It is imperative to design details, such as window placement and circulation, so that they are not associated with the same type of detail application in a space considered uninviting.

In top right example the high, narrow strip windows with lack of subject matter for view besides the sky are associated with windows in a basement.

Tight, winding halls, as indicated in the building type study of Forum des Halles, will bring about a confined and disoriented feeling.

Dark, tight halls may be associated with "catacombs", here is another case where an uneasy feeling is brought on by association with another oppressive environment that has some similar elements.
The form of the transition element is very important to the overall effectiveness of that transition or movement into the underground space.

A strong, steep slope may be as poor a transition as a straight vertical shaft; the slope may give the appearance of a "slide" down into the underground cave.

A smooth, effective transition can be obtained by stepping down gradually. This method of build up to the surface will provide the occupant with an easier perception of his relationship to the surface.
Transition into the underground space is important in overcoming the "cave" myth concerning an underground building. Transition from above ground to below ground as well as interior to exterior transitions involve more than a single point of entry or a simple barrier separating the areas. Transition should include consideration for movement from one area to another and the approach from a distance, as well as, the architectural elements viewed from one area in another area. Transition of form, color, and texture is as important as location change.
Multiple access to a space will help to reduce the feeling of confinement in a space. People can feel closed in and become uneasy unless they can readily see more than one means of egress.

In large underground structures occupants may tend to remain in the general area of the only major "escape" point. Having more than one "escape" point readily visible to the occupants will help to promote a sense of security in that they have more than one means of egress if necessary.

This can help encourage movement through the entire space.
Air is an important element in the psychology of design. First of all, because the underground space is confined by earth and the entry may be sheltered the flow of fresh air into the space will be greatly reduced. This will eventually bring about a stuffy feeling. Even though fresh air is an important physiological necessity, the absence of fresh air will cause people to want to leave the area and move to a more comfortable zone. Fresh air and odors are not always a bad thing. In some areas it may be desirable to isolate the underground space from environmental odors, in others the natural odors may be pleasant. Atrium/lightwells may be a source of considerable turbulence under certain wind conditions. It is better to control the intake of fresh air and avoid turbulence especially if this becomes a cold windy area in the winter.
The shape of the atrium/lightwell wall has a significant psychological impact on the underground space. A straight vertical wall or atrium with all walls vertical can give a cold, hole in the ground feeling.

A better use of form would be a sloped or terraced wall where plants of some type could be grown. This not only provides a possibility for colorful plants to look at, but facilitates a better angle for exterior view and makes a better transition from above grade to below grade.

It is also important to consider the size and form of an atrium in its plan view. Widening the atrium will quickly change the perceived size. Sloping the side walls will open it even more and facilitate still wider views.
Spatial orders are those normally unperceived but extremely important organizers of spaces. Spatial orders direct the way people perceive and interact with their environment. Spatial orders exist in both natural and man-made environments.

Spatial orders are important to psychology since the conflicts between spatial orders may cause a feeling of uneasiness in the occupants of a space.

Integration of normal perceived spatial orders in the underground is very useful.

One possible integration would be to bring the natural order into the interior space such as an order to plants which carries into an interior space.

Each situation and use must be carefully analyzed to prevent spatial order conflicts. Conflicts can easily arise, especially in multi-function spaces, because spatial orders are very individualistic and personal.
Some studies have shown that the preferred height of ceilings on the average is 10'.

The preferred slopes are 0 (horizontal) and a 4/12 slope. Slope ceilings can provide an interesting and stimulating contrast to the horizontal plane. Slope ceilings may be stronger structurally and produce a more open, spacious feeling on the interior.

It is imperative to analyze the slope and height of the ceiling so as not to produce a dark corner or a low ceiling which may increase the feeling of confinement.

When the roof of an underground building is covered and drainage is not a problem, the ceiling at the earth side walls can be sloped up to create a less confining environment.
Excessive contrast between the exterior and interior can cause visual discomfort.

In some places high contrast can be used to emphasize architectural elements, planters, circulation nodes, etc. As a general rule for lighting levels, high contrast should be avoided.

