Chapter 2
Idea Generation

Chance favors only the prepared mind.

Louis Pasteur

Genius is one percent inspiration and ninety-nine percent perspiration.

Thomas Edison

Creativity

Creativity has been defined as

- "the act of generating new and useful ideas, or of re-evaluating or combining old ideas, so as to develop new and useful perspectives in order to satisfy a need" (Quantumiii—http://www.quantum3.co.za/CI%20Glossary.htm)
- "any act, idea, or product that changes an existing domain or that transforms an existing domain into a new one" (Csikszentmihalyi, 1996)
- "purposely making new and valuable products …[to] include significant truths, illuminating explanations, and useful technologies." (Martin, 2007)

A detailed model has been developed by Csikszentmihalyi (1996) who outlines seven steps in the creative process

1. Problem definition and conscious study
2. Focused thinking and unconscious processing
3. "Eureka!" moment
4. Clarification and commitment
5. Experimentation
6. Dissemination
7. Propagation of the idea leading to acceptance

R.L. Shewfelt, *Becoming a Food Scientist: To Graduate School and Beyond*,
DOI 10.1007/978-1-4614-3299-9_2,

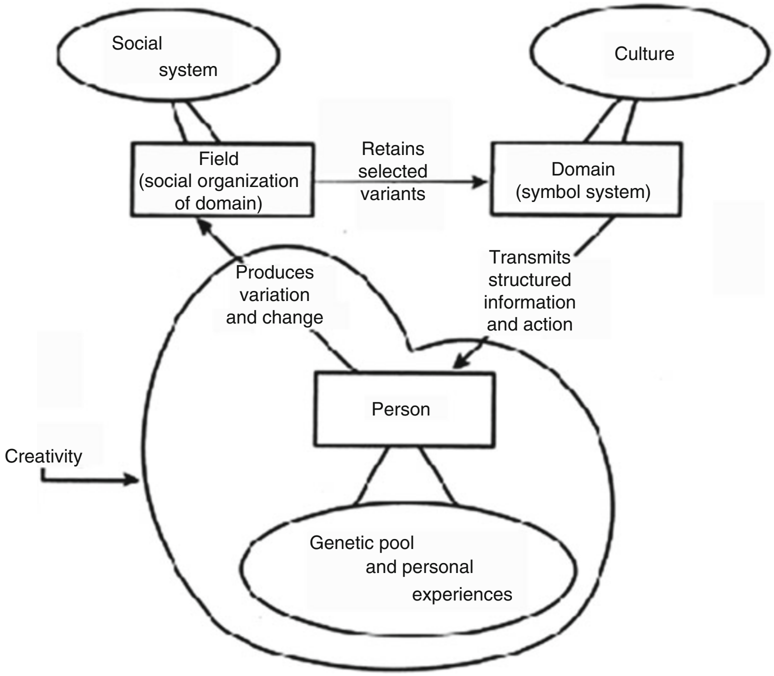


Fig. 2.1 Csikszentmihalyi model of creativity as modified by Weisberg (2006). Reprinted by permission of John Wiley and sons publisher

The first four steps fit into all three definitions shown above, but the last three steps require concrete evidence of creativity. Such a situation raises many questions

- Is someone creative even if what is created is not disseminated?
- Can an idea be creative or must it produce something?
- If an idea is generated today, forgotten, and then revived later and disseminated by someone else, who is creative—the thinker or the disseminator? Read about Mendel in Henig (2001).

The analogy is like the old argument about a tree falling in a forest and whether it makes a sound when it falls if no one is there to hear it. To become a sound, does a person need to hear it or could it be another animal or even an insect? Was Gregor Mendel creative since his ideas were not disseminated until more than 30 years after he completed his research and almost 20 years after his death (see Henig, 2001)? Csikszentmihalyi argues that the creative person must take the idea to a product, but Weisberg has modified Csikszentmihalyi's model to confine creativity to an idea development as shown in Fig. 2.1. Weisberg accounts for the influences of culture (science in our case), the domain (food science), genetics (our innate abilities), and experience (mistakes and insights) on the creative person. The change induced by the creative person could be an ultimate product (new food product, research paper, funded grant proposal) or merely an idea that stimulates creativity for others in the domain.

