INTRODUCTION

The word *Synectics,* from the Greek, means the joining together of different and apparently irrelevant elements. Synectics theory applies to the integration of diverse individuals into a problem-stating problem-solving group. It is an operational theory for the conscious use of the preconscious psychological mechanisms present in man's creative activity. The purpose of developing such a theory is to increase the probability of success in problem-stating, problem-solving situations. This increase depends on awareness of the mechanisms which must be worked through to arrive at solutions of fundamental novelty. (Novelty is fundamental to the degree that it is general. A special cam may be a new way to make a particular apparatus function better, but this cam is not applicable to any other piece of apparatus. A transistor, on the other hand, is applicable to a wide range of uses.)

The study of creative process is encumbered by the fact that, being a process, it is in motion. Traditionally, creative process has been considered after the fact—halted for observation. But when the process is stopped, what is there to observe? The Synectics study has attempted to research creative process in vivo, while it is going on. To understand the digestion process of a cow it is possible to put a picture window in the cow's stomach(s). However, a window opening onto the brain of a man who is acting creatively would be useless because not enough is understood about the brain to know what we would be seeing. Therefore, the only way to learn about creative process is to try to gain insight into the underlying, non-rational, free-associative concepts which flow under the articulated surface phenomena. To do this, Synectics research has required problems to be solved and people to be observed.

The Cambridge Synectics group, which was the first and is a continuing source of the data and hypotheses examined in this book, enjoys a symbiotic relationship with industry. In spite of substantial assistance of many kinds from personnel at the Department of Defense, the Institute of Contemporary Art, the Rockefeller Foundation, Harvard University, and Massachusetts Institute of Technology, American industry has become the most prominent laboratory element in Synectics research. The Cambridge Synectics group needs problems to solve and groups with which to work in order to continue its research. Industry needs problems solved and must have creative groups within it to continue producing basic novelty. In the course of this work the Cambridge Synectics group has developed increasing experimental insight into the conception and reduction to practice of radically novel ideas—from observing its own process as well as the process of groups in training.

The present Cambridge Synectics group consists of six men of varied background (physics, mechanics, biology, geology, marketing, and chemistry). Part of their time is spent in sessions attacking invention problems. Tape recordings of successful sessions (where a concept promising enough to test is developed) are analyzed to learn how the concept originated. Another part of their time is devoted to implementation—building working models, conducting experiments, and investigating market potentials. There are frequent discussions of progress which serve two purposes. First, they keep the group in touch with how a project is going. Second, by hearing about how individuals overcome specific problems, more is learned about the invention process. The other activity of the group is teaching. Certain members select candidates and train selectees from client companies in the use of the Synectics method.[1]

The group functions under two leaders. One handles administrative matters; the other guides the sessions themselves. However, there is a high degree of democracy. For example, any member can call together other members of the group for a session, and administrative decisions of any moment are decided by the whole group.

This book is an interim report on research which will continue for years to come. The objective of the research to date has been to develop an operational concept of human creativity and to test this

[1] Wilson, William: "Operational Creativity," Marketing & Transportation Paper No. 2 (Michigan State University, East Lansing, Michigan, 1958).

concept. The conclusions stated and implied in this book form the basis on which other successful Synectics groups have been founded; when a scientific experiment repeatedly yields similar results, such confirmation is held to be a demonstration of the validity of the underlying hypothesis. However, not all the conclusions (although based on experimental evidence) are to be taken as fixed and final, but as hypotheses in transition, suitable for further research and study. Synectics research hinges on the following assumptions:

(i) that the creative process in human beings can be concretely described and, further, that sound description should be usable in teaching methodology to increase the creative output of both individuals and groups. This assumption places Synectics theory in direct conflict with the theory that any attempt to analyze and train imagination and those aspects of the human psyche associated directly with the creative process threatens the process with destruction. In other words, true analysis of the creative process is considered impossible since if the individual attempts to examine himself in process, the process ceases immediately, and his examination is bankrupt. This theory implies that illumination is destructive. At present this prejudice seems groundless. Synectics' attempts to illuminate the creative process have resulted in several working hypotheses which are useful in practice and have increased markedly the creative output of both individuals and groups;

(ii) that the cultural phenomena of invention in the arts and in science are analogous and are characterized by the same fundamental psychic processes;

(iii) that individual process in the creative enterprise enjoys a direct analogy in group process.

The purpose of the book is to describe the evolution of Synectics' theory of creative process, the hypotheses that underly the theory, and the actual implementation of the theory in specific cases.

Research: The aim of Synectics research, since 1944, has been to uncover the psychological mechanisms basic to creative activity. The recurrent problem has been how to discover these mechanisms when they were buried within the subjective responses of individuals. The main body of this research consisted of oscillating between gaining concrete insight about the psychological mechanisms and testing the validity of these mechanisms in problem-stating, problem-solving situations. The latest part of Synectics research has been directed toward exploring the use of problem-solving groups trained in the Synectics mechanisms. Test groups are presently operating in a number of American companies with considerable—and increasing—success. This success results from the Synectics mechanisms becoming defined more and more functionally as the research develops along increasingly concrete lines. Growing interest has been shown in the implications of Synectics at all levels of education. Up to now the methodology had to be tested in a practical climate where experiments could be judged on the basis of pragmatic criteria. However, Synectics research is about to be applied experimentally to educational processes as known today in our schools and colleges.

Hypotheses: Synectics theory holds that:

(i) creative efficiency in people can be markedly increased if they understand the psychological process by which they operate;

(ii) in creative process the emotional component is more important than the intellectual, the irrational more important than the rational;

(iii) it is these emotional, irrational elements which can and must be understood in order to increase the probability of success in a problem-solving situation.