High contrast can cause dark areas to appear like caves. People will want to move to the lighter areas where they feel more comfortable.

It is also important to consider the contrast levels between the interior space and an exterior atrium at night. A highly lighted interior with a dark atrium and large glass area may not give the desired visual privacy.
Color and texture are two important elements in creating a livable environment. Lack of texture on interior surfaces can produce a boring, mundane atmosphere and cause the desire for a view to be directed to the exterior.

Texture and form should be included. Varied forms and angles may help provide visual stimulation.

Light, bright colors will make a space seem bigger. Bright colors also are useful because they reflect light around the space to other surfaces.

It is important to provide an adequate level of stimulation by texture without approaching the level of over stimulation by too much texture variation.
Skylights may not be perceived and may also have little or no effect on an occupant's psychological well-being. If there is a large contrast between the relative light levels of areas without skylights and those with skylights, then the sky light may be perceived or noticed by someone. However, if light levels are not in high contrast the light-well may not even be noticed.

Thus, if a lightwell is not providing a sufficient amount of natural light then it may serve equally as well to have an "artificial" skylight.

The impact of skylights is also determined by the use of the light brought in. If the light is used simply to light a hall which is already lighted the impact may be minimal. If the skylight is above a planter or circulation node the impact of the skylight can be much stronger.
The essence of this concept is the different perception of a physical and visual barrier when earth is bermmed against that barrier compared to when the barrier stands alone. People remember the environment and defining barriers of a space that they see as they enter a space. A wall which is bermmed with earth behind it may produce a different orientation of activity inside a space than a wall which is open on the opposite side. Even though a space may be the same size as another and have the same quality of physical and visual activity earth confined walls and ceilings may feel more oppressive.

An interior wall which has a corridor or another room on the opposite side of it will be perceived differently than one which has earth on the opposite side.
Open spaces allow view from all areas to all others.
Privacy is limited.
Feeling of confinement is limited because all areas of space are seen providing a larger perceived area than a single room.

Less freedom of movement.
Greater privacy.
Spaces adjacent to central zone but physical separation exists.

Increased privacy between zones.
View to central zone is still maintained.
Movement, view, noise - are restricted and more control over these is possible.
Lends itself to large scale projects.
Building underground can have several benefits. Placing a building underground can effectively increase the surface area for use as a natural landscaped area. Thus a potential for increased psychological benefits from this extended green space exists.

Placing buildings underground in an urban area will reduce the apparent feeling of high density and overcrowding. This psychological benefit of a feeling of lower density will also be enhanced by the reduced obstruction of distant views by buildings.

Building underground can also eliminate the problems of noise that can develop in the city where sound easily reflects off of the building facade.
One possibility can be derived by combining the function of a visual focus which acts to filter a view with the function of defining an atrium area. This atrium area can serve as a semi-private zone. The visual focus can also be constructed such that it acts as a wind buffer or filter. The buffer could also be used to direct movement, as well as wind, and could become a transitional element. Here a synthesis of many smaller concepts and functions is derived which can serve to integrate the variable design elements into a coherent unit.
The purpose for developing the following series of principles was to address the most basic of design elements as they relate to underground design. Form, texture, rhythm, pattern, and color are a few of the principles inherent in all design and that are studied here in their relationship to underground design. Many of these smaller, more detailed principles work together to create a total understanding of those larger concepts defined earlier. It is impossible to look at a single concept without examining several different principles. Though these principles are directed at the underground scenario, some may certainly be applicable to all design situations in general.
Straight walls are by far the most common type of form used based on past use in underground/earth sheltered buildings. They do not provide much visual stimulation in their form unless they are staggered.

Curved forms in walls can provide a more pleasing and exciting interior form. They tend to indicate a centralized organization in the building which may direct attention away from earth bermed walls. It is also important to consider that focusing inward while reducing perception of walls may also reduce the perceived size of the space. Curved walls are also somewhat more structurally stable than straight walls depending on the degree of arc.