When starting out my career as a very green faculty member, I had a mentor who may have been the most creative person I have ever met. Any time I went into his office, I would come away with more researchable ideas than I could ever hope to explore. Our small department was incredibly productive, and many of the researchable ideas were directly attributable to him. His publication record was slim, but his ability to generate ideas was particularly impressive. By Csikszentmihalyi's model, he was not creative, but Weisberg would classify him as very creative. However, any creative person must disseminate that information to receive credit leading to Rule#2.

RULE # 2
To obtain credit for any scientific discovery you must be the first person/research group to publish it.

It would appear that there are at least two distinctive types of creativity—breakthrough creativity (Ogle, 2007) and problem-solving creativity (Wakefield, 2003). Breakthrough creativity involves major changes in thinking in an area of research leading to scientific revolutions (Kuhn, 2007) such as the theories of relativity (Einstein, 1920) and the elucidation of the structure of DNA (Watson and Crick, 1953). It tends to favor those who think across disciplines and either ignore some critical theories or are ignorant of them (Ogle, 2007) and appears to favor those individuals or teams who can work across the learning styles described in Chap. 1—assimilation (steps 1 and 2 of Csikszentmihalyi's model), diverging (step 3), accommodating (steps 4 and 7), and converging (steps 5 and 6). Breakthrough ideas also require proper timing and the necessary infrastructure to be accepted and implemented (Ogle, 2007). Creativity does not have to be earth-shattering (Runco, 2003). Creativity is also necessary to solve problems that confront scientists on a daily basis. This type of creativity makes incremental progress pushing the boundaries of accepted theories and principles. It requires the use of critical thinking skills (Chap. 11) and is most effectively employed by a combination of assimilation and converging. I prefer to think of creativity as a continuum ranging from incremental improvement to breakthrough creativity with many intermediate stages between these two extremes. For more insight into the creative process as it relates to scientific discovery, read books by Runco (2003), Simonton (2004), and Martin (2007).

Creativity and productivity appear to be related to age with creativity peaking in the late 1920s and early 1930s for most scientists and downhill from there (Simonton, 2002) Effective scientists are able to combine creativity with experience and resource accumulation to make the greatest contribution in the early 1940s with some variation by field (Fig. 2.2). Productivity can extend up to age 60 (Simonton, 2004).

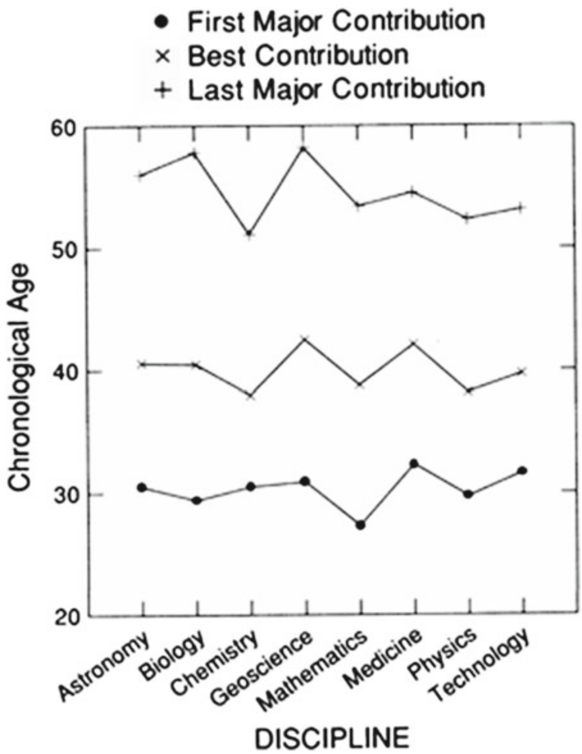


Fig. 2.2 Contributions to science by age and discipline as plotted by Simonton (2004). Reprinted by permission of Cambridge University Press

An important concept that goes along with creativity is flow defined as "an almost automatic, effortless, yet highly focused state of consciousness" (Csikszentmihalyi, 2008). Flow is something any creative person must capture to be successful. The characteristics of flow include:

- Setting specific goals
- Obtaining rapid feedback
- Balancing challenges and appropriate skills
- Assessing needs and converting them into action
- Eliminating distractions for complete concentration
- Suppressing any fear of failure
- Losing self-consciousness
- Losing complete track of time
- Developing a cycle of successes

Gough (1952) developed an Adjective Check List to relate to different personality types. He related this list to the creative people (Gough, 1979) and the list is reproduced in Fig. 2.3. Take the test and see how well you score on creativity.