Practice: Establishing Synectics problem-stating and problem-solving groups goes through three phases: selection of personnel, training in Synectics, and integration back into the client environment. During the training process from time to time judgments are made of the group's progress by evaluating its solutions to previously unsolved client problems. Although Synectics theory is being applied broadly, a group in training limits its effort to technical problems. Technical solutions can be evaluated more positively than solutions to problems in areas like policy or finance.

Examples: Concrete examples of tape recorded sessions have been chosen to illustrate elements of Synectics in practice. For the benefit of the general reader I have attempted to select examples which do not include highly complex and technical scientific material.

TWO · THE OPERATIONAL MECHANISMS

Synectics defines creative process as the mental activity in problem-stating, problem-solving situations where artistic or technical inventions are the result. I use the expression "problem-stating, problem-solving" rather than merely "problem-solving" in order to include the definition and understanding of the problem. The operational mechanisms of Synectics are the concrete psychological factors which support and press forward creative process. The mechanisms do not pertain to the motivations for creative activity, nor are they intended to be used to judge the ultimate product of an esthetic or technical invention. Psychological states such as empathy, involvement, play, detachment, and use of irrelevance are (as we have seen) basic to creative process but they are not operational. The Synectics mechanisms are intended to induce appropriate psychological states and thus promote creative activity.

Words like intuition, empathy, and play are merely names put to complex activities in the hope that the naming of the activity will in fact describe it. Experience has shown it to be most difficult to feed back into a problem-stating, problem-solving situation such nominalistic abstractions. When dealing with an individual or a group faced with problem-stating and problem-solving, it is ineffectual to attempt to persuade the individual to be intuitive, to empathize, to become involved, to be detached, to play, or to tolerate apparent irrelevance. However, in our research experience the Synectics mechanisms effectively increase the probability of success when creativity is called for. They draw the individual into the psychological states.

The Synectic process involves:

(i) making the strange familiar;
(ii) making the familiar strange.

Making the strange familiar: In any problem-stating, problem-solving situation, the first responsibility of individuals involved is to understand the problem. This is essentially an analytical phase where the ramifications and the fundamentals of the problem must be plumbed. However, if only this analytical step is taken, no novel solution is possible. For work on a problem to get started, some concrete assumptions must be made, although in the course of the problem-stating, problem-solving process, the understanding of the problem may change. It is the function of the mind, when presented with a problem, to attempt to make the strange familiar by means of analysis. The human organism is basically conservative, and any strange thing or concept is threatening to it. When faced with strangeness the mind attempts to engorge this strangeness by forcing it into an acceptable pattern or changing its (the mind's) private geometry of bias to make room for the strangeness. The mind compares the given strangeness with data previously known and in terms of these data converts the strangeness into familiarity.

This is, of course, an obvious part of problem-solving. However, Synectics is an attempt to describe those conscious, preconscious and subconscious psychological states which are present in any creative act. Therefore, it would be an omission not to mention the analytical, the making-the-strange-familiar mechanism. The great pitfall, the traditional danger, in making the strange familiar is in becoming so buried in analysis and detail that these become ends in themselves, leading nowhere. The process of making the strange familiar, if used alone, yields a variety of superficial solutions; but basic novelty demands a fresh viewpoint, a new way of looking at the problem. Most problems are not new. The challenge is to view the problem in a new way. This new viewpoint in turn embodies the potential for a new basic solution.

Making the familiar strange: To make the familiar strange is to distort, invert, or transpose the everyday ways of looking and responding which render the world a secure and familiar place. This pursuit of strangeness is not a blasé's search for the bizarre and out-of-the-way. It is the conscious attempt to achieve a new look at the same old world, people, ideas, feelings, and things. In the "familiar world" objects are always right-side-up; the child who bends and peers at the world from between his legs is experimenting with the familiar made strange. (One sees the familiar tree as a collection of solids in an otherwise empty space. The sculptor consciously may invert his world and see the tree as a series of voids or holes carved within the solid block of the air.)

Owen Barfield quotes a South Sea Islander's pigeon-English description of a three-masted, screw steamer with two funnels: "Thlee-pieces bamboo, two-pieces puff-puff, walk-along inside, no-can-see."[1] In our terms, the conceptions which frame the steamship are firmly established in the realm of the familiar. Here, the familiar Western concept of steamship is juxtaposed with the strange pigeon-English version. Barfield says, "Now when I read the words, 'Thlee-pieces bamboo, two-pieces puff-puff, walk-along inside, no-can-see,' I am for a moment transported into a totally different kind of consciousness. I see the steamer, not from my own eyes, but through the eyes of a primitive South Sea Islander. His experience, his *meaning* is quite different from mine, for it is the product of different concepts. This he reveals by his choice of words; and the result is that, for a moment, I shed Western civilization like an old garment and behold my steamer in a new and strange light."[2] The steamer seen by the Western mind in this light is reconstituted and presented as alive and malleable to the imagination.

These several mechanisms for making the familiar strange are not a collection of mental tricks for the achievement of superficial novelty. They have been developed and are used in the several Synectics groups as a systematic way of solving actual invention problems. Thus, Barfield's "new look" at the familiar steamer could be the starting point for considering propulsion. Combined with technical competence it could in turn lead to a new viewpoint for the development of a new invention.

The attempt to make the familiar strange involves several different methods of achieving an intentionally naive or apparently "out of focus" look at some aspect of the known world. And this look

[1] Barfield, Owen, *Poetic Diction* (London: Faber & Faber, 1957), p 49.
[2] *Ibid.*

can transpose both our usual ways of perceiving and our usual expectations about how we or the world will behave. The experience of sustaining this condition can provoke anxiety and insecurity. But maintaining the familiar as strange is fundamental to disciplined creativity. All problems present themselves to the mind as threats of failure. For someone striving to win in terms of a successful solution, this threat evokes a mass response in which the most immediate superficial solution is clutched frantically as a balm to anxiety. This is consistent with the natural impulse to master the strange by making it familiar. Yet if we are to perceive all the implications and possibilities of the new we must risk at least temporary ambiguity and disorder. Human beings are heir to a legacy of frozen words and ways of perceiving which wrap their world in comfortable familiarity. This protective legacy must be disowned. A new viewpoint depends on the capacity to risk and to understand the mechanisms by which the mind can make tolerable the temporary ambiguity implicit in risking.