Undulating curves provide even greater visual stimulation and variety of form. In large scale they can be used to define subspaces. This wall is even stronger than a single curve.
The perception of underground is one of moving down into the earth. If a building moves farther into a hill, or as a person moves away from an entry or light well into the building, the floor level steps up, then the perception of moving down into a confining underground may be reduced.

A central living area may be recessed for a more intimate feeling. It is advisable that this lowered floor level be near the center of a building or space and not the earth side edges.

The variance in floor levels will provide an element of both physical and visual spatial variety which makes the space more interesting and exciting.
Flat ceilings are normally fine and do not draw significant attention. In the underground building a form in the ceiling may increase the perceived openness of the space.

Curved ceilings provide a flowing height with an open feeling. More importantly the edge between ceiling and wall is not as perceivable.

The edge at an earth side without a window can be confining. As long as a view is provided from a space that is horizontal and provides view of all 3 view formats, a high strip window will not have nearly the "basement window" effect it normally has.

Optimum placement would be high ceilings at earth edges with ceilings either curved or sloped.
The straight, vertical wall is the most common. When placed high enough and in a small enough atrium it has a confining feeling by providing extremely limited view. The sloped atrium wall allows a wider view angle. The effect on perception is simply to increase the size of the atrium.

The stepped atrium not only allows a wider view angle but also provides flat levels for plantings and other activity areas. The stepped form has the effect of pulling people into the atrium. It also gives the feeling of being able to leave the atrium even if the steps are actually not meant to be walked on. The drawback is that it may increase the perceived depth because the steps act as depth markers.
The atrium may be designed such that the overall size can be perceived from the interior of the building. It can be designed so that the perceptually defining edges are easily recognized. This allows the individual viewing to fully perceive his relationship to the exterior. The person is then fully aware of the limits and boundaries of that space. Another approach to atrium design is to de-emphasize the boundaries of the atrium. This is done in the Japanese garden. Elements and edges are designed such that the space, though actually small, gives the feeling of continuing past visual boundaries. It implies a much larger space exists and that one is simply in a smaller area of that much larger space.
The scale at an entry is important to the initial perception of a building. An extremely small scale entry can give a very closed and confining feeling at the entry. Low, dark openings will give an initial perception of a dark building interior.

Large entries with plenty of glass to allow visual perception of the interior before entry is made will be perceived more positively than a small, tight entry.

In underground buildings the size and design of the entry should not give the perception that the interior will be in any way confining.
Scales vary from large and open down to intimate. The size, number, type, and location of surrounding elements has a major impact on the perception of a space. An intimate zone, as long as it is not confining, will make the person more comfortable. The smaller, intimate zone will make the person feel as if he has a domain to control. The perception of elements that define a space, such as a ceiling, is partially determined by their scale. The larger beams cause the ceiling to be perceived as much more heavy and ominous. The ceilings and beams in an underground building must give the perception of a light and airy ceiling.
Scale is an important concept to consider since perception of scale is important to the perception of space. Elements need to make the scale of a space appear larger. However, it is critical not to make the individual who is experiencing a space feel smaller than normal and hence dominated by his surroundings. Elements that are in a normal scale or common scale relationship will not be as perceptually significant as elements that are not of normal scale, particularly if they are larger in scale. Elements such as doorways, windows, and stairs have an inherent perceived scale. Making doorways smaller can make a person be perceived as larger than normal.
Patterns of materials can cause wide variations in perception of the size of a space and its form.

Line of site is important to understanding the correct pattern of materials to be used. Always consider the main direction of view and the size of a space when choosing a pattern in materials.

Pattern lines parallel to the direction of the line of sight will tend to increase the perceived depth of a space. The viewer's position in a room will appear farther away from a window aperture standing perpendicular to material pattern. Pattern lines perpendicular to the direction of the line of sight will tend to reduce the perceived depth of a space.

Do not use patterns which increase perceived depth of an underground room.
In viewing the aperture and the interior space both horizontal and vertical planes contribute to the perception of depth and size of space.

Pattern lines on a wall in a square room will tend to contribute to the perception of depth more than they will in a room with greater horizontal dimensions.