__ affected	__ honest	__ original
__ capable	__ humorous	__ reflective
__ cautious	__ individualistic	__ resourceful
__ clever	__ informal	__ self-confident
__ commonplace	__ insightful	__ sexy
__ confident	__ intelligent	__ sincere
__ conservative	__ interests narrow	__ snobbish
__ conventional	__ interests wide	__ submissive
__ dissatisfied	__ inventive	__ suspicious
__ egotistical	__ mannerly	__ unconventional

Fig. 2.3 Adjective checklist developed by Gough (1952) and evaluated for creativity (Gough, 1979) as referenced by Piirto (2004) and Weisberg (2006). Check all the adjectives that apply. See answers at the end of the chapter

Sociology of Science

Scientists take on many roles in the laboratory (Merton, 1979). Few scientists take on all the roles Merton describes, but most do take on more than one role depending on the situation. They can serve as:

- Technological advisors to graduate students, organizations, federal agencies, and many other groups.
- Technological experts in specific areas of research.
- Technological leaders in that field.
- Sages who are all-knowing persons on a particular topic.
- Scholars who seriously study an area and uncover new knowledge.
- Systematizers who sort information into more understandable forms.
- Experimentalists who publish and contribute to the knowledge base.
- Fighters for truth who argue against myths and legends which become part of popular culture.
- Disseminators of information either in the popular press or in the classroom.
- Creators of knowledge from common problem-solving to development of theories.

What are the preferred learning styles described in Chap. 1 for each of these categories?

When sociologists look at science they see several influences. Society is willing to support science when they see positive benefits coming out of the process. The incredible advances in medicine and treating diseases as well as the successes in space in the 1960s and 1970s have provided science with a good reputation. Space failures, skepticism on global warming, lack of success with fire ants, and highly publicized food poisoning outbreaks have tarnished that reputation. Science follows popular trends, and grant funding calls the shots. Federal and industry dollars are

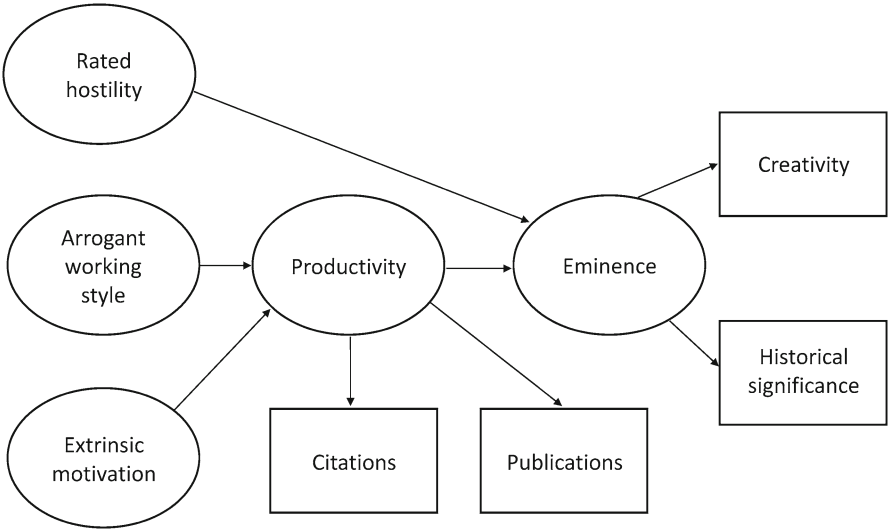


Fig. 2.4 Factors affecting creativity and scientific eminence as modeled by Feist (1993) and adapted by Weisberg (2006). Reprinted by permission of John Wiley and Sons publisher

funding obesity research, the search for "healthy" foods, and food safety. Every 8 years or so there are major shifts in funding brought about by external events and priorities set by the party in power. Recent elections have highlighted both the importance and controversy associated with health care and alternative energy sources.

The reward system for scientists is fairly clear. It is set in numbers of research publications and grant funding amassed. Priority, or the first person/lab that publishes a significant breakthrough, is heralded by other scientists in the field. The "Received" date on the bottom of any research article is the one used to establish priority. Competition for priority among elite scientists is as brutal as for television news scoops. Frequently there are multiple discoveries of key principles due to publication of previous work that does not rise to the level of the big discovery but makes it possible. The most famous multiple discovery is that of Gottfried Leibniz and Isaac Newton inventing calculus (Merton, 1979).