Synectics has identified four mechanisms for making the familiar strange, each metaphorical in character:

(i) Personal Analogy;
(ii) Direct Analogy;
(iii) Symbolic Analogy;
(iv) Fantasy Analogy.

According to our observations, without the presence of these mechanisms no problem-stating, problem-solving attempt will be successful. The mechanisms are to be regarded as specific and reproducible mental processes, tools to initiate the motion of creative process and to sustain and renew that motion. There are romantic and popular prejudices against any such mechanization of human creativity. However, Synectics consciously intends this very mechanization. The mechanisms are thus by definition subject to conscious and deliberate use as primary *means*. In addition, through practice they become habitual as ways of seeing and acting. Even those individuals who by habit unconsciously make use of them have been observed to intensify and heighten their creative effectiveness as a result of the conscious effort to establish and expand the application of these tools.

PERSONAL ANALOGY

Personal identification with the elements of a problem releases the individual from viewing the problem in terms of its previously analyzed elements. A chemist makes a problem familiar to himself through equations combining molecules and the mathematics of phenomenological order. On the other hand, to make a problem strange the chemist may personally identify with the molecules in action. Faraday "looked . . . into the very heart of the electrolyte endeavoring to render the play of its atom visible to his mental eyes."[3] The creative technical person can think himself to be a dancing molecule, discarding the detachment of the expert and throwing himself into the activity of the elements involved. He becomes one of the molecules. He permits himself to be pushed and pulled by the molecular forces. He remains a human being but acts as though he were a molecule. For the moment the rigid formulae don't govern, and he feels what happens to a molecule.

Einstein recognized the role of empathic personalized identification: "The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be 'voluntarily' reproduced and combined . . . this combinatory play seems to be the essential feature in productive thought. . . . The above mentioned elements are, in my case, of visual and some of muscular type."[4] Here a great man of science working in the most abstract area of thought admits "muscular" identifications even with the *a priori* constructs of mathematics. Kekule, by identifying himself with a snake swallowing its tail, developed an insight

[3] Tyndall, John, *Faraday as a Discoverer* (London: Longmans, Green, 1868), pp. 66–67.

[4] Hadamard, Jacques, *The Psychology of Invention in the Mathematical Field* (Princeton: Princeton University Press, 1945), pp. 142–143.

into the benzene molecule in terms of a ring rather than a chain of carbon atoms.[5] Keats describes his writing of *Endymion:* "I leaped headlong into the sea, and thereby have become better acquainted with the sounds, the quicksands, and the rocks, than if I had stayed upon the green shore and piped a silly pipe, and took tea and comfortable advice."[6] Thus, in both science and art, detached observations and analysis are abandoned in favor of Personal Analogy.

Example of Personal Analogy: A Synectics group had been attacking the problem of inventing a new and practical constant speed mechanism: How to run a shaft at speeds varying from four hundred to four thousand rpm so that the power take-off end of this shaft always turns at four hundred. In analyzing the technical elements, the group began to find immediate solutions. As might be imagined all these "solutions too soon" took the form of gears and wheels, cones, or liquid clutches. Since many competent engineers had tried to solve this constant speed problem there was little hope for arriving at anything elegant unless a totally new viewpoint were gained. The mechanism for making this familiar problem strange was Personal Analogy. A sketch was drawn on the blackboard showing a box with a shaft entering and going out. The entering shaft was labelled "400 to 4000"; the exiting shaft was labelled "400 constant." One after the other, each member of the group metaphorically entered the box and attempted without tools to effect with his own body the speed constancy required. Here are some excerpts from the recorded session:

A: Okay I'm in the damn box. I grab the in-shaft with one hand and grab the out-shaft with the other. I let the in-shaft slip when I think it's going too fast so that the out-shaft will stay constant.

B: But how do you know how fast the out-shaft is really going?

A: I read a watch and count.

C: How do you feel in there?

[5] Libby, Walter, "The Scientific Imagination," *Scientific Monthly,* XV (1922), pp. 263–270.

[6] Keats, John, *The Letters of John Keats,* M. Buxton Forman ed. (London: Oxford University Press, 1935), p. 223.

A: Well, my hands are getting . . . too hot to hold I guess . . . at least one hand, that is . . . the one that's acting like a clutch . . . slipping.

C: B, how about you hopping into the box.

B: I see myself in there but I can't do anything because I don't have anything to measure rpm or time . . . I guess I'm in the same spot as A.

C: How about you, D?

D: . . . I'm in the box and I am trying to be a governor . . . to be a feedback system . . . built in. . . . Let's see. If I grab the out-shaft with my hands . . . and let's say there's a plate on the in-shaft so that my feet can press against it. I put my feet way out on the periphery of the plate and . . . what I really would like is for my feet to get smaller as the speed of the in-shaft increases because then the friction would be reduced and I would hold on to the out-shaft for dear life and its speed might remain constant. . . . The faster the in-shaft went the smaller my feet would become so that the driving force would stay the same.

C: How could you get your feet smaller?

A: That's not the way to ask the question . . . better say, "How keep friction constant?"

E: If for some reason, some anti-Newtonian reason, your feet came closer together on the plate as the speed of the in-shaft increases then your leverage would be reduced. . . . I mean that you might keep the resultant force on the out-shaft constant.