However, most rooms will have greater horizontal dimensions than vertical dimensions. Since it is somewhat easier and quicker for the eye to gather information from a horizontal plane, the horizontal floor will contribute more to the perception of depth of the room than lines in the wall.

Wall - contributes to height perception, horizontal boundaries.

Floor - contributes to depth perception.
In most cases this pattern 1 de-emphasizes the depth of a space. However, if the size of material spacing is reduced as the distant wall is approached, for instance a window wall, the perceived depth of the space in 2 will be greater than that in diagram 1. In an underground space this would make the window and atrium appear farther away and the space more confining.

The spacing could possibly be reversed such that increments are progressively larger as window wall is approached. This would have the effect of shortening the space. The material spacing, if made smaller on the wall plane, would serve to emphasize the vertical dimension of the space more, possibly making the space appear taller.

It is very important to include material spacing patterns which do not make space more confining.
Pattern lines running parallel to the window aperture will shorten the perceived length of a space when placed on the floor.

On a wall, lines parallel to the aperture face will make the perceived depth of the space less than lines parallel to the line of sight. However, they will increase the perceived depth when compared to a patternless surface.

Closely spaced lines as in diagram 2 will significantly increase the perceived depth over the spacing in diagram 1, particularly if the wall pattern is tighter than the floor pattern.

Application of lines parallel to sight line on a wall when mixed with lines parallel to window wall on floor will also emphasize depth, probably even more than vertical lines. Hence, vertical lines on wall are suggested but pattern should be as widely spaced as possible.

Principle 12
Unless a specific perceptual effect is desired from horizontal or vertical pattern, it may be advisable to use an angular pattern.

Figure tends to direct eye to corner joint at ceiling thus slightly opening the aperture perceptually and pressing ceiling down at rear.

Figure 2 pulls eye down at front corner where wall joins the floor. The pattern also causes an apparent expansion in the wall height as one moves back into space and thus opens the space up.

The angled pattern could also be carried around the ceiling in an attempt to reduce the perception of the ceiling/wall joint. Careful analysis of pattern is necessary to create a line pattern that continues from wall around ceiling and does not emphasize wall/ceiling joint.
Patterns in materials can serve as connectors between spaces. A continuous pattern in a material on the floor plane which is the same in two spaces or, for example, an interior and exterior space, will begin to connect those spaces. The continuous pattern will result in a subtler transition between spaces. It is possible though by the pattern to emphasize the converging perspective lines and thus draw attention to the depth of a space where it is not desired to perceive that depth, i.e. underground.
Vertical lines at an aperture that runs from ceiling to floor will somewhat detract from the impact of the wall and window.

If curtains or mirrors are provided at the sides of apertures it will begin to increase the perceived size of the opening; particularly, if the wall at the window edge is set at an angle to the plane of the window.

Some patterning will emphasize the size and shape of a window as illustrated in the top two diagrams. Given equal glass and wall areas, pattern lines running in the same direction as major glass dimension will cause window to be perceived as smaller than pattern lines perpendicular to largest dimension of glass.

In drawing 3 the size of aperture may be perceived as the actual puncture in the wall plane whereas the aperture may in reality only be the central portion of that penetration of the major wall plane.

Principle 15
Rhythm not only applies to patterns in materials but also to organization of structure and virtually any system in a building with repetitive members.

Rhythm in material patterns is important in both large and small underground buildings.

Rhythm in planes is easier to use as a perceptual element in large underground buildings because in the large scale project the planes may be perceived in a larger number than in a small building such as a residence.

In larger buildings rhythms can be used to denote nodes in circulation. By varying the sizes of spaces or introducing alternate rhythms in structure, special gathering spaces can be noted.

Rhythm in planes is only effective if the pattern can be perceived so that changes in pattern or interruptions are easily noted.
Heavy texture can provide necessary visual stimulation in the underground building. Too heavy texture though, may cause an uncomfortably high level of stimulation and reduce satisfaction by increasing the perceived level of crowding.

If heavy texture is maintained, it should be ordered and regular. The ordering of texture into a perceivable pattern will facilitate quick recognition by the brain and yet provide a higher level of stimulation than a plain wall. It may be possible to incorporate a rougher or higher level of texture when the entire surface is constructed in a perceivable pattern.