Evaluation of scientists is also a driving force for the scientific enterprise. Most scientists want and seek recognition and excellence. Eminence has been linked to creativity by Feist (1993) and Weisberg (2006) as shown in Fig. 2.4. Recognition comes from salary increases, employers bidding for services, awards, and other recognition. The "Matthew" effect indicates that the first discoverer in a field receives undue recognition while subsequent researchers, even if they have more clear explanations, do not receive adequate recognition (Merton, 1979). In science, the second discoverer is indeed the first loser. I remember hearing the sad story of the second person to independently describe the ethylene pathway in plants with dramatic implications for fruit ripening. He missed priority by two weeks! I heard his story sitting beside him on a bus ride from New Hampshire to Boston, but I can't remember his name. I do know the name of the man who established priority—Shang Fa Yang

(Bradford, 2008). The referee process tends to give the benefit of the doubt to recognized scientists with respect to accepting manuscripts for publication and awarding grants and tends to penalize younger, less recognized scientists.

Welcome to Academe

Promotion and tenure (P&T) is an important process in sorting out ineffective scientists in universities. The typical P&T process brings in a young scientist at the Assistant Professor level. Reputation is established by publications (particularly in prestigious journals), grant funds, invited presentations, teaching, etc. A well-respected researcher who is an adequate teacher is more likely to get promoted than a well-respected instructor who is an adequate researcher. While there are slight distinctions between being promoted and receiving tenure, most scientists promoted to Associate Professor are granted tenure, while tenure is not awarded to those who fail to be promoted within 7 years. For more information on the P&T process, see Chap. 18.

Idea Generation

So where do researchable ideas come from? Anywhere and everywhere. Ideas come from:

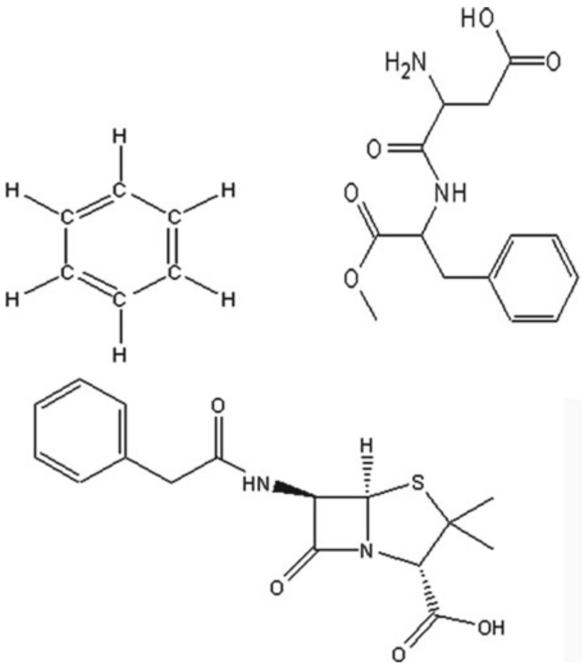
- Previous research (a good researcher generates fewer answers than new questions see Chaps. 3, 9, 11 and 12)
- Observation (in daily life, from the news media, from conversations)
- Frustration (things that irritate us both consciously and unconsciously, demanding a solution)
- Funding agencies (use funding as a carrot to study areas they have determined to be important)
- Questions (from annoying people who can't ignore the obvious)
- Dreams and serendipity (weird ideas that just pop into the mind; see Roberts, 1989)

As the quotations that open the chapter indicate, we must be prepared for a good idea when it comes to us and to struggle with it until we can make proper use of it. There are many stories about how ideas were generated. Some of my favorites are:

- Alexander Fleming who saw the future of antibiotics when most would only have seen spoiled plates and a failed experiment (Bankston, 2001).
- Jim Schlatter who noted a sweet taste on his fingers (Robinson and Stern, 1998).
- Friedrich Kekulé who supposedly dreamed of cats chasing their tails that led to proposing the structure of the molecule that is the basis of all phenolic compounds so important in functional foods (Roberts, 1989).

All three provided keys to the important molecular structures shown in Fig. 2.5.

Fig. 2.5 Molecules that inspired breakthrough creativity in science. Can you name them?