C: I kind of go for that "anti-Newtonian" thing . . . we're fighting centrifugal force here.

E: How about a non-Newtonian liquid? . . . a liquid which draws near to the center of rotation instead of being flung out?

B: You'd have an anti-gravity machine.

E: Fine.

A: The only thing that gets closer and closer to the axis of rotation is a string with a weight on the end . . . a string tied to a stick. You twirl the string and it wraps around the stick till it gets shorter and shorter, . . . finally you don't have any string left.

E: How about a liquid made up of many strings . . . or even better an elastic fluid. . . . Listen! Imagine a fluid that's made up of a billion rubber bands. The faster the axis of rotation goes the more the rubber bands wind up on the axis.

C: You'd have to have those rubber bands sticking and unsticking all the time . . . or breaking and unbreaking, wouldn't you?

E: Maybe . . . maybe . . . but it's not nuts. . . .

B: You know what I like about this crazy way to think about this? It's got a built-in governor . . . that's the trouble with present mechanisms. They're hooligans with tachometers and rpm measurers . . . a womb hung round with barking dogs . . . this damn anti-Newtonian liquid would tell itself when to take it easy.

One of the members of the group built a model on this principle. But it was inefficient. It would have been suitable for a sensing device, but not as a power transmitting unit. So the same member built a mechanical analogy of the liquid constant speed device. This model definitely proved the principle and appeared to be efficient and economical.

The mechanism of Personal Analogy is easily understood after exposure to Synectics technique. However, its application demands extensive loss of self. Some individuals habitually are so wed to rigid inner control and rational behaviour that any alternative behaviour is anxiety inducing. To evoke this mechanism the "teacher"[7] sets the example of Personal Analogy (e.g., in above example, he is the first to enter the transfer box) so that the novice loses his fear of loss of control. The novice needs to see what happens to someone else first. Then hesitatingly and finally with relaxed confidence the novice will begin to use the mechanism himself.

DIRECT ANALOGY

This mechanism describes the actual comparison of parallel facts, knowledge, or technology. Sir March Isumbard Brunel solved the

[7] See chapter V for further exposition of the "teacher" role.

problem of underwater construction by watching a shipworm tunnelling into a timber. The worm constructed a tube for itself as it moved forward, and the classical notion of caissons came to Brunel by Direct Analogy. Hadamard points out, "Especially, biology, as Hamite used to observe, may be a most useful study even for mathematicians, as hidden but eventually fruitful analogies may appear between processes in both kinds of study."[8] Albert Einstein observed that "combinatory play seems to be the essential feature in productive thought."[9] And Alexander Graham Bell recalled, "it struck me that the bones of the human ear were very massive, indeed, as compared with the delicate thin membrane that operated them, and the thought occurred that if a membrane so delicate could move bones relatively so massive, why should not a thicker and stouter piece of membrane move my piece of steel. And the telephone was conceived."[10]

Example of Direct Analogy: A Synectics group was faced with the problem of inventing a dispenser which could be used with various products from glue to nail polish. The dispenser was to be in one piece without a top to be removed and replaced with each use. These specifications meant that the mouth of the dispenser had to be designed to open for dispensing and to close tightly after use. Group members directed themselves to a new way of thinking about the problem. Among the mechanisms which were brought to bear on the problem was Direct Analogy. The group asked itself what actions in nature operated the way the dispenser must in order to satisfy the conditions imposed by the problem.

A: A clam sticks its neck out of its shell . . . brings the neck back in and closes the shell again.

B: Yeah, but the clam's shell is an exoskeleton. The real part, the real anatomy of the clam is inside.

C: What difference does that make?

[8] Hadamard, *op. cit.*, p. 9.
[9] Reiser, A., *Albert Einstein* (London: Thornton Butterworth Ltd., 1931), p. 116.
[10] MacKenzie, Catherine, *Alexander Graham Bell* (New York: Houghton Mifflin, 1928), pp. 72–73.

A: Well, the neck of the clam doesn't clean itself . . . it just drags itself back into the protection of the shell.

D: What other analogies are there to our problem?

E: How about the human mouth?

B: What does it dispense?

E: Spit . . . the mouth propels spit out whenever it wants . . . oh, oh. It isn't really self cleaning . . . you know, dribbling on the chin.

A: Couldn't there be a mouth which was trained so that it wouldn't dribble?

E: Maybe, but it would be contrived as hell . . . and if the human mouth can't keep itself clean with all the feedback in the human system. . . .

D: When I was a kid I grew up on a farm. I used to drive a hayrack behind a pair of draft horses. When a horse would take a crap, first his outer . . . I guess you'd call it a kind of mouth, would open. Then the anal sphincter would dilate and a horse ball would come out. Afterwards, everything would close up again. The whole picture would be as clean as a whistle.

E: What if the horse had diarrhea?

D: That happened when they got too much grain . . . but the horse would kind of wink a couple of times while the anal mouth was drawn back . . . the winking would squeeze out the liquid . . . then the outer mouth would cover the whole thing up again.

B: You're describing a plastic motion.

D: I guess so . . . could we simulate the horse's ass in plastic?

Later the particular Synectics group working on the dispenser problem built a product which operated almost exactly as described by the above analogy. Diversity of backgrounds among group members provides the richness essential for the successful application of the mechanism of Direct Analogy.