A high level of detail can be incorporated in the pattern as long as an overriding pattern is easily perceivable. Structured patterns are suggested for highly textured surfaces in the underground.
Heavy texture applied to a plane emphasizes this plane. Heavy texture is easily associated with heavy mass. Hence, heavily textured ceilings will tend to be compressive and domineering in the underground scenario. It is not recommended to apply heavy, rough texture to ceiling plane in underground buildings.

Heavily textured floors will have opposite appearance as a ceiling. Rough texture on floors will of course emphasize that plane, but the associated heaviness, corresponds to its physical location as a floor plane. Textured floor planes will not be as oppressive or confining in the underground building environment.
Texture will emphasize an element when contrasted to surrounding levels of texture. Generally, heavy, rough textures will create a stronger emphasis when compared to a smooth plane. The greater the contrast between the amount of surface area of each particular texture, the greater the emphasis will be on the smaller element.

Texture around a penetration in a wall plane will emphasize that penetration when the texture around the opening is juxtaposed to the level of texture on the basic wall plane. The area of textural differentiation will be perceived first followed by the penetration. Thus the textural variation serves to emphasize the opening or a material joint by first calling attention to a change in normal texture.
Smooth, taut surface will de-emphasize the plane.

Smooth and highly reflective surfaces can act as mirrors which tend to open up a space even more.

Optimal surface texture for use in underground buildings on wall planes.

Moderate level of texture.

Surface begins to draw attention from window.

Surface texture begins to be powerful articulation in space.

The maximum level of textural articulation recommended for an entire wall plane.

Heavy, rough texture on wall plane.

Total surface becomes harsh and domineering wall plane is strongly emphasized; if mixed with a dark tone could be confining.

Not recommended for total wall surface in underground.
With equal sized walls and apertures, texture will make an aperture appear smaller when applied around an opening. Texture causes the apparent opening to recede thus appearing smaller due to perspective depth. Texture will draw the attention of the eye away from an aperture and the view it provides.

Heavier textures will tend to draw attention more than lighter textures. Extremely intricate texture or texture without a pattern or order may be difficult to look at for extended periods of time.

The application of highly textured materials at window apertures is thus not recommended in underground buildings.
Volume of a space is important to understanding and predicting the level of confinement that a space produces.

Far more important than volume though, is the height to width relationship as illustrated in diagrams. Though both spaces represent equal volumes, space 2 is much more confining.

As a general rule spaces need to be wider in dimension than the height to reduce confinement. This is simply due to the ease of horizontal physical and visual movement.
As a general guide to spatial proportions in the underground environment the volume model at left should serve as a guide. The height to width ratio should be approximately 1:3. No more than 1:2 height to depth ratio should be used unless either one of the following conditions is met:

1). Introduction of a lightwell/skylight mechanism for rear area.

2). Large open area to one side which would serve as a perceived secondary means of egress.
Almost as important as the interior spatial proportion, is the exterior atrium proportion. In order to provide a highly active atrium with a wide variety of plant life the height of atrium wall to the depth of atrium should maintain a 1:3 relationship. This will provide ample sunlight even at lower sun angles. At less than 1:3 the shade begins to overtake the entire floor of the atrium excluding the possibility of growing short plants except during the main growing season.

Note that the critical wall height is not the aperture height, rather, it is the atrium wall height that is critical. A lower atrium wall can effectively reduce needed atrium depth.
Concerning height to width relationships of a space, with the width being the horizontal dimension of the room running parallel to the aperture, it is better to keep major spaces within a 1:1.5 and 1:3 height:width ratio. If the ratio is less than 1:1.5, 1:1 for instance, the space will be too confining horizontally.

If the ratio is greater than 1:3 the space will begin to be confining vertically.

These ratios represent room or single space sizes. They hold true for perceptions of a complete space. Divisions within this space will break the overall space down into smaller perceived areas whose dimensions must be analyzed individually.