A major portion of my research on the quality of fresh fruits and vegetables over the past 20 years (Shewfelt, 1986, 1999, 2000; Shewfelt and Prussia, 2009) was stimulated by an annoying questioning of my major premise by an audacious graduate student who was not even a member of my laboratory (Pendalwar, 1989).

A well-prepared mind belongs to one who reads widely. Such reading includes popular articles, professional journals, and books. Look for overviews and focus in on in-depth studies or read about unrelated topics. A successful idea generator is one who has many ideas and can separate out the really good ideas from the OK ideas from the really bad ideas. When reading a scientific article hone in on the main message and then consider the next logical research objective. When evaluating ideas, ask the following questions:

- Does this idea excite me?
- Can it be formulated into achievable objectives?
- Would these objectives be achievable within a realistic time frame?
- Do I have the capabilities to pursue this idea?
- Do I know someone who can complement my capabilities to pursue this idea?
- Does it have practical significance?
- Will it be viewed favorably by my colleagues and evaluators?
- Is it fundable?

If the answers to enough of these questions are "Yes," then it is an idea worth pursuing. Success is not guaranteed, but our chances for success are better. If there are several "No" answers to these questions, we must be willing to accept the consequences if we fail. Many successful research pioneers embarked on topics that were not likely to succeed. So too, many who failed to make P&T and sought jobs in other fields. We look more carefully at how to turn an idea into a defined research problem in the next chapter.

Creativity can be cultivated through reading outside our research area. Ogle (2007) says that breakthrough creativity works best when crossing idea spaces. An idea space is similar to a thought collective discussed in Chap. 14. For example, food microbiologists and food engineers operate in different idea spaces with different assumptions and goals. A person or team who can operate in two or more idea spaces can make linkages that suggest new research directions. Ogle suggests that a background in physics combined with limited knowledge in biology allowed Crick and Watson to revolutionize biology by elucidating the structure of DNA. He also indicates that webs of information help create novel ideas that can be exploited.

An example of one chemist whose love of reading led to success is provided by the life of Herbert Brown. He graduated with a degree in organic chemistry, and his girlfriend gave him a graduation present of the only chemistry book she could find, *The Hydrides of Boron and Silicon* (Stock, 1933). Although it had nothing to do with organic chemistry, Herbert was an avid reader, seeing possibilities of working across the idea spaces of inorganic and organic chemistry. He started out his career at the University of Southern California, but he was denied tenure after 9 years. He was able to find a position at Wayne State University and subsequently went to Purdue University. His research in organoborane chemistry was recognized with half of the Nobel Prize in Chemistry in 1979. He and Georg Wittig were recognized "for their development in the use of boron-and phosphorous-containing compounds, respectively, into important reagents in organic synthesis" (http://nobelprize.org/nobel_prizes/chemistry/laureates/1979/index.html). He generously shared his prize money with the girlfriend who had given him the book that started him on his career, which is not that surprising as she had subsequently become his wife (see http://nobelprize.org/nobel_prizes/chemistry/laureates/1979/brown-autobio.html).

Another way of cultivating creativity is by focused thinking. Focused thinking requires complete concentration—no music or other distractions. No multitasking is allowed. A walk in the woods, a comfortable couch in an out-of-the-way venue, lying down in the grass watching the stars, a quiet niche in the library, or daydreaming through an incredibly boring seminar can all be conducive to focused thinking. During focused thinking, we start with a specific or general topic and then let the mind run. There will be diversions to topics that are completely unrelated, but occasional prompting back to the topic at hand may provide some links that are useful. At the end of a focused learning session, a quick debriefing and recording of our ideas for later consideration is advised.

For more ways of cultivating creativity, see suggestions by Piirto (2004).

Answer to Fig. 2.3

Adjectives positively related to creativity:

capable, clever, confident, egotistical, humorous, individualistic, informal,insightful, intelligent, interests wide, inventive, original, reflective, resourceful, self-confident, sexy, snobbish, unconventional

Adjectives negatively related to creativity:

affected, cautious, commonplace, conservative, conventional, dissatisfied, honest, interests narrow, mannerly, sincere, submissive, suspicious

Give yourself a point for every adjective you checked that matches one in the positive attributes and subtract a point for every adjective you checked that matches one in the negative attributes. Top score is +18. Lowest score is −12. How well does this scale really measure creativity?

Answer to Fig. 2.5

Benzene, aspartame, and penicillin.

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