Readings of classical scientific discovery as well as seventeen years of practical invention indicate that a biological perception of physical phenomena produces generative viewpoints. Helmholtz, in discussing the invention of the ophthalmoscope, is clear about the influence of various different scientific fields coming together. "I attribute my subsequent success to the fact that circumstances had fortunately planted me with some knowledge of geometry and training in physics among the doctors, where physiology presented a virgin soil of the utmost fertility, while on the other hand I was led by my acquaintance with the phenomena of life to problems and points of view that are beyond the scope of pure mathematics and physics."[11] The strained comparison of a scientific observation in one field with that of another field tends to force an expression of a problem in a new way. Francis Galton emphasized the necessity for adequate knowledge so that the potentially destructive intrusion of alien ideas can be sifted and matched.[12]

Pasteur writes that his successful work on the dissymmetry of natural organics was based "on varied notions borrowed from diverse branches of science."[13] And Cavendish's habit of "carrying on together, widely dissimilar inquiries"[14] permitted him to be continually comparing the phenomena and theories of one branch of science with those of another. In the arts too we can see the effect of Direct Analogy. For instance, the literature of Goethe was founded in music. He says, "It often seems to me as though an invisible genius were whispering something rhythmical to me, so that on my walks I always keep step to it, and at the same time fancy I hear soft tones accompanying some song."[15] And Schiller states, "With me the conception has at first no definite or clear object: this comes later. A certain musical state of mind precedes it, and this, in me,

[11] Koenigsberger, Leo, *Hermann Von Helmholtz* (Oxford: Clarendon Press, 1906), p. 77.

[12] Galton, Sir Francis, *Inquiries into the Human Faculty and its Development* (London: J. M. Dent & Sons Ltd., 1919).

[13] Vallery-Radot, R., *The Life of Pasteur*, tr. R. L. Devonshire, 2 vols. (Westminster: Archibald Constable & Co., 1902), Vol. I. p. 223.

[14] Wilson, G., *The Life of the Hon. Henry Cavendish* (London: Cavendish Society, 1951), p. 20.

[15] Bielschowsky, Albert, *Life of Goethe*, tr. W. A. Cooper, 3 vols. (New York: G. P. Putnam's Sons, 1905), Vol. III, p. 78.

is only then followed by the poetic idea."[16] In both art and science, then, the mechanism of Direct Analogy functions as a constructive agent of creative process.

From one of the toughest-minded successful industrial inventors of the century comes an example of Direct Analogy which occurred in the course of the invention of tetraethyl lead. "Speculating then on why kerosene knocked worse than gasoline, as it was known to do, the two men reasoned that it might be because kerosene did not vaporize as readily as gasoline. They recalled that the wild flower, the trailing arbutus, with its red-backed leaves, blooms early in spring, even under the snow. If only kerosene were dyed red, they speculated, it might—like the leaves of the trailing arbutus—absorb heat faster, and so vaporize quickly enough to burn in the engine like gasoline."[17]

The area of analogy and symbolism has been adopted by Synectics almost out of whole cloth. Mechanisms of metaphor employing Symbolic Analogy and Personal Analogy as well as Direct Analogy are implemented in our day to day experimental work. Synectics theory agrees with the conviction that a man does not know even his own science if he knows *only* it.[18]

SYMBOLIC ANALOGY

This mechanism differs from the identification aspect of Personal Analogy in that Symbolic Analogy uses objective and impersonal images to describe the problem. The individual effectively uses this analogy in terms of poetic response. He summons up an image which, though technologically inaccurate, is esthetically satisfying. It is a compressed description of the function or elements of the

[16] Schmitz, L. D., *Correspondence between Schiller & Goethe*, 2 vols., tr. L. D. Schmitz (London: George Bell & Sons, 1879), Vol. I, p. 154.

[17] Boyd, T. A., *Biography of C. F. Kettering* (New York: E. P. Dutton, 1957), p. 100.

[18] Whitehead, A. N., *The Aims of Education* (New York: Macmillan, 1929).

problem as he views it. In the course of making the problem familiar to himself, the chemist employs extensive quantitative tools. When using the mechanism of Symbolic Analogy he views the problem qualitatively with the condensed suddenness of a poetic phrase. The major difference between Symbolic Analogy and the other mechanisms is quantitative. In Personal Analogy the process of identification takes a long while for all the nuances to be expressed. A Direct Analogy may be quite straightforward but uncovering the comparison of its conceptual ramifications requires substantial time. A Symbolic Analogy is immediate. Once made, in a blurt of association, it is there, complete![19]

The cultural bifurcation of art and science in our society, and the prevalence of advanced trade schools where limited experts are ground out of the curriculum, tend to make it difficult for technical graduates to understand or use the esthetic qualitative mechanisms. However, as we have observed in the case of the other mechanisms, their use can be learned, not abstractly, but through practice. They are used apprehensively at first, but when the student sees them work, producing rich viewpoints which lead to a basic solution, even the apprehensive individual is willing to use such mechanisms to an increasing degree.

Example of Symbolic Analogy: A Synectics group was presented with this problem: How to invent a jacking mechanism to fit into a box not bigger than four by four inches yet extend out and up three feet and support four tons. The application was to be toward moving objects like houses and loads of freight. At the time, common practice was to exert initial displacement with a mechanical or hydraulic jacking mechanism which was small enough to fit into the available opening. This jack with movement limited by the ram length would push the load to the extent of its capability, then the workman replaced it with a larger and then a larger and then a

[19] Kohler, Wolfgang, *Gestalt Psychology* (London: G. Bell and Sons Ltd., 1930), pp. 207–231. Symbolic Analogy is a Gestalt response where the physical, neural, and mental patterns of activity are suddenly integrated into a compressed articulation.

larger unit. It was apparent that there was a need for one unit to do this job instead of a series.[20] In this case the group employed Symbolic Analogy to look at jacks in a new way:

A: . . . how about a biological jack where the power source would be a kind of virus culture. You drop some "food" into the culture and the animals breed and occupy more space thus offering a power source.

B: I think that such zoological entities would stop increasing after their ecology got up to a pressure of a couple of pounds per square inch.

A: Yeah. I guess you're right . . . but at least it's not another ratchet.

C: I wonder if the secret to this problem is energy or instrument?

