clues of the biological mechanisms involved in addiction was the discovery of Opiate receptors in the brain. Researchers, Snyder and Pert (1993), were trying to understand why a drug such as naloxene was capable of bring people out of a heroin coma. Through their research they found that now only did the brain have its own opiate receptors, but also produced its own opiate like substance, endorphins. This finding lead to much more research on how the brain responds to ingested chemicals and what mechanisms effect a persons desire to use various chemicals.

For obvious reason, studying human populations is difficult. Especially

when it comes to perform experiments that could have detrimental effects. For this reason, and others, researchers often study animal populations and then try to draw conclusions that apply to humans. Animal studies are often used when looking at biological mechanism of addiction. Researchers have bred rat strains that are called Alcohol Preferring (AA) and Alcohol Non-Preferring (ANA). Being able to breed a strain susceptible to alcohol abuse is one clue that addiction has a heritable component.

When looking at human populations it is not possible to manipulate breeding or other factors. We need to look at the situation as is and attempt to draw conclusions from what we observe. This is the reason Familial and Twin studies become important. With these populations we can look at traits and try to separate out that which is inherited from that which is taught.

Adoption studies have shown a clear pattern of heritability among adopted children of alcoholic parents, even when reared in homes with little or no alcohol use (McGue 1999). Additionally, these finding are supported by repeated studies on twins. Monozygotic twins show a much higher concordance of alcoholism than Dizygotic twins and twins as a population show higher prevalence rates when compared to sample populations (McGue 1999). Heritability estimates in these studies have shown rates of 49% to 64%. This clearly shows that alcoholism has a very high (1/2 to ¾) rate of heritability.

It is one thing to know that something such as alcoholism is heritable. It is another to understand the how's and why's of this transmission. For that, researchers need to look deeper into the biochemical process. Science has been exploring genetics and neurological process to get a better understanding of why some people are more

susceptible to addictions. One interesting study identified a Gene labeled ADH2*2, a variation of the ADH2 gene, as providing protection against alcoholism (Brown University 2002). This genetic variation occurs in 20-30% of the Jewish population. People of Jewish descent have traditionally had low rates of alcoholism. This has often been attributed to social-cultural factors. This research sheds new light on another possible answer.

One hypothesis of why people use alcohol and drugs is the Self-Medication hypothesis. The basic theory states that the use of these substances allows one to calm an over excited brain or excite and overly sluggish brain. A recent study by the National Institute of Health (2001) looked at the brains response to income signals called "Mismatch Negativity"(MMN). Individual identified as at a high risk for alcoholism also showed a larger MMN than the control sample. The researchers hypothesized that brain hyperexcitability may lead people to use alcohol the self-medicate this excitation.

A 1999 study by Clyde Hodge et al identified the enzyme PKCe as moderating the effects of the GABA-A neurotramsitter. Mice who lacked this enzyme were 75% less likely to consume alcohol than the control group with the enzyme. This theory is in line with other current theories that state that Alcoholism is a response to the bodies increased toleranace of alcohol. This increased tolerance is because of the effect of certain genes and neurotransmitters.

Collette Dowling in her book, *You Mean I Don't Have to Feel This Way,* Dowling explore a theory first proposed by James Hudson and Harrison Pope of Harvard Medical School. The theory, called Affective Spectrum Disorder, attributes a wide range of mood and personality disorders to a common organic cause. Disorders such as

bulimia, bipolar disorder, depression, alcoholism, obsessive-compulsive, etc. all respond to the same medications leading the researchers to theorize a common root. All these disorders seem to be effected by improper levels of certain neurotransmitters, predominately serotonin. The next step would be to discover what mechanisms cause this deficit of serotonin and additional ways to treat it.

An anecdotal example of Affective Spectrum Disorder would be the case of P. P struggled with alcoholism for many years, periodically going into treatment and quickly falling back into old patterns of use. Finally after years of this cycle she went in for a psychiatric evaluation. She was diagnosed with bipolar disorder and went on medication. Within weeks she had stopped drinking and has been sober for over 8 months.