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**Principle 2**

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**SPATIAL PROPORTION — 92**
In the underground building any vertical planes which block the view in a main space should be filters rather than solid planes. As filters they would still allow a definition of auxilliary spaces but not totally restrict light or view. Planes do not have to run the full vertical height of a room. Planes at floor level which are only a few feet high will direct movement and define spaces within a building. It is important to keep these planes well below the line of view especially if they would represent an obstruction of the only view to a space.
Barriers in the underground must be designed very carefully as they represent a possible obstruction of necessary view. A solid portion of a wall at either side of a window wall will change the direction or thrust of major view and activity in a room. Because a view through a room into an atrium contains a high level of detail and several layers of visual stimulation, that view is preferred to a view angle that includes only a view of the room. Therefore, any thing within this view angle becomes significant.

Opaque planes which limit interior view will direct view through the interior space to a specific area. It is critical in underground design to keep those planes which restrict view to major spaces at a minimum size.
The perception of edges is a prime influence on the perceived size of a space. The perception of an interior edge \(^1\) is the most important in creating spatial definition and ultimately the feeling of being confined by a small space. By placing a window at this edge, the perceived impact of this edge as a spatial definer is lessened. The wall and space appear to continue on.

Edge \(^2\) is important to the definition of the atrium and relating interior position into the context of the exterior. The edge at the ceiling plane is also a critical spatial definer. This impact can be minimized by a curved, arched, ceiling or by creating a line on the wall lower than the edge and wrapping both material and color around the edge.

Principle 28
Though it is desirable to provide a view of 3 levels of view image (foreground, surround, sky), it may be necessary to reduce the aperture. The optimum condition is to provide view of all 3 levels. The worst condition is only providing view of the sky.

However, to completely cut off view of the sky when viewing through a window to an atrium will constrict space and increase perceived level of confinement.

Less restrictive would be the raising of the sill level so that only surround and sky level are viewed. This still allows a visual connection with those areas providing maximum stimulation. It is also easy to move closer to window and gain access to the ground view.
The view of an atrium is extremely important for producing a satisfactory underground environment.

The edges of the atrium serve to define the space, particularly if the window aperture runs wall to wall. If the atrium edges are not visible there may be a tendency for people to stay closer to window in order to have contact with that exterior spatial definer.

If opaque wall surface is placed adjacent to an aperture such that the edges of that atrium are no longer visible then the majority of activity and zone of maximum satisfaction with the interior space will occur as close as possible to the aperture. Size of space may not change but confinement significantly increases. This edge serves to stop the space at that point.
As well as defining the edges of the atrium in an attempt to show the size and boundaries of the atrium, it is also possible to de-emphasize the interior edges and maintain the complete perception of atrium boundaries.

By minimizing both edges, the barrier becomes more of a visual barrier and less of a physical barrier. The barrier is perceived as a negotiable obstacle in the path of movement, not as a physical separator of interior and exterior spaces. Compare this to a horizontal window above a sill which runs full width of room or a centrally located window.
Hue and intensity are two important factors in choosing the appropriate "color" to use. The hue is the pure color. A warm hue will be seen as an active color in most cases and will make objects appear larger and heavier. Cool hues tend to make objects lighter and smaller. Intensity is the relative purity of the hue when diluted with a base of white for instance. A less intense color will appear lighter than a very intense pure color. Brightness is also important. This represents the relative brightness when compared to a base gray scale.

The use of darker gray values will make the ceiling and walls heavier and more ominous. The darker planes emphasize the plane of glass. Dark ceiling planes are not advisable because they perceptually are heavy and do not allow the space to feel open. Dark floor planes are not a problem since their weight is located at a place where they do not confine the space. Dark walls may have much the same effect as the ceiling but not as dramatic. This will depend on the form, contrast, texture, and other conditions.

* See color psychology in appendix A.
When used to attract attention and provide variety of stimulus, colors can be a viable mode for emphasizing elements. Dark colors can emphasize elements when placed against a lighter color surface.

The color which is used the most will set the base for comparison of colors and gray values on elements. It takes less of a darker color to be perceived as the main color than it does of a lighter color.