D: It can't be energy because you could always drive it with a flexible shaft from an electric motor. You would not have to put the motor in there . . . just use the flexible shaft.

E: You could use a slow burning powder that would develop energy as you added oxygen to it.

B: But how would you fit in the actual mechanical moving element which would transfer the power?

A: This goddamn conundrum is like the Indian rope trick! Let the client go to some Indian fakir for the job.

C: It goes in soft and comes out hard . . . goes in soft and comes out hard . . .

D: What the hell are you talking about! . . . Comes out hard!

C: The Indian rope trick. The rope is soft when the guy starts with it. He shows it to everybody. The whole magic is how he makes it hard so he can climb up on it.

E: The penis does this hydraulically.

C: I like this Indian rope trick way of thinking. . . . How could we build a powerful Indian rope trick . . . strong enough to hold up many tons?

[20] Another application was a space-saving replacement for traditional bulky airplane landing gear, particularly a problem in jets.

E: No joke . . . you could do it hydraulically.

B: How?

E: It's obvious. Just collapse a rubber tube into the four inches they're allowing us . . . then pump water or oil into it under high pressure. . . .

B: It would wobble all over hell.

E: Put it inside a telescopic shaft . . . in fact the telescopic shaft could *be* the collapsible thing . . . just pump it up. . . . Oh! That would mean beautifully machined parts . . . and seals. . . . Jesus me beads, what a sealing hooligan. . . . But what's wrong with the rubber tube?

A: Somehow I'd feel safer if the damn thing were made of good steel. . . . If I have to rely on it for my life I don't want some God damn condum. . . .

B: You could reinforce the rubber . . . but this is getting crappy now . . . it hasn't got the elegance of the Indian rope trick concept. . . . We lost it somewhere.

C: How could steel go in soft and come out hard?

B: That's what a steel tape measure does. It comes out and that little bend in it stiffens it enough so that you can actually hold it out in front of you a ways . . . then it all rolls up into the case.

E: But you can't hold up anything with it . . . it would collapse.

B: Put two of them back to back so that they stiffen each other. . . . Have them separate in the case and join as they come out so that they become a monolith.

A: You know bicycle chains can only bend in one direction. They fold right up in the other direction. If you put two of them into a case and designed the thing so that when they come out of the case they were linked they would be as stiff as you needed, yet would roll up tight as hell.

E: I like that . . . I really like that but I'm bothered about how to link the two chains . . . that's tough . . . just saying it doesn't do it.

C: I bet if you just tied them together at the top that they would stay together . . . that's the way they're built.

A model was built based on the Symbolic Analogy of the Indian rope trick. It functioned exactly as described in the session.

Maxwell, for instance, made mental images to represent the elements of every problem—symbols without words. They were a kind of private painting.[21] And Sir Francis Galton said, ". . . I fail to arrive at the full conviction that a problem is fairly taken on by me, unless I have continued somehow to disembarrass it of words."[22] Both Maxwell and Galton used the mechanism of Symbolic Analogy to get away from the familiar over-rationalized, word-intoxicated view of a problem.

FANTASY ANALOGY

For Sigmund Freud, creative work in general, and art in particular, is the fulfilment of a wish, although he does not say, as he has been accused of saying, that it is nothing but a wish. The artist must know how to transform, to depersonalize, to hide the source of his wish. When he is successful in so doing, and his work is accepted, then he has accomplished through fantasy what he could have won in no other way. The wish-fulfilment theory reveals the connection between the artist's motives as a human being and his chosen method of gratifying them. Success depends upon his ability to defer consummation of the wish in fantasy and to make real the wish by embodying it in a work of art.[23]

Example of Fantasy Analogy: Synectics accepts Freud's wish-fulfilment theory of art, but turns it onto technical invention as well and uses it operationally. For instance, when faced with the problem of inventing a vapor proof closure for space suits, a part of the

[21] Campbell, L., and Garrett, M., *The Life of James Clark Maxwell* (London: Macmillan, 1882), pp. 259–260.

[22] Galton, Sir James, "Thought Without Words," *Nature*, May 1887, p. 29.

[23] Freud, Sigmund, *New Introductory Lectures on Psychoanalysis* (New York: W. W. Norton, 1933), 22nd lecture; Freud, Sigmund, *An Outline of Psychoanalysis* (New York: W. W. Norton, 1949), chap. 5.

Synectics approach was to ask the question, "How do we in our wildest fantasies desire the closure to operate?"

G: Okay. That's over. Now what we need here is a crazy way to look at this mess. A real insane viewpoint . . . a whole new room with a viewpoint!

T: Let's imagine you could will the suit closed . . . and it would do just as you wanted by wishing . . . (Fantasy Analogy mechanism)

G: "Wishing will make it so . . ."

F: Shh, Okay. Wish fulfilment. Childhood dream . . . you wish it closed, and invisible microbes, working for you, cross hands across the opening and *pull* it tight. . . .

B: A zipper is kind of a mechanical bug (Direct Analogy mechanism). But not air tight . . . or strong enough. . . .

G: How do we build a psychological model of "will-it-to-be-closed"?

R: What are you talking about?

B: He means if we could conceive of how "willing-it-to-be-closed" might happen in an actual model—then we. . . .

R: There are two days left to produce a working model—and you guys are talking about childhood dreams! Let's make a list of all the ways there are of closing things.

F: I hate lists. It goes back to my childhood and buying groceries. . . .

R: F, I can understand your oblique approach when we have time, but now, with this deadline . . . and you still talking about wish fulfilment.

G: All the crappy solutions in the world have been rationalized by deadlines.

T: Trained insects?

D: What?

B: You mean, train insects to close and open on orders? 1-2-3 Open! Hup! 1-2-3 Close!