Discussion

Addiction is a huge problem. The social costs are staggering. The quicker effective treatments are developed to minimize this problem the better society will be. This makes the understanding of the biological addictive mechanisms crucially important.

There is no doubt that addiction has a strong heritable component. Twin and adoptions studies have clearly shown this to be true. Some people are born with a predisposition towards addiction. This isn't to rule out environmental effects. Having a predisposition does not mean one will become an addict. The amounts of abused substance, family norms, peer pressure, etc. all impact if and when this predisposition will become a problem.

Knowing that addiction is heritable is only the first piece of the puzzle. The more difficult aspects are to discover and understand how these heritability is produced

and how to treat it. Most likely there is not one genetic cause. Rather a multitude of genetic effects can lead to disorder like addiction. Much further research is needed in this area to understand all the different mechanisms at work. As researchers zero in on specific genes responsible for addiction a new world of treatments becomes possible. One such preliminary treatment involved rats treated with a virus carrying the D2 receptor gene. After treatment these rats showed a 43% drop in their preference for alcohol and drank 64% less than the control group (Panyotis, et al. 2001). Research such as this is a big step towards targeting specific genetic abnormalities that lead to substance abuse.

As a final note, it is important to remember that the research cited in this paper is only a small portion of the available research. Every day new data is being released. Our understanding of the genetic pathways of addiction are just beginning to unfold. Over time, as we increase our knowledge better and more effective treatments will be developed. Addictions may never be eliminated, yet with a better understanding of the problem we can go a long way towards minimizing the costs and societal damage this disorder causes.

References

Belenko, S., (1998) Behind Bars: Substance Abuse and America's Prison Population. *National Center on Addiction and Substance Abuse at Columbia University, Retrieved* July 16, 3003 from http://www.casacolumbia.org/publications1456/publications_show.htm?doc_id=5745

Burton, R., (1621) *The Anatomy of Melancholy,* (Reprint) New York: New York Review of Books

Cartwright, W., (1999). Cost of Drug Abuse to Society. *Journal of Mental Health Policy and Economics,* 2, 133-134

Dowling, C (1993) *You Mean I Don't Have To Feel This Way? New Help for Depression, Anxiety and Addiction.* New York: Bantam Press

Genetics May Explain Jewish Alcoholism Rates (2002) Abstract, *The Brown University Digest of Addiction Theory and Application. 21(12) 10*

Hodge, C., Et Al. (1999) Enzyme Linked to Alcohol Craving. *Nature Neuroscience,* 12

May, P. A. & Gossage, J. P. (2002), Estimating the Prevalence of Fetal Alcohol Syndrome: A Summary, *National Institute of Health Publication*, Retrieved July, 14, 2003 from http://www.niaaa.nih.gov/publications/arh25-3/159-167-text.htm

McGue, M., (1999), Behavioral Genetics of Alcoholism. APA Publication

Panayosis, T. K., Volkow, N., Friemuth, P. Hiroyuki, U., Hiroyuki, I., Roth G., Ingram, D.K., and Hitzeman, R. (2001), Overexpression of Dopamine D2 Reduces Alcohol Self Administration. *Journal of Neurochemistry,* 78(5) 1094-1103

Sampson PD, Streissguth AP, Bookstein FL, Little RE, Clarren SK, Dehaene P, Hanson JW, Graham JM Jr., (1997) Incidence of fetal alcohol syndrome and prevalence of alcohol-related neurodevelopmental disorder*, Teratology*, 56(5) 317-336

Snyder, S & Pert, C. (1973) Opiate Receptors: Demonstrations in Nervous Tissue. *S cience* 179

Stimmel, B., (1996) *Drug Abuse and Social Policy in America,* New York: The Halworth Medical Press