F: Have two lines of insects, one on each side of the closure—on the order to close they all clasp hands . . . or fingers . . . or claws . . . whatever they have . . . and then closure closes tight. . . .

G: I feel like a kind of Coast Guard Insect (Personal Analogy mechanism).

D: Don't mind me. Keep talking. . . .

G: You know the story . . . worst storm of the winter—vessel on the rocks . . . can't use lifeboats . . . some impatient hero grabs the line in his teeth and swims out . . .

B: I get you. You've got an insect running up and down the closure, manipulating the little latches . . .

G: And I'm looking for a demon to do the closing for me. When I will it to be closed (Fantasy Analogy mechanism), Presto! It's closed!

B: Find the insect—he'd do the closing for you!

R: If you used a spider . . . he could spin a thread . . . and sew it up (Direct Analogy).

T: Spider makes thread . . . gives it to a flea. . . . Little holes in the closure . . . flea runs in and out of the holes closing as he goes. . . .

G: Okay. But those insects reflect a low order of power. . . . When the Army tests this thing, they'll grab each lip in a vise one inch wide and they'll pull 150 pounds on it. . . . Those idiot insects of yours will have to pull steel wires behind them in order. . . . They'd have to stitch with steel. *Steel* (Symbolic Analogy mechanism).

B: I can see one way of doing that. Take the example of that insect pulling a thread up through the holes. . . . You could do it mechanically. . . . Same insect . . . put holes in like so . . . and twist a spring like this . . . through the holes all the way up to the damn closure . . . twist, twist, twist, . . . Oh, crap! It would take hours! And twist your damn arm off!

G: Don't give up yet. Maybe there's another way of stitching with steel. . . .

B: Listen . . . I have a picture of another type of stitching. . . . That spring of yours . . . take two of them . . . let's say you had a long demon that forced its way up . . . like this. . . .

R: I see what he's driving at. . . .

B: If that skinny demon were a wire, I could poke it up to where, if it got a start, it could pull the whole thing together . . . the springs would be pulled together closing the mouth. . . . Just push it up . . . push—and it will pull the rubber lips together. . . . Imbed the springs in rubber . . . and then you've got it stitched with steel! (See figure 5.)

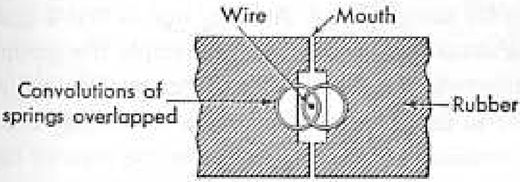

Figure 5. Cross-sectional Diagram

In the above transcription I have taken the liberty of pointing out symptoms of various mechanisms in action, but the real purpose of the transcription is to give an example of the mechanism of Fantasy Analogy. Conscious self-deceit appears in all the mechanisms to a greater or lesser degree but in the mechanism of Fantasy Analogy it is paramount. When a problem is presented to the mind it is most useful to imagine the best of all possible worlds, a helpful universe permitting the most satisfying possible viewpoint leading to the most elegant of all possible solutions.

A world where insects perform as required is this kind of universe. Common sense outlaws such fabrication which "foolishly" flies in the face of established law: How would our problem change if gravity didn't hold? What would happen to our viewpoint if entropy could be ignored? To tolerate these naive inconsistencies is irrational. It is irrational and like the other mechanisms, Fantasy Analogy has operated usually underground in the subconscious because the rational character of man denies himself and the world the vision of that part of himself which is other than proudly coherent.[24]

[24] This mechanism is akin to Freud's concept of the role of wish-fulfilment

Fantasy Analogy is particularly effective if used first in the process of making the familiar strange. This mechanism is an excellent bridge between problem-stating and problem-solving. For instance, in the preceding example, "the-willing-to-be-closed" and insect fantasy were forms of restatement of the problem in imaginative terms. The group was saying, "This closure problem is described by imagining some insects who do the closing job." Another reason for using Fantasy Analogy first is that it tends to evoke the other mechanisms. In the closure example the group goes from Fantasy Analogy to Direct Analogy to Personal Analogy, etc.

It is easier to imagine the mechanism of Fantasy Analogy operating as a conscious self-deceit fantasy in the area of the arts than in the sciences. A painter or writer can describe the world however he wishes whereas the traditional notion of the scientist is that he is limited by the phenomenological and theoretical "givens" of the world order. So long as this traditional notion is in force, technological breakthroughs will be inhibited. The technological inventor deserves and must give himself the same freedom as the artistic inventor. He must exercise the right to imagine the best (fantasy) solution to a problem while temporarily disregarding the laws defined by the implications of his solution. Only in this way can he construct an image of the ideal.

The expression "conscious self-deceit" is used to express the fact that the problem solver must be aware of the laws which conflict with his ideal solution—yet he must be willing to pretend the laws don't exist. Michael Faraday used self-deceit, as Synectics describes it, in the course of his electromagnetic research. He found that he was forced to put aside the electrical terms of his day because, "they do great injury to science, by contracting and limiting the habitual views of those engaged in pursuing it."[25] By disbelieving

in creative process. The difference lies in the Synectics use of self-deceit at a conscious level.

[25] Crowther, J. A., *Michael Faraday* (New York: Macmillan, 1920), p. 144.

the traditional science of his day, Faraday was able to see a more coherent hypothesis than had been realized.

The trained expert tends to be super-rational and feels threatened by any thinking which attacks his logical universe. This attitude makes breakthrough impossible. "It used to be held that God could create everything except what was contrary to the laws of logic. The truth is that we could not say of an 'unlogical' world how it would look."[26] Thus one may view a problem pretending that the laws of physics are not valid. In this way it is possible to sneak in a new way of thinking. The immutable laws usually do hold, but by pushing them out of phase for a moment one can peek in between. By the time the laws are permitted by the mind to snap back into control, the mind has derived a new viewpoint and can discover useful aberrations of the laws underlying the new viewpoint so essential for basic solution.

CONCLUSIONS

Abstractions such as intuition, deferment, empathy, play, use of irrelevance, involvement, detachment—these abstractions are almost impossible to teach because of their lack of concreteness; i.e., they are non-operational. However, the mechanisms (Direct Analogy, Personal Analogy, Symbolic Analogy, Fantasy Analogy) are psychological tools which at the conscious level almost everybody has experienced to a greater or lesser degree. Therefore it is possible to introduce them without making the individual feel that he is being manipulated. Because he correctly feels that his natural potential is being enhanced, his resistance is considerably reduced. It is absurd when dealing with rigidly conventional people to say, "let us balance a variety of irrelevancies now." On the other hand, they do not feel threatened, for instance, by an analogy from another science to

[26] Wittgenstein, Ludwig, *Tractatus Logico-Philosophicus*, (London: Routledge and Kegan Paul Ltd., 1922), p. 43.

compare with the technology implied by the problem at hand. However, the mechanism of Fantasy Analogy tends to induce the other mechanisms rather than being evoked by them.

Play with analogies covers a scale with an endless variety of levels, ranging from that which is apparent to the popular mind to that which is known only to an expert. On the simple end of the scale are analogies which are associations leading to fairly naive comparisons, such as the connection of the horse's anal sphincter with a self-sealing, self-cleaning dispenser. Applying this mechanism required no special knowledge of the physiology of the terminus of the equine lower bowel. The image of the simple sphincter function on the level of superficial perception was sufficient.

At the opposite extreme of the scale useful mechanisms derive from academic knowledge in depth. For instance, a Synectics group was attempting to solve the problem of how to invent a new kind of roof which would be more actively serviceable than traditional roofs. Analysis of the problem indicated that there might be an economic advantage in having a roof white in summer and black in winter. The white roof would reflect the sun's rays in summer so that the cost of air conditioning could be reduced. The black roof would absorb heat in winter so that the cost of heating could be minimized. The following is an excerpt from the session on this problem:

A: What in nature changes color?

B: A weasel—white in winter, brown in summer; camouflage.

C: Yes, but a weasel has to lose his white hair in summer so that the brown hair can grow in. . . . Can't be ripping off roofs twice a year.

E: Not only that. It's not voluntary and the weasel only changes color twice a year. . . . I think our roof should change color with the heat of the sun. . . . There are hot days in the spring and fall . . . and cold ones too.

B: Okay. How about a chameleon?

D: That is a better example because he can change back and forth without losing any skin or hair. He doesn't lose anything.

E: How does the chameleon do it?

A: . . . . a flounder must do it the same way.

E: Do what?

A: Hell! A flounder turns white if he lies on white sand and then he turns dark if he lands on black sand . . . mud.

D: By God, you're right: I've seen it happen! But how does he do it?

B: Chromatophores. I'm not sure whether it's voluntary or nonvoluntary. . . . Wait a minute; it's a little of each.

D: How does he do it? I still don't plug in.

B: Do you want an essay?

E: Sure. Fire away, professor.

B: Well, I'll give you an essay, I think. In a flounder the color changes from dark to light and light to dark. . . . I shouldn't say "color" because although a bit of brown and yellow comes out, the flounder doesn't have any blue or red in his register. . . . Anyway, this changing is partly voluntary and partly nonvoluntary where a reflex action automatically adapts to the surrounding conditions. This is how the switching works: in the deepest layer of the cutis are black-pigmented chromatophores. When these are pushed toward the epidermal surface the flounder is covered with black spots so that he looks black . . . like an impressionistic painting where a whole bunch of little dabs of paint give the appearance of total covering. Only when you get up close to a Seurat can you see the little atomistic dabs. When the black pigment withdraws to the bottom of the chromatophores then the flounder appears light colored . . . Do you all want to hear about the Malpighian cell layer and the guanine? Nothing would give me greater pleasure than to. . . .

C: You know. I've got a hell of an idea. Let's flip the flounder analogy over on to the roof problem. . . . Let's say we make up a roofing material that's black, except buried in the black stuff are little white plastic balls. When the sun comes out and the roof gets hot the little white balls expand according to Boyle's law. They pop through the black roofing vehicle. Now the roof is white, impressionistically white that is, à la Seurat. Just like the flounder, only with reverse English. Is it the black pigmented part of the chromatophores that come to the surface of the flounder's skin? Okay. In our roof it will be the white pigmented plastic balls that come to the surface when the roof gets hot. There are many ways to think about this . . .

The knowledge of zoology imparted by B was not childlike or naive. As contrasted to the anal sphincter analogy, the flounder analogy was backed up by technological insight without which no new viewpoint would have been possible.

Over a period of seventeen years Synectics research has observed that the richest source of Direct Analogy is biology. This is because the language of biology lacks a mystifying terminology, and the organic aspect of biology brings out analogies which breathe life into problems that are stiff and rigidly quantitative.

Although the mechanisms are simple in concept, their application requires great energy output. In fact, Synectics does not in any way make creative activity easier but rather is a technique by which people can work harder. At the end of sessions we have observed complete fatigue on the part of the participants. This fatigue comes less from the concentration involved in working through the constructive mechanism, and more from the variable balance which is so necessary. The mere stringing together of metaphors is nonproductive. Synectics participants must keep in the back of their minds the problem as understood so that they can identify those mechanisms which illuminate the problem. This oscillation between, on the one hand, apparently irrelevant analogy formation and, on the other, comparing the analogy with the elements of the problem is enormously tiring. Individuals who can learn (or who already know how) to entertain a great variety of variables without becoming confused are much more apt to be effective in a creative situation. However, the price they pay is exhaustion which is